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First Aid

Search-and-rescue teams must number among their members persons trained to provide first-aid treatment to victims of accident or illness. The challenges facing first-aiders can be heightened because of weather conditions, location of a victim, distance from a road or aircraft landing zone, and the need to render aid using only the supplies and equipment the team has carried with them. Advanced first-aid training with an emphasis on wilderness emergencies prepares team members with the medical skills they need and a methodology for addressing emergencies in remote settings.

Upon finding an injured or ill person, a SAR team's routine generally will follow the same protocol as for incidents in the frontcountry:

Take Charge

Team members will focus their attention on the job of making people safe. Their training and experience will nearly always infuse their efforts with an air of authority.

Approach With Care

Rescuers must be aware of falling rocks, slippery footing, steep slopes, and other hazards as they come to the aid of ill or injured persons. Becoming injured themselves or causing further injury to the subject can dramatically compound the seriousness of an emergency situation.

Provide Urgent Treatment

The first rescuers on the scene will make a quick assessment of the victim's situation and address any conditions that could be life-threatening; this includes checking and treating for shock if necessary.

Conduct a Thorough Examination

Once the victim is out of immediate danger, first-aiders will conduct a systematic and thorough head-to-toe evaluation.

Develop and Carry Out a Plan

At the completion of the full evaluation, team members will determine what to do next, often by including radio consultation with the SAR incident commander and other SAR personnel. In some cases, evacuation to a trailhead can begin immediately. In other instances, an ill or injured person must be cared for over a period of time while awaiting the arrival of additional SAR team members or the preparation of an evacuation plan. In either case, first-aiders will continually monitor the victim's condition and maintain a written record of their findings and any treatment they have given.

First-Aider Notes

First-aiders dealing with persons who have suffered injury or illness record each patient's condition by monitoring vital signs at regular intervals and writing down the data. These written records often include information that is subjective and objective, that makes assessments of the situation based on all available data, and that suggests a plan of action.

First-aider notes are essential for tracking changes in a patient's condition—information that can be critical in determining the nature and degree of an illness or injury and the urgency with which evacuation might be required. The notes also can remind first-aiders to be thorough in their examination, treatment, and monitoring of every person in their care.

Wilderness Incident Note

SCENE

Name:
Location:

Other Patients? N / Y How Many?

OBJECTIVE

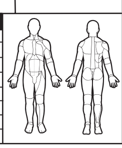
Chief Complaint:

OBJECTIVE: Patient Physical Exam

Airway:	Abdomen:
Breathing	Back:
Circulation: major bleeding?	Pelvis:
	Extremities:

RArm:	LArm:
RLeg:	LLeg:

Notes



Assessment of Situation and Plan of Treatment

Injury List	Potential Problems
(list most important first)	(estimate time course)

Plan of Action

Patient Ambulatory?
Litter carry?
Spinal Immobilization?
Urgency: Critical Stable Minor
Plan for each injury:

Notes

Evacuation

Once the subject of a search has been found, evaluated, treated, and stabilized, the team must decide on the best way to transport that person to safety. Searchers in radio contact with an incident commander can develop a coordinated effort to bring the victim to the frontcountry.

Foot Power

Evacuees who can walk without further injuring themselves should be encouraged to do so. SAR team members must continue to monitor the person's physical condition and respond to significant changes.

Hand Carry

If the subjects are not seriously incapacitated, they may be carried short distances piggyback or with a two-person carry. Rescuers must use proper technique to protect themselves from injury.

Horseback

Gentle saddle horses or mules can be used to transport victims whose illness or injuries would not be further complicated by the ride. Team members might need to ride double or walk alongside the animals to steady the evacuees.

Vehicle

Where there are convenient roads, four-wheel-drive vehicles generally provide the easiest and most efficient means of evacuating subjects of searches to a rendezvous with an urban ambulance service. In some areas, specially equipped ambulances can bring out ill or injured parties.

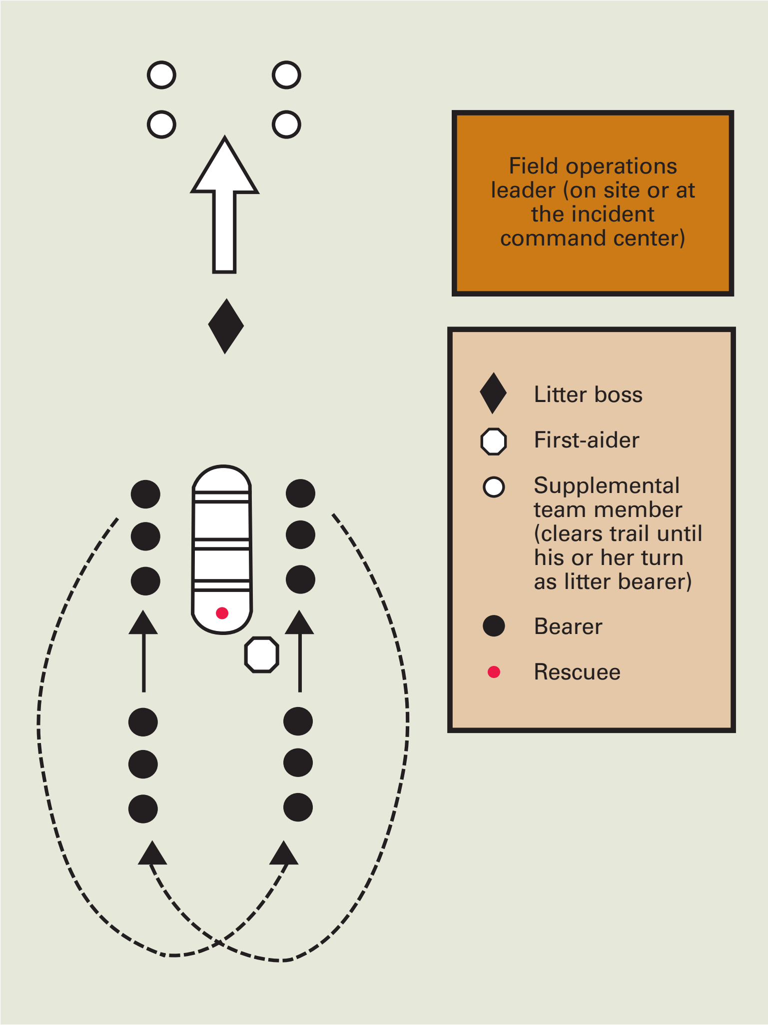
Aircraft

If a rescue helicopter is available, it might be used to evacuate a subject by winch lift from a remote site or it might land at a nearby helispot to pick up the subject. Fixed-wing air ambulances also can be used for evacuations from remote locations if there is a suitable landing strip nearby. Ideally, subjects are flown directly to a medical facility for further evaluation and treatment.

Litter Carry

Carrying an ill or injured person over a long distance can be demanding and difficult. It might require a large, well-drilled team, especially if the terrain is rough or the victim's location is far from a road. Because of the complexity of a litter evacuation, many SAR units have special litter teams to handle the procedure.

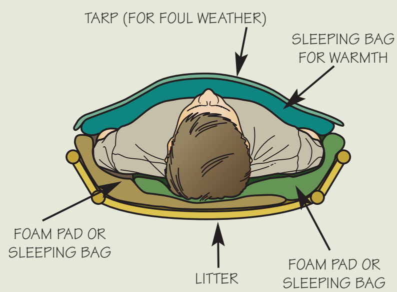
The field operations leader is responsible for the evacuation and for the safety of all personnel. The litter boss supervises the carrying of the litter. In matters pertaining to the well-being of the evacuee, the first-aider has the last word. Trail clearers lead the way and prepare the route for the litter bearers until it is their turn to serve as litter bearers. Belayers and rope handlers are required if there might be a need for a technical evacuation.



Litter-Carrying Techniques

Prepare a litter by padding it with foam pads and a sleeping bag. To place an injured person on a litter, six team members kneel next to the subject, three on each side, and work their hands beneath the person. On command, they raise the patient high enough for the litter to be slipped underneath, then lower him or her gently into position. Depending on the weather, more sleeping bags and perhaps a nylon tarp can be used to insulate the patient in a warm, protective cocoon.

Cross Section of a Litter



An injured or ill person might be carried on a litter.

Having sent the trail clearers ahead to remove any obstacles, the litter boss in charge of the carry will have bearers of similar height pair off on opposite sides of the litter. The SAR team member with primary responsibility for first aid will take a position near the victim's head, and all other team members will follow behind. The bearers kneel by the litter and, if available, place carrying straps across their backs and over their shoulders. By holding onto a knot in the strap, a bearer can distribute the weight of the load across his or her back and opposite arm, rather than bearing the weight with only one arm.

UNIVERSAL LITTER WHEEL

With a universal litter wheel, a small SAR team can roll a loaded litter over trails, rough roads, and open, low-angle terrain.

On command from the litter boss, the bearers lift the litter and move forward, walking out of step to avoid swinging the victim. Litter bearers change positions every few minutes. A fresh pair of bearers grasp the foot of the litter while the pair of bearers at the head of the litter step to the side of the trail. The active bearers adjust their grips to ensure correct spacing on either side of the litter. Using this technique, bearers can keep the litter moving, refreshing the carrying team without setting down the litter.

Communications and Navigation

Reliable communications are essential to the success of an SAR operation and for the safety of everyone involved. For this reason, portable two-way radios are carried by team leaders, litter bosses, field coordinators, and members of the support staff, giving the incident commander control over the entire search and evacuation. (Many SAR teams use ham radio technology, especially the two-meter band and the FCC "technician" license, to facilitate communications. During operations involving large numbers of searchers and rescuers, coordinators sometimes rely on Family Radio Service radios for inter-team communications.)

Search-and-rescue teams can use global positioning systems (GPS) for finding their way, plotting the parameters of search areas, and generating records of locations pinpointed during their activities. Transmitters can relay information about a team's position back to a search base where the data can be downloaded into laptop computers and incorporated with topographic mapping software to give the incident commander real-time awareness of the progression and status of every team in the field.

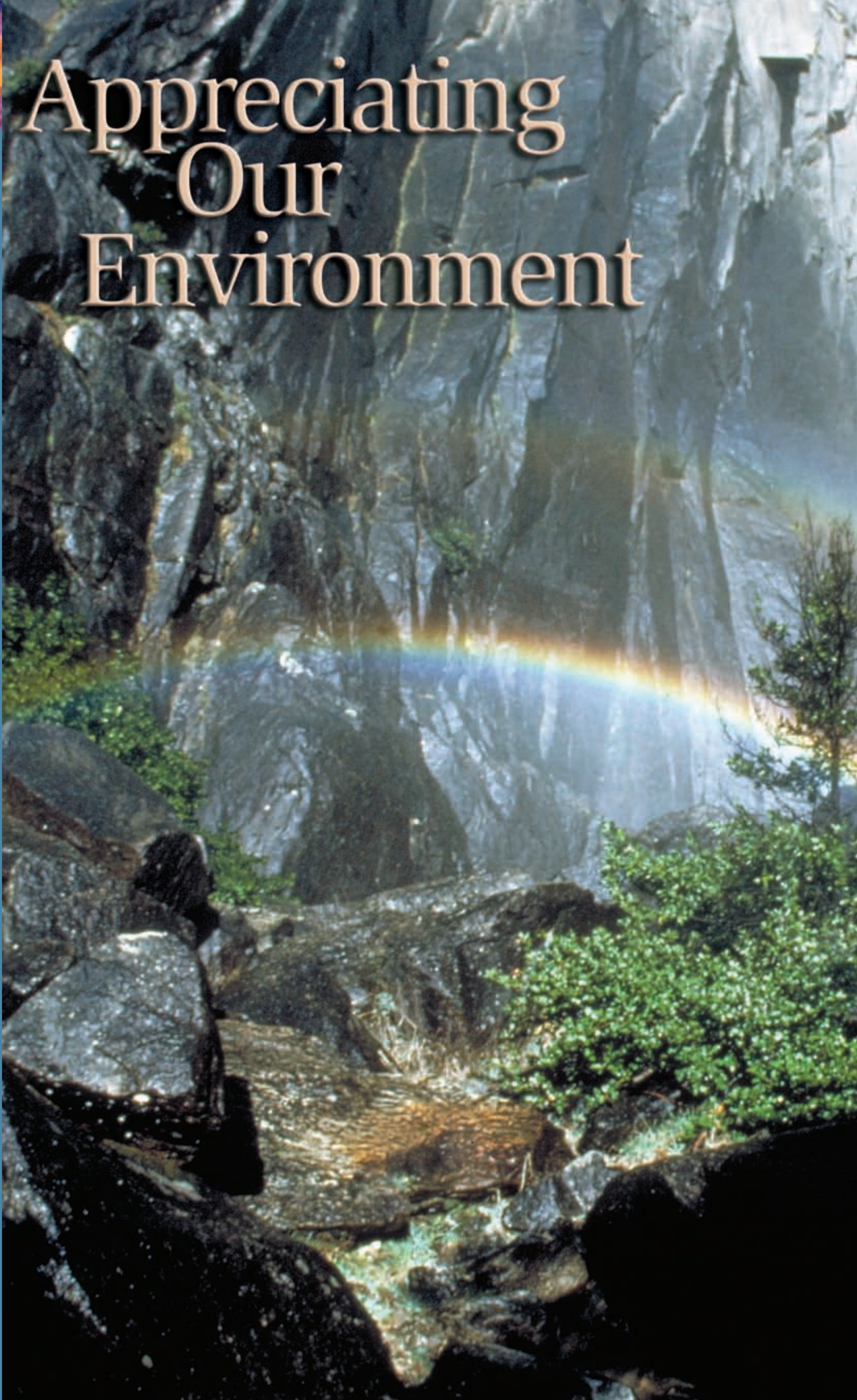
Evaluation and Training

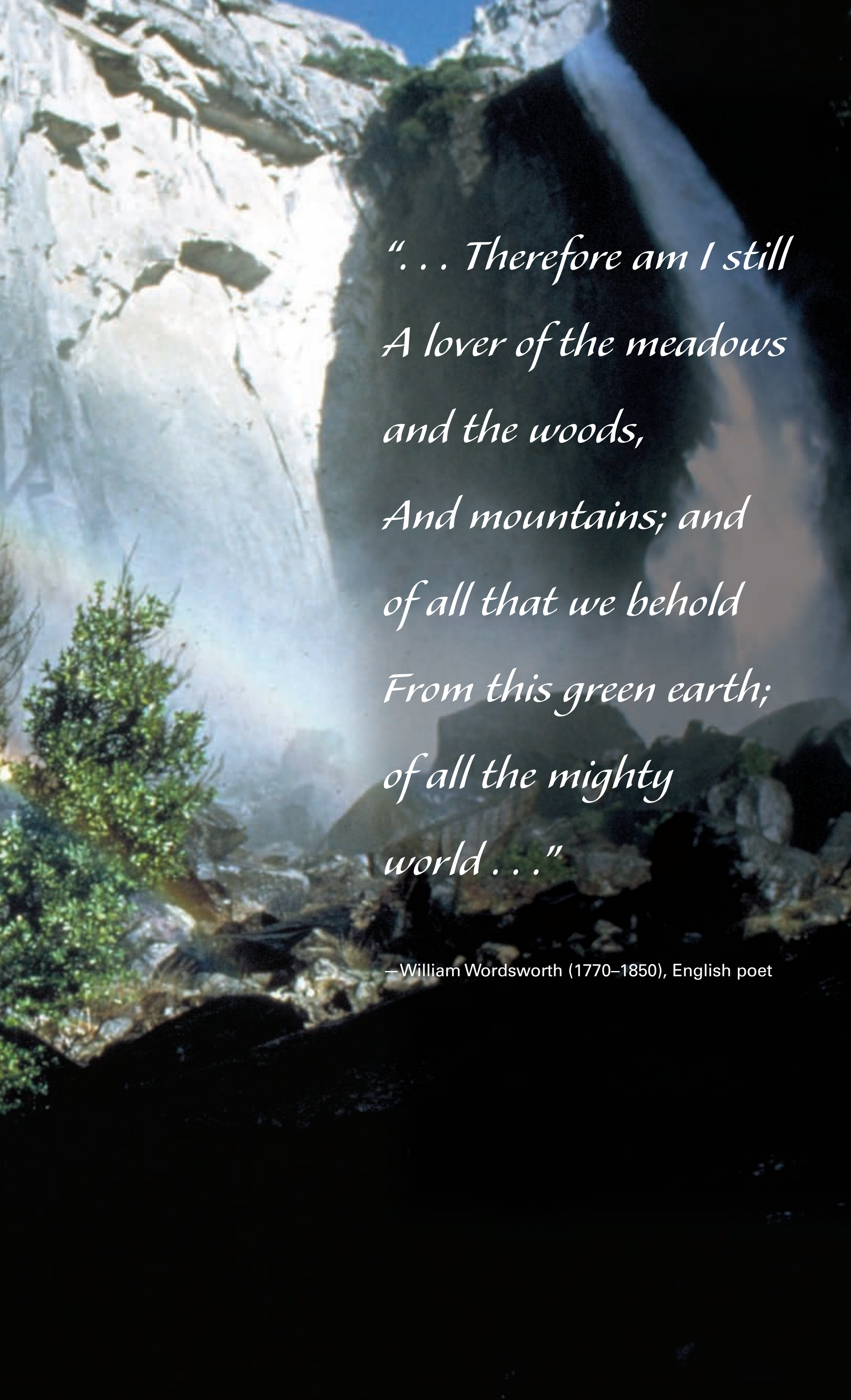
At the conclusion of every SAR mission, unit members review and evaluate everything that happened. This is not a faultfinding session, but rather an objective attempt to uncover weaknesses in a team's performance and to determine ways to rectify them. Good SAR units improve their operations with each mission; with honest evaluations and effective training, they seldom repeat a mistake.

SAR training must include instruction and practice in search methods, evacuation, wilderness navigation, first aid, and the maintenance of personal and team equipment. Field exercises and simulated searches and rescues should be conducted on various types of terrain in all weather conditions. SAR missions might be risky for both subjects and rescuers. Training and preparation of rescuers maximizes the chances for success and minimizes the chances for further injuries.

"SAR providers conduct ground search-and-rescue incidents to safely locate, access, stabilize, and transport the subject in the shortest possible time frame with the most efficient type and number of resources while following any applicable laws, rules, regulations, and policies."

—Robert Koester, *Field Operations Guide for Search and Rescue,* 1996

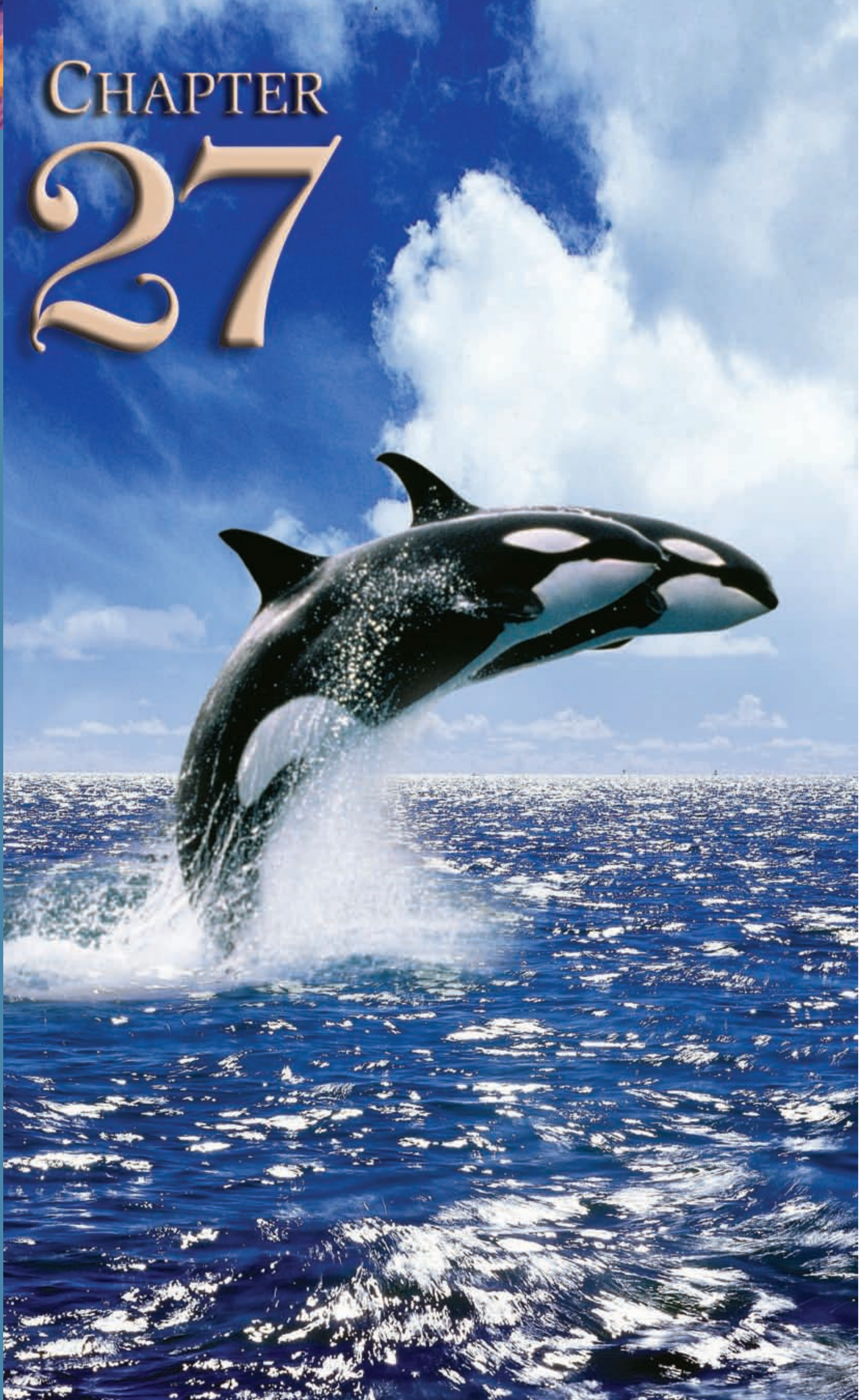

Appreciating
Our
Environment



". . . Therefore am I still
A lover of the meadows
and the woods,
And mountains; and
of all that we behold
From this green earth;
of all the mighty
world . . ."

—William Wordsworth (1770–1850), English poet

CHAPTER 27



27

Understanding Nature

"When we try to pick out anything by itself, we find it hitched to everything else in the Universe."

—John Muir (naturalist, wanderer, and a founder of the Sierra Club), *My First Summer in the Sierra,* 1911

Turning in the rising air, a hawk drifts above a mountain forest. A lizard stands motionless in the shade of a desert cactus. Fireflies in the bushes near a prairie stream light up a humid summer evening. Tides beneath your kayak rise and fall. Geese, whales, salmon, and butterflies follow the calls of distant migrations, while an earthworm in the cool soil burrows a few feet in its lifetime. Overhead, a mere hint of universal expanse twinkles in the past light of galaxies and stars.

The natural world around us is spectacular beyond our wildest imagination. It can be gigantic—towering redwoods, rivers coursing for a thousand miles or more, great herds of animals nearly covering a grassy plain. Nature is tiny, too—the eye of an insect, the veins of a leaf, the microscopic structures of cells, the ecosystems of your neighborhood.

In the eruption of a volcano, the jolt of an earthquake, the roar of a forest fire, and the howl of a storm, nature makes itself known with explosive power. Natural phenomena also can move so slowly that we might notice no change in our lifetimes. Continents drift about the globe at mere inches a year. Through many generations, animals evolve, adapt, and sometimes disappear.

The more we learn about nature, the more we realize how interconnected are its parts. The relationships among plants, animals, and their surroundings are so intricate we can unravel only the most obvious mysteries. Even so, doing our best to understand our world is essential to the planet's well-being and, ultimately, to our own. It is vital that we make good choices in how we treat nature.

Learning about nature is as easy as getting out into the middle of it with our senses wide open. We can step outside our homes and, wherever we are, nature is all around. Hiking can give us a sense of the shape of the terrain as it rolls beneath our feet. We can discover the folds of valleys, the heights of mountains, the breadth of deserts and prairies. Being outdoors allows us to appreciate heat, cold, wind, and precipitation firsthand. We can hear birds, the rush of water, the songs of frogs, and the drumming of grouse, or perhaps delight in the silence of a moment. Touch, smell, and taste come into play as well, as we feel the textures of stones, note the aromas of flowers in bloom, and savor the sweetness of a mountain huckleberry.

Every outdoor adventure is a doorway opening into understandings of the environment that can be as satisfying and challenging as any other aspect of a journey. In its complexity and simplicity, nature presents us with an overwhelming certainty that we are sharing Earth with other members of a worldwide community, and that their fates—and ours—are intertwined.

The World Around Us

Gaining an understanding of nature begins with paying attention. Look around. Ask why things are as they are. Start anywhere—watching wildlife near your camp, wondering why the leaves on trees near your school change color in the autumn, poking around a beach at low tide to see what the receding waters have revealed. Enjoy the puzzles and the wonder of the planet we call home. The more you see, the more you will be aware of what there is to notice. Nature will pull you in, presenting you with some answers and posing more questions. The mysteries are endless, and so is the delight.

You don't have to be a scientist or a scholar to enjoy nature—just interested and willing to ask questions. And you don't need to know scientific names of plants and animals, rock formations, or types of clouds to appreciate what you observe, at least not at first. It helps, though, and over time you will want to read and learn more.

One way to increase your understanding of nature is to look for the larger ways in which nature is organized—the systems, cycles, and chains providing the frameworks of existence.

Learning about nature can be as simple as a walk through a park or as involved as a lifetime career. There are many vocational possibilities in the study and management of natural resources, including fish and wildlife management, forestry, and soil and water conservation. Understanding nature is carried on in a variety of academic fields such as the following:

- **Astronomy**—the study of the heavens and celestial phenomena
- **Biology**—the study of living organisms
- **Botany**—the study of plant life
- **Geology**—the study of minerals, formations, and occurrences in the Earth
- **Meteorology**—the study of weather and atmospheric patterns
- **Paleontology**—the study of life forms and systems through fossil evidence
- **Zoology**—the study of animals

Ecosystems

A *population* is a group of the same animal or plant species living together. A *community* is all the populations of plants and animals in an area. An *ecosystem* is made up of those communities plus their physical surroundings—the land, weather, water, amount of sunlight, and everything else coming together to form the web of life.

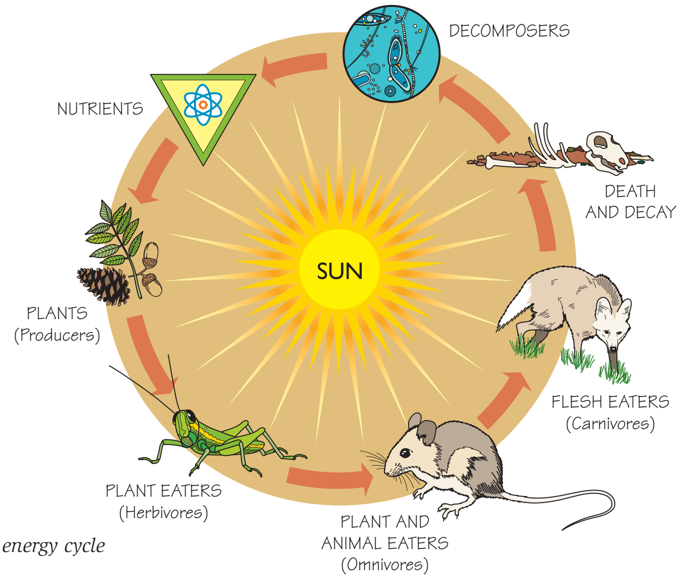
No two ecosystems are alike. Many, however, share general similarities based on their locations, elevations, and other factors. Those similarities enable us to compare one area to another, and help us better comprehend what we are seeing.

Examining ecosystems can help us understand why the principles of Leave No Trace are important guidelines to follow during every outdoor adventure. It also can heighten our awareness of the importance of stewardship—giving something back to the environment that provides us not only pleasure and challenge, but also the basic necessities of life for all species.

For more on exploring ecosystems, see the chapter titled “Observing Nature.”

ECOLOGY

Studying animals and plants in the context of their surroundings is called *ecology.* The term comes from the Greek words *oikos,* meaning “house,” and *logos,* meaning “word” and “reason.”



The energy cycle

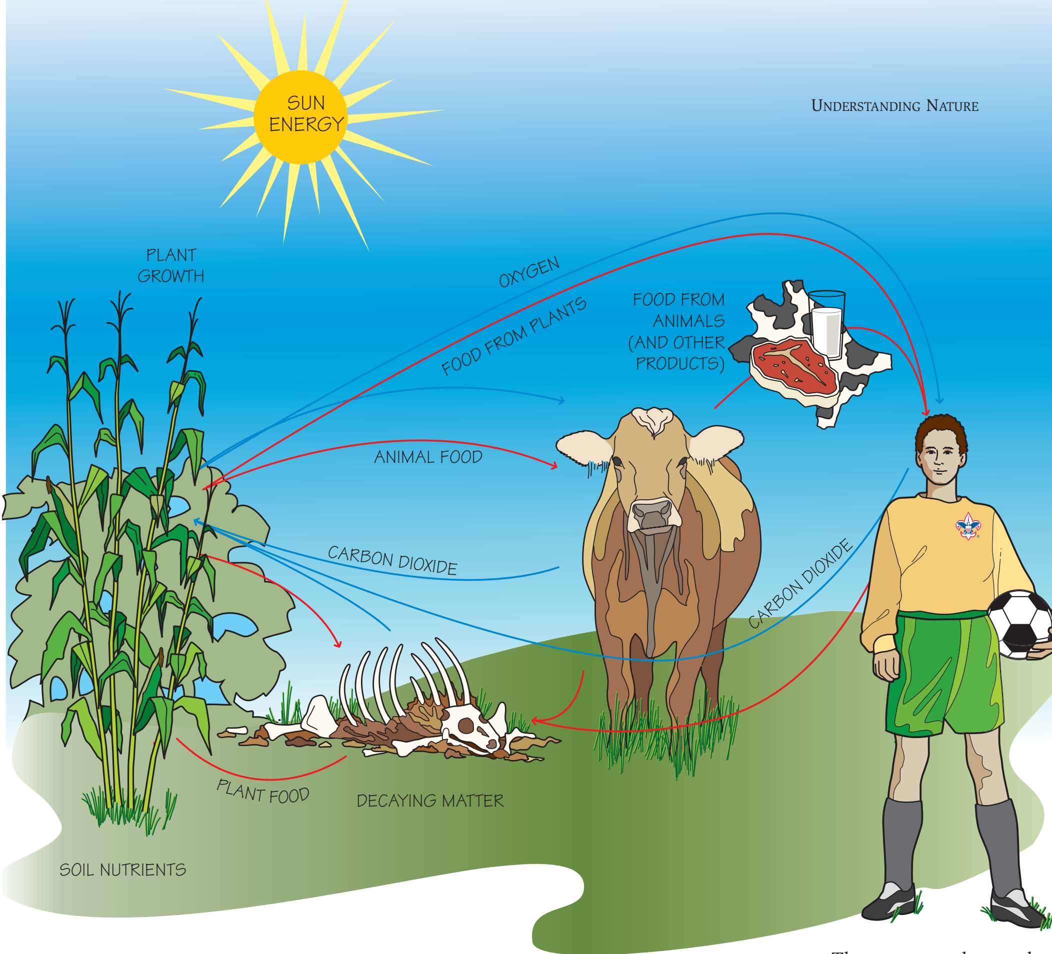
Energy Cycles

Living things must have nourishment in order to exist, to grow, and to reproduce. Calories providing that nourishment move through the environment, changing form as they transfer from one being to another. Solar energy propels the cycle. Combined with water and nutrients from the soil, for example, sunshine provides the means for plants to produce leaves. Insects eat those leaves. Spiders snare the insects in their webs and feast on them; the spiders, in turn, are devoured by field mice. Hawks swoop down and make meals of the mice. As the birds die, their remains decay and become nutrients enriching the soil, cycling back into the growth of new vegetation that insects can eat.

> *"There is value in any experience that reminds us of our dependency on the soil-plant-animal-man food chain, and of the fundamental organization of the biota."*
>
> —Aldo Leopold, *Sand County Almanac,* 1949 (His writings explore the complexity of the environment and the importance of caring for it.)

Every living organism, humans included, is part of an energy cycle. While all share a common need for nourishment, species have developed nearly endless variations in the ways they have adapted, both to thrive in the environments in which they find themselves and to give shape to the ecosystems of which they are a part.

For more on the complexities of species, see the chapters titled "Plants" and "Wildlife."



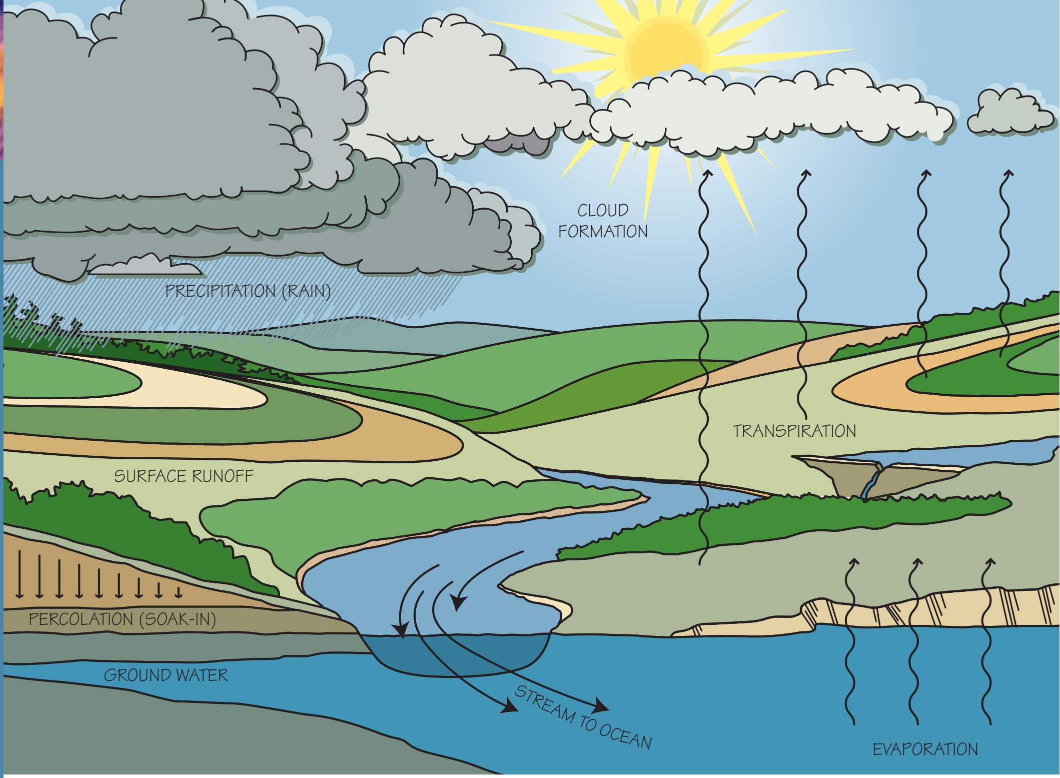
The oxygen-carbon cycle

Oxygen-Carbon Cycle

Animals absorb oxygen, use it in processes that provide energy for their bodies, and exhale carbon dioxide. Carbon dioxide is also produced when plants and animals decay, and when wood, coal, and other carbon-based materials burn.

Plants must absorb carbon dioxide in order to survive. In a chemical reaction powered by sunlight, chlorophyll allows plants to combine water with carbon dioxide to produce the simple sugars that plants use for food. The process is called *photosynthesis*—making something with the aid of light. A by-product of photosynthesis is the oxygen relied upon by animals.

Animals use oxygen and exhale carbon dioxide. Plants absorb carbon dioxide and give off oxygen. Animals and plants are dependent upon one another, interacting in ways that make it possible for many species to thrive. These cooperative arrangements are forms of *symbiosis*—interdependence of species—and are an essential aspect of life on Earth.



The water cycle

Water Cycle

From the driest desert cactus to fluid creatures in the ocean's depths, all living things must have water. Water allows nutrients and gases to pass through the cells of plants and the tissues of animals. It washes away wastes and regulates temperatures. It serves as a means of transportation for many species and a lifelong habitat for many others.

Water circulates through the environment in a cycle that, like the energy cycles and oxygen-carbon cycle, is energized by the sun. Heat from the sun evaporates water from oceans, lakes, and streams. The vapors form clouds that can be carried long distances by the wind. When the air cools or becomes loaded with moisture, the vapor can fall as rain, snow, sleet, or hail.

Much of the precipitation percolates into the soil where it can be absorbed by the roots of plants. Some finds its way into underground aquifers and other natural reservoirs, then rises again to flow from springs or wells. Small streams join together to form rivers returning water to lakes and oceans and, through evaporation, once again to the sky.

As with the intricacies and variety of the energy cycles and oxygen-carbon cycle, the Earth's water cycle interacts with all beings in remarkable, far-reaching ways. Marine scientists, for example, are discovering that water in the Earth's oceans circulates in patterns as profound as air masses overhead. Warmer water cools and sinks as it approaches the Arctic Ocean and Antarctica, and cold, dense currents deep beneath the surface can flow for thousands of miles. Water warming and swelling back toward the surface churns nutrients upward where they can be utilized by great varieties of sea life.

Change/Succession

Nature is forever changing. Regions of the planet that once were sea beds now are prairies, deserts, and mountain ranges. Shifts in the climate have sometimes transformed lush jungles and wetlands into snowfields and glaciers, then changed again to create conditions in which animals and vegetation could thrive. Plants and animals must adapt to meet the challenges of their environments. Species unable to change have disappeared forever—traces of them today are found only in fossils unearthed by paleontologists.

Changes in ecosystems can occur in shorter time spans, too. For example, picture a pond near a forest. Over a period of years, soil washing from hillsides into the water slowly collects along the edges of the pond. Grass seeds carried by the wind sprout in that new mud. As the grasses die, they mat down and decay, creating a nutrient-rich bed for larger rushes and cattails. Increasing numbers of fish and amphibians find safety among the roots and stalks, and insects lay their eggs on the leaves.

The remains of those plants and animals also sink into the mud, building more of the fertile soil and slowly raising and drying the edge of the pond. Shrubs and small trees move in, with slower-growing trees establishing themselves in the shade of trees that have grown more quickly. They, too, will live, die, and form more soil. At last, large trees mature into a stand called a *climax forest.*

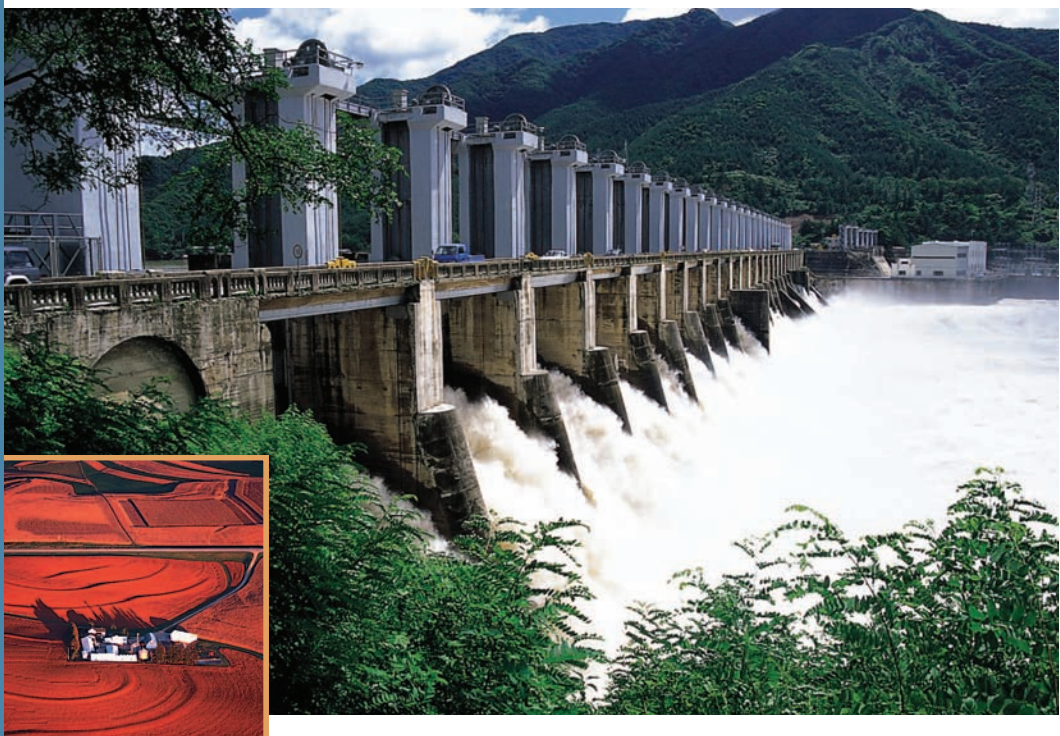
The pond might have disappeared completely, and the forest might stand for many years. Change will continue to occur, though. Fire might sweep through the trees, or an insect blight might dramatically alter the forest's composition and appearance, and a new phase of the plant succession cycle will begin.

Change and Diversity

From microscopic bacteria to eagles, bears, wolves, and other predators at the top of a food chain, an ecosystem is healthiest when it is rich in the variety and numbers of species thriving within it. The more species in an area, the more flexible the ecosystem is as a whole, and the better able plants and animals will be to adapt to change. A *diversity* of species—that is, many plants and animals that are unlike one another—provides a storehouse of environmental possibilities, the raw material for adaptation and survival.

For instance, when bees harvest nectar from clover blossoms to make honey, pollen sticks to their legs and they carry it from one clover plant to another. It's a symbiotic relationship that benefits both species. The clover provides nourishment for bees, and the bees play a vital role in the pollination of the vegetation. If bee populations don't survive a harsh winter, though, or if they succumb to pesticides sprayed too near their hives, the clover will have lost a reliable means of spreading pollen and might not be able to reproduce. Other species dependent on the clover might also go into decline.

A diverse ecosystem might include hummingbirds, insects, and other animals who carry pollen, too. By helping to fertilize the clover, they will have filled the void created by the absence of the bees. If there are no pollen-carrying alternatives to the bees, the clover may be replaced by plant species that don't rely on insects for pollination. Diversity of this sort cushions the effects that change has upon an area, and that increases the stability and health of an ecosystem.



As individuals and as a society, our treatment of the environment is our legacy to the future. Our legacy is up to us.

Human-Caused Change

Healthy, diverse ecosystems tend to be stable and to evolve slowly. Aside from the effects of storms, droughts, volcanic activity, and fire, the forces of nature in forests, prairies, riparian zones, and other environments often take decades or centuries to create perceivable change.

When humans become involved, however, ecosystem change can happen quickly. We can pave open land for highways, parking lots, and developments; and plow under prairie grasses to make way for crops.

Our vehicles, factories, and power plants can pump exhaust into the atmosphere, and the waste products of modern society often find their way into our landfills and waterways. A dam built across a river will generate electricity for dozens of cities and bring an end to annual floods, but it also will alter fish migrations, shoreline vegetation, and the lives of river species for dozens of miles up and down the stream.

Our ability to cause dramatic change carries with it the responsibility to make wise decisions on issues and actions that can affect the health of the environment. While humans are capable of activities that are destructive to ecosystems, we also can do much to conserve and heal the environment.

Small actions matter, and personal choices are important. As individuals, we can become informed consumers and active recyclers. As groups of people, we can work toward creating sustainable communities that exist in harmony with the environment. As citizens of our states and nation, we can learn about the issues and take part in the political processes that determine the fates of our public lands.

For more on caring for the environment, see the *Fieldbook* Web site and the chapter titled "Being Good Stewards of Our Resources."

Wilderness Recreation

The national park system came into existence to protect America's natural and cultural heritage. The USDA Forest Service, Bureau of Land Management, U.S. Fish and Wildlife Service, Soil Conservation Service, and other federal, state, and local agencies were established with the goal of managing America's natural resources with conservation stewardship that endures long-term sustainability for future generations. Many legislative mandates have attempted to guide our relationship with the environment. Among the most striking is the Wilderness Act, passed by Congress in 1964 to set aside large tracts of unspoiled lands to be protected in their natural states.

"A wilderness, in contrast with those areas where man and his own works dominate the landscape, is hereby recognized as an area where the earth and its community of life are untrammeled by man, where man himself is a visitor who does not remain."

—from the Wilderness Act of 1964, U.S. Congress

As a result of the Wilderness Act of 1964, Congress established the National Wilderness Preservation System to protect some of America's remaining wild lands. To be considered wilderness, an area had to be at least 5,000 acres in size. No public roads could penetrate it, and it could have no significant ecological disturbances caused by human activity. The intent of Congress is that people should be able to see and enjoy environments unchanged by the influence of humans.

Identifying wilderness areas is one way to help preserve environmental complexity and diversity to the greatest extent possible, and to allow the processes of nature to run their courses. Wilderness landscapes give us examples of how the environment functions when we leave it alone, and that can help us better understand and manage areas that have been developed. Wilderness also serves as an environmental bank account, preserving a storehouse of species and systems that might otherwise disappear.

"Nature is rude and incomprehensible at first, Be not discouraged, keep on, there are divine things . . . more beautiful than words can tell."

—Walt Whitman (American poet), "Song of the Open Road," 1856

In addition to its infinite scientific value, wilderness can nourish the human spirit and refresh the soul. By bringing us close to nature undisturbed, to these remnants of our once-wild continent, wilderness allows us to recognize and cherish the complexity of ecosystems everywhere and to act with the best interests of the environment foremost in our minds.

For more on understanding nature and discovering hands-on ways to protect and improve the environment, see the other chapters in the "Appreciating Our Environment" section, especially "Examining the Earth."

CHAPTER 28

Observing Nature

"When we use all of our senses outdoors, we live fully in the present moment, and so live more richly and intensely."

—Joseph Cornell, environmentalist, outdoor educator, and Scouter

Here are some truths about observing nature. There is always something going on. What's going on is always exciting. We often look, but don't see, though we can change that by learning the skills of effective observation. What we see can help us understand that everything is connected. Observing the relationships of organisms to one another helps us expand our vision beyond ourselves, increasing our appreciation for all forms of life.

Every environment has much to teach us. Have you ever snorkeled around a coral reef or gone skin-diving to the ocean floor? At low tide many people wander along beaches searching for signs of marine life that have washed ashore, and during certain seasons some go out in boats and watch pods of migrating whales. The great swamps of the Southern states are full of remarkable plants and animals, and so are the deserts of the Southwest, the prairies of the Midwest, and the forests of the Northeast. So might be a city park, a Scout camp, and a backyard. In fact, nearly every spot on the globe supports natural communities varied and diverse beyond your wildest imagination.

From a city green space to an expanse of wilderness, we go out into the world to see what's there. And what's there—everywhere we look—is evidence of the complexity and wonder of nature.

The Big Picture

Flora is the Latin word for plants. *Fauna* refers to animal life. In their sound and rhythm, they are words that seem to go together. In the environment, what they represent is absolutely inseparable—vegetation and animals interacting in ways that form balanced ecosystems.

Most of us enjoy observing animals in the wild. There can be real pleasure in watching deer and elk grazing, a beaver working on a dam, an eagle on the wing, or perhaps even a bear crossing a distant ridge. Plant life is nearly infinite in its variety, complexity, and mystery, too. Add the geology of an area, the weather patterns, and there is no end to what can be observed, enjoyed, and studied.

Respect What You Observe

One of the principles of Leave No Trace is to respect wildlife. It reminds us to stay far enough from animals not to disturb their natural patterns of behavior, and to be especially thoughtful of their need for space during seasons when they are mating, nesting, raising young, and enduring winter. As observers, we can extend that level of respect to the rest of the environment, too, acting in ways that leave the areas we visit, and their inhabitants, in the same condition when we depart as when we arrived.

Being a Good Observer

Drop a pebble into a pool of water and notice how the ripples run out in circles, one outside the next. A skilled observer's line of sight is similar to those rings of ripples. First, scan the area a few feet to the front and sides of you. Sweep your eyes along, taking in the whole scene rather than focusing on just one or two things.

Then sweep your eyes to take in the next line of "ripples"—an arc about 20 feet away. Look out a little farther and do the same thing. With practice, you can scan a wide area quickly. Animals, plants, tracks, and curious geologic phenomena will seem to pop out of the background. You'll also have a sense of the area as a whole, rather than seeing just a few highlights.

Extending Your Range

An eagle can see much better than you can, even if you have 20/20 eyesight. While our senses are not as acute as those of many animals, we do have the power to expand our range with mechanical aids, and to enhance our ability to capture experiences with cameras, pens, brushes, and paper. We also can extend our observational abilities by going out early in the morning and in the evening, on stormy afternoons and moonlit nights—every season and every hour of the day presents different aspects of nature.

Binoculars and Magnifying Glasses

Binoculars allow you to study wildlife without approaching too closely, and to bring into view details too small to be seen by the naked eye. They can be invaluable for watching birds and other animals. A magnifying glass is ideal for examining plants, insects, and the details of soils and stones.

Most binoculars are marked with an equation—7 × 35, for instance. The first number represents the magnifying power of the binoculars; in this case, an object will appear seven times larger than normal. The second number indicates the diameter of a binoculars' larger lenses, measured in millimeters. Binoculars with higher numbers will capture a wider range of vision in more detail, but also might be heavier and more difficult to hold steady. Binoculars also vary greatly in the amount of light they capture, and thus the brightness of the image.

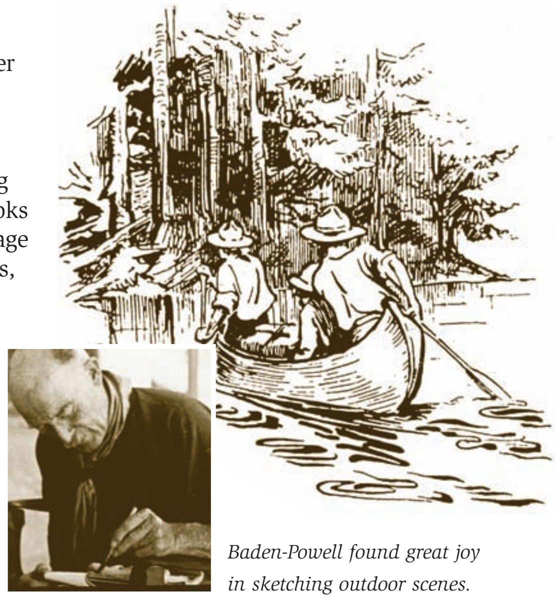
Photography

Photographing flowers, animals, and landscapes provides a memorable means for you to record high points of your adventures and to share your discoveries with others. Any reliable camera can provide the means for you to begin capturing nature on film. As you become adept at the basics, the addition of telephoto and close-up lenses can augment your photographic range. Digital cameras and computerized image-management programs offer a variety of ways to gather and present your images, all without the cost of film.

Drawing

Robert S. S. Baden-Powell, Daniel Carter Beard, and Ernest Thompson Seton—individuals who played key roles in establishing the Scouting movement—shared a common passion for sketching outdoor scenes. Each carried sketchbooks and pencils on adventures and filled page after page with pictures of wild animals, plants, and backcountry life.

You don't have to be a great artist to enjoy drawing what you see. Examining plants, animals, and landscapes with an eye toward capturing them on paper can give you fresh perceptions of nature, and trigger a special relationship with the subjects of your art.



Baden-Powell found great joy in sketching outdoor scenes.

Journals

During their three-year journey across the American West in the early 1800s, the explorers Meriwether Lewis and William Clark wrote daily in their journals. They noted their locations, the vegetation and wildlife they saw, and accounts of their activities and those of others in their expedition. To this day, their journals are invaluable records of one of the great American adventures.

Try keeping a journal during your own trips, and you might discover the same pleasure and personal value in writing as did Lewis and Clark. A simple notebook is all you need—just write something every day you are in the back-country. Keep a log of animals and plants you see, make notes about the weather, and write descriptions of other natural phenomena that catch your attention. Your skill as a keeper of journals will grow, and you will have a record that years from now will remind you of some of your favorite journeys.

Becoming an expert tracker takes patience and practice. The more time you spend at it, the easier it will be for you to decipher signs left by wildlife, and the more surely you can figure out behavior patterns and activities of animals you are following.

Tracking Animals

Every animal traveling on land leaves tracks where it passed. Following those tracks can teach you much about what an animal eats, where it sleeps, and its daily habits. With luck, your tracking skill might lead you to the creature itself.

Tracking is detective work, the solving of mysteries. Why is that twig broken? Did an animal rooting for grubs turn over those stones? What made these scratches on the trunk of a tree? One by one, clues can lead you along the route traveled by an animal and deeper into its life. Are you able to guess where it is headed? Can you find a spot where it might have slept? Did it leave any droppings? Is there evidence of what it has been eating?

You have to find some tracks before you can follow them. Winter snows hold a surprising number of tracks. During other seasons, try the soft soil near ponds and streams. In dry country, scan the dust for prints and look for pebbles and rocks that have been disturbed.

Study a Single Track

Closely examine the shape of a track you wish to follow. Measuring and sketching it can help you find it later even if it becomes mixed in with other tracks.

Wolf tracks in sand

Track Early or Late

Tracking can be easiest early in the morning and late in the day when shadows cast in the prints make them stand out more than when the sun is directly overhead. Sharply defined tracks probably were left more recently than those with eroded edges.

Look for More Than Just the Prints

Bent or matted grass, broken twigs, stripped bark, and displaced pebbles might help you see an animal's path. Watch for burrows, caves, insect mounds, and nests.

Droppings, known as scat, can give evidence of an animal's diet. Break scat apart with a stick. Hulls of seeds, skins of berries, and bits of leaves suggest the animal is an *herbivore*—an animal that eats only plants. Small bones, fur, and feathers might appear in the scat of *carnivores*—animals that feed on other animals. Mixed scat indicates an *omnivore*—a species whose diet includes both animal and plant material. Scat tends to dry from the outside in. If it is completely dry, you know the animal passed by some time ago. Moist scat is much fresher; the animal might be near.

Beaver gnawings on a tree is one obvious sign of an animal habitat.

Imagine Yourself in the Place of the Animal

Should you lose the line of footprints you are following, ask yourself where you would go if you were the animal, then look in that direction. Mark the last print with a stick and explore all around it until you again pick up the animal's trail.

Notice Landmarks

Tracking can be an absorbing activity, but don't become so interested that you get lost. Be alert to your surroundings, noticing and remembering landmarks that will guide you back to your starting point.

Collect Tracks

Perhaps you've heard the old saying, "Take only photographs, leave only footprints." By making plaster casts, you can bring home the footprints, too.

When you find a track you want to preserve, mix up some plaster of paris. (Plaster of paris is available at pharmacies. Container labels will have mixing instructions.) Turn a cardboard strip into a collar by notching the ends together. Place the collar around the track and pour in the mix. Let it harden—10 to 15 minutes in warm weather—then lift the cast and brush off the dirt. On the back of the cast, write the date, the location where you found the track, and the identity of the animal that made it.

You can also cast plaster molds of tracks in the snow. In addition to plaster of paris, you'll need a mist bottle such as those used with glass cleaner. Spray the track with a fine mist of water and wait a few moments while it freezes. Mix the plaster using cold water (warm plaster will melt the print). Put a collar around the track and pour in the plaster. Give it plenty of time to harden.

By themselves, casts of prints are fine souvenirs of your adventures. You can also press them into damp sand to recreate the original prints.

Casting a mold is a way to bring home a souvenir of a track you found.

"Something, I think, also [could] be done toward developing the boy's mind by increasing his powers of observation, and teaching him to notice details."

—Robert S. S. Baden-Powell (1857–1941), founder of the worldwide Scouting movement

Though tracking wildlife requires movement on your part, perhaps the best way to observe animals is not to travel at all. You are likely to see more in an hour of sitting quietly than during a full day of hiking.

Observing Wildlife

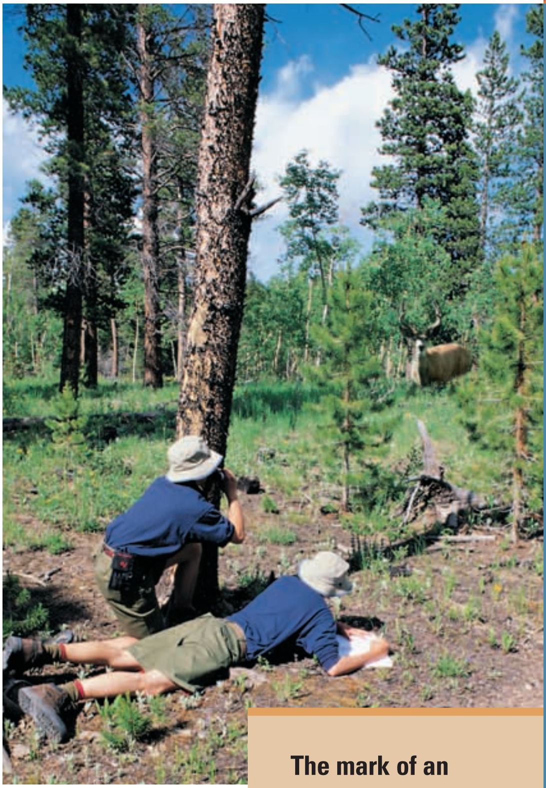
Humans traveling in the backcountry usually create enough disturbance to send wildlife scurrying for cover, but if you are motionless and silent, many animals will have difficulty detecting your presence. Use this to your advantage by finding a place to sit comfortably. Hide in the brush, or climb into a tree and wait to see what animals pass nearby. Crouch behind a snowdrift, at the edge of a meadow, or beside a game trail. Position yourself downwind from the likely locations of wildlife so that your scent doesn't give you away. Before long, animals will resume their normal activities and come into your field of view.

Sunrise and dusk often are the best times to observe animals, when they can be more active than during the middle of the day. A great many animals are active at night. Under a full or partial moon, you are likely to discover lots of wildlife activity, though your observations might lean more toward sounds than sights.

Attracting Animals

Blow on a duck call and you might bring a circling flock of birds near your hiding place. Make a kissing sound against the back of your hand and deer might come to investigate. Whistle softly and a running rabbit might stop in its tracks, while a shrill whistle in high mountain country can bring marmots out of their burrows to see what's going on.

Stalking Wildlife



Stalking wild animals is a skill as old as humankind. For eons, it was a means of getting close enough to animals to increase hunting success. Today, stalking can be a way to observe their habits and to take photographs and make sketches. Stalking also can be a demanding discipline that depends on your ability to use all of your senses, on your understanding of the animals you are observing, and on your willingness to practice patience.

You might, for example, see a deer grazing in a meadow. Although the deer is busy eating, it raises its head now and then to sniff the air, listen, and glance around for signs of danger.

Study the landscape and decide how you might slip closer to the animal. Are there folds in the terrain where you can hide, or trees and brush that will conceal your presence as you ease toward the meadow? What is the wind direction? If a breeze is blowing toward the deer, it can pick up your scent long before it sees you. Is the ground covered with dry leaves that will crunch beneath your footsteps, or with soft grass that will muffle the sound of your approach? Is the deer standing still or in motion? Will mist or fog help conceal your presence and dampen noises? Are there other animals or people in the vicinity that might startle the deer before you get close?

The mark of an expert stalker is the ability to reach a point where animals can be observed, and then to leave so quietly that the animals are never aware you were there.

As you stalk toward the deer, remember that while its senses are keen, it has trouble seeing things that don't move. Freeze whenever the deer lifts its head, and hold still until it looks away. Stay in shadows as much as you can. When you reach an observation spot with a clear view of the animal, enjoy watching for as long as you want, then withdraw as quietly and invisibly as you approached. Always keep enough distance between yourself and wildlife so that you aren't disturbing their activities, causing them anxiety, or blocking their access to sources of food, water, or critical habitat.

Watching Birds

As you observe birds, the six S's—size, shape, shadings, song, sweep, and surroundings—offer a means for you to gather clues that can lead to a bird's identification. Even if you aren't interested in finding out its name, noticing the S's will solve some of the mysteries about a bird.

Size

Hummingbirds are just a few inches long and weigh only ounces. A turkey vulture weighs several pounds and has a wing span of 3 feet or more. Compare the size of a bird you see with the sizes of birds you know. Is the new one larger than a sparrow? About the same size as a robin? Smaller than a crow? A bird's size might affect its methods of gathering food, making its nests, and avoiding predators.

Hummingbird

Shape

Notice the shapes of birds and try to guess how their physical features play into their abilities to adapt to their environments. The great wings and powerful talons of eagles, hawks, and other raptors allow them to drift overhead and then to snag their prey and lift it into the sky. The long, slender legs of herons and many other shorebirds enable them to wade in waters where they can feed on small fish. Beaks are clues to the diets of birds, capable of tasks ranging from cracking small seeds or drilling holes in wood to sipping flower nectar or catching insects on the wing.

Shadings

Bright feathers help many birds attract mates. For others, drab colors act as lifesaving camouflage. The ptarmigan is a good example. Its brown feathers hide it during summers in mountain forests. When winter comes, the ptarmigan's feathers become as white as the snow.

Ptarmigan

Goliath heron

Song

Birds use their songs to warn of danger, mark their territories, and find mates. When you know the songs of birds, you can identify them even without seeing them.

Sweep

"Sweep" refers to the movements a bird makes. Some hop or scurry across the ground. Others flit from tree to tree. Soaring birds can catch updrafts of wind and hover without flapping their wings. Some birds dive into bodies of water in pursuit of prey. Close observation of the sweep of birds can lead to a greater understanding of how each has adapted to its surroundings.

Surroundings

Like all animals, birds have certain habitat needs. They must find food, cover, water, protection from predators, and places to mate and raise their young. The first five S's (size, shape, shadings, song, and sweep) are ways that birds have adapted to their surroundings.

Great blue herons during their courtship ritual

Observing Plants

Vegetation is so much a part of our outdoor experiences that we may hardly notice it all around us. Noticing, though, is what observing nature is all about, and when it comes to seeing plants, there is enough of interest to keep a careful observer occupied for a lifetime.

The chapter titled "Plants" will discuss specific means of examining and identifying vegetation. More general observation can help you unravel some of the ways in which plants are intertwined with animals, terrain, and other aspects of an ecosystem.

Notice, for example, the sizes and shapes of the trees, and how close together they are growing. Pick a single tree and examine the color of the leaves or needles. Smell the bark and feel its texture. Have birds built nests in the branches? Has a woodpecker in search of a meal drilled holes in the trunk? Have deer rubbed their antlers against the bark, or have hungry elk standing on drifts of snow nibbled the low-hanging twigs? Is there evidence of fire, disease, or strong winds? Study the network of fine lines crisscrossing the surface of a leaf. Search the ground for fruit, seed pods, or nuts, and break one open. If you have a plant identification book, find a description of the tree and read about its uses, range, longevity, and special characteristics.

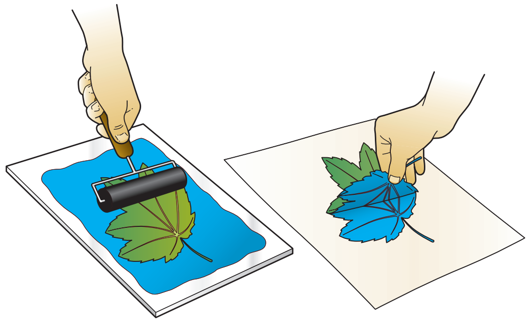
Trees, grasses, flowers, and other forms of vegetation serve as living habitats for all kinds of life. The following questions can help you begin your exploration of a plant and the ways in which it is woven into its ecosystem.

1. ***How is it similar to and different from nearby plants?***
2. ***How are the leaves or needles shaped?***
3. ***Does it bear flowers or fruiting bodies?***
4. ***What kind of soil is it growing in? Sandy, wet, dry, gravel, black dirt?***
5. ***Who is visiting the plant? Do any creatures use it for food or as a home?***
6. ***How is the environment influencing the plant? (For example, is the plant growing in sunshine or shade?)***
7. ***How is the plant affecting the environment around it?***

Pressing Leaves

When you have leaves you would like to preserve, put each one between two sheets of paper, lay the sheets on a board or other flat surface, then place heavy books or some other flat weight on top. Give the leaves several days to flatten and dry. Mount them in a scrapbook along with the details of where and when you found them, the identity of each plant, and any other information you have learned about each plant's natural history.

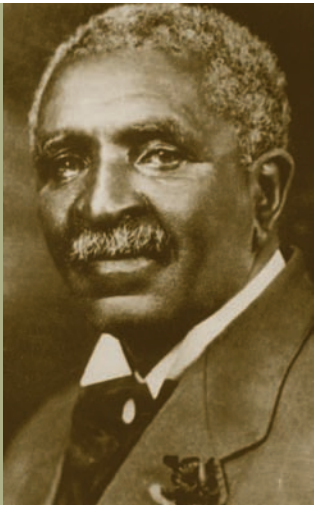
Making Leaf Ink Prints



Use a rubber roller to spread a dab of printer's ink on a glass plate. Place a leaf on the glass with the veined side against the ink. Run the roller over the leaf several times, then lay the leaf, inked side down, on a clean sheet of paper. Cover the leaf with a piece of newspaper and run the roller over it to make a print. After the ink dries, arrange the pages in a scrapbook.

Observing the Earth (and Its Neighborhood)

All of nature is interesting, all its parts are connected with all the others, and trying to make sense of it is tremendously important. The following chapters in this book provide guidance to help you explore geology, meteorology, botany, biology, and astronomy. In every case, the key to understanding is simply to begin looking.



"Anything will give up its secrets if you love it enough."

—George Washington Carver (American botanist, agricultural chemist, and educator)

CHAPTER 29

Examining the Earth

"These cliff-bound glaciers, seemingly wedged and immovable, are flowing like water and grinding the rocks beneath them. The lakes are lapping their granite shores and wearing them away, and every one of these rills and young rivers is fretting the air into music, and carrying the mountains to the plains."

—John Muir (19th-century naturalist and a founder of the Sierra Club), 1868

Many of us are drawn to the out-of-doors by its timeless tranquility and beauty. We're sure that the mountains we climb this summer will be there next year, too. The tumbling streams that lull us to sleep seem to have flowed forever, and it might be difficult to imagine that the deep valleys and broad plains could ever have been much different from how they are today.

Yet the seeming permanence of terrain is an illusion, as the land is always changing. The quiet, wooded campsites we like so much might once have been at the bottom of an ocean or buried beneath immense expanses of ice. The hills we hike could have been seared by the heat of volcanic blasts or torn apart by earthquakes. Even as we stand on them, granite mountains are slowly rising, or dissolving beneath our feet. Eruption and erosion, creation and decay—the Earth is being continually reshaped, time and again cast anew. It is a relentless, powerful, and fascinating process, and as we explore the world, we are surrounded everywhere by evidence of its complexity and grace.

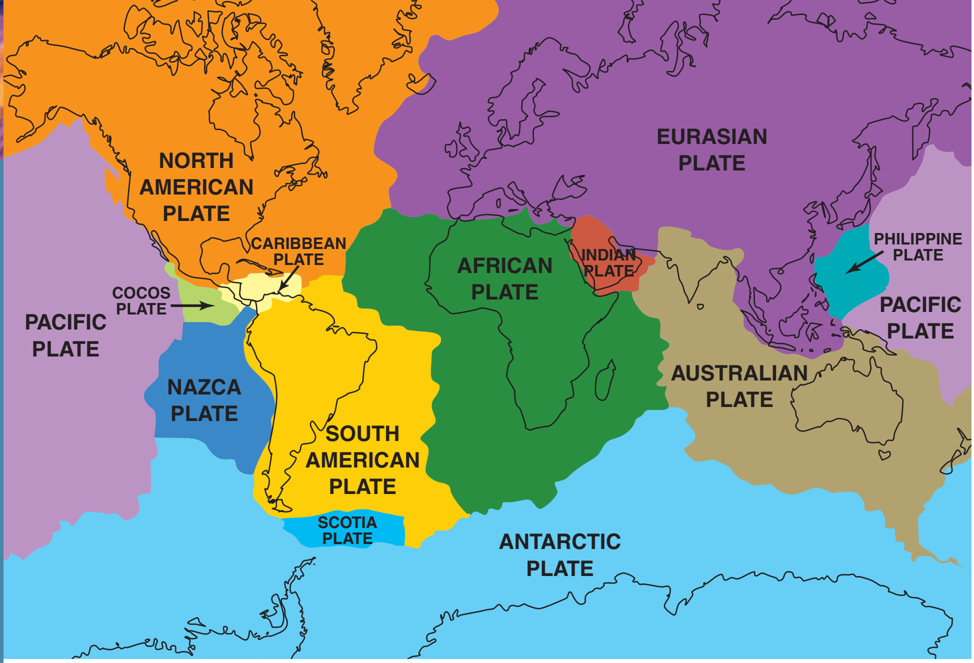


Plate tectonics

Formation of the Earth

Scientists suggest imagining a time-lapse camera photographing the Earth's surface from its beginnings to the present. Even at a rate of one frame exposed every 100 years, the finished film would take weeks to show. Opening scenes of molten rock glowing red gradually give way to those of a globe with its surface dividing into continents and oceans. Mountain ranges heave through the Earth's crust only to diminish. Ice fields flow out from the polar caps, then recede. Seas draw back to reveal vast prairies. Earthquakes and volcanoes abruptly alter the landscape, and the continents drift slowly about the globe. Strange plants and animals flicker into view and then are gone, the dinosaurs perhaps the most recognizable. Humans finally appear on the screen, the history of their civilizations taking only a few seconds at the end of the long film of the Earth's history.

GEOLOGY
Geo **means "earth"; the suffix -*logy* indicates "a subject of study." *Geology,* then, is the scientific examination of the formation and development of our planet.**

Many geologists studying the development of the planet believe the Earth came into existence as a molten ball composed of various elements. The lighter elements drifted toward the surface of the globe, leaving at the center a dense iron core. A crust formed as the Earth's surface cooled, and even today that crust ranges from about 9 to about 47 miles thick. Temperatures and pressures deep within the Earth are still high enough to keep rock in elastic or plastic form. The great slabs, or *plates,* of the Earth's crust float upon this mantle like so many gigantic islands, drifting, colliding, and overlapping. Known as *plate tectonics,* this slow, remarkable motion can drive mountain ranges skyward.

Plate Tectonics

The major plates of the Earth's crust are named for the areas of land and sea under which they lie. The *North American Plate*, for example, is the underpinning of most of North America and a good share of the Atlantic Ocean. Bordering its western edge is the *Pacific Plate* extending beneath the Pacific Ocean. Other prominent plates are the *Australian, African, South American, Eurasian, Philippine*, and *Antarctic*.

The plates might move only inches a year, but even so slow a migration has far-reaching effects. The motion of adjoining plates takes one of four forms—*separating, sliding, undercutting*, and *colliding*. These motions are caused by convection currents as magma slowly churns deep inside the Earth.

Separating

When two plates pull away from one another, they create a *zone of divergence*. The African Great Rift Valley and the Red Sea are good examples. Occurring primarily under the oceans, zones of divergence allow magma to rise and fill the gaps between the plates.

Sliding

Plates moving parallel to one another can cause earthquakes, especially along the *fault zone* at the edges of the plates, such as occurs in California.

Undercutting

When one plate slides under another plate, it can curve downward, creating a *subduction zone* that is a source of volcanoes, earthquakes, and mountain building, as found in the Ring of Fire surrounding the Pacifc Rim.

Colliding

When one plate slams into another, layers of rock thrust upward can form mountain ranges, such as in the Himalayas, where the Indian Plate is smashing into Asia.

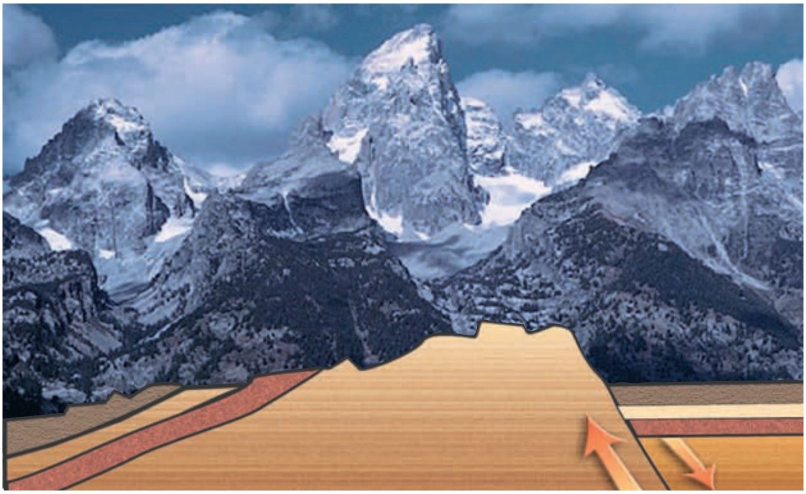
Terrain Formation

The center of the North American Plate, near the Appalachian Mountains, is relatively stable. Far from the active edges of the tectonic plates, the prairie states tend to be flat, often layered with the sediment of ancient oceans that once flowed over them. Farther west, stress in the Earth's crust has created mountain ranges in a variety of ways, primarily through *volcanic activity*, *faults, folds*, and *continental uplifts*.

Volcanic eruptions occurring in California, Oregon, Washington, and Alaska are caused by pressure and instability as tectonic plates sliding under one another sometimes form cracks in the Earth's crust that allow magma to flow to the surface. The colliding edges of the North American and Pacific plates can be traced along the West Coast of the United States, past British Columbia, and through the Aleutian Islands.

Volcanoes

When hot, fluid rock called *magma* finds passage to the surface, it may erupt as a volcano. In some cases an initial eruption can explode with devastating force, as did Mount Saint Helens in the state of Washington, and the flow of magma may continue for a long time, as does that from Mauna Loa on the island of Hawaii. The Cascade Range of the Pacific Northwest is volcanic in origin, and the Hawaiian Islands are the tops of immense volcanoes that, when measured from their bases on the ocean floor, are the tallest mountains on the planet.

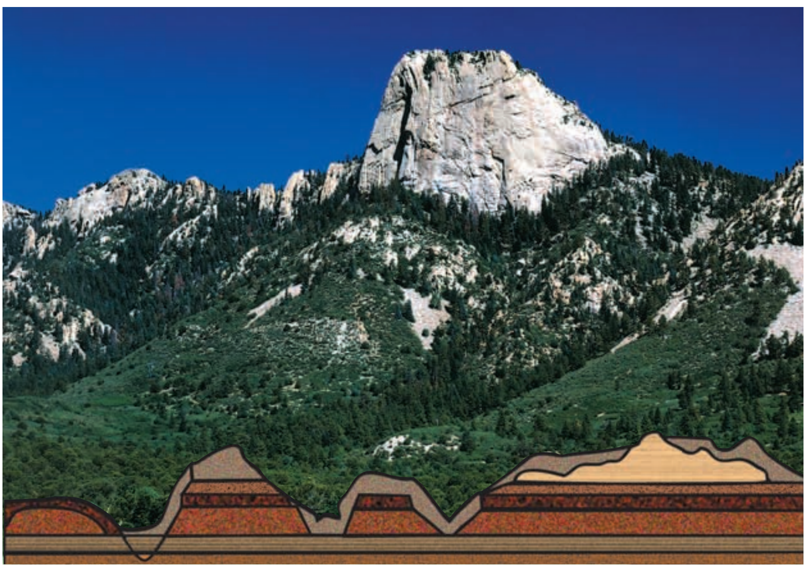


Faults

Pressured by plate movement, the Earth's crust may fracture and shift, creating high walls, zones of broken rock, and disrupted streambeds. Additional plate movement can jumble these terrain features and create the angular shapes of mountain ranges that include the Sierra Nevada and the Tetons.

Folds

Instead of fracturing, a plate of soft, sedimentary rocks may fold. Sections of the Appalachian Mountains were formed this way.



Continental Uplifts

Large sections of the Earth's crust are sometimes forced upward by internal pressures created by plate motion. When that happened in western North America, the towering Rocky Mountains came into being.

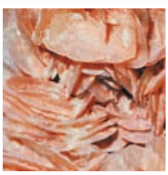
Mica

Rocks

The elements that make up the Earth (oxygen, silicon, etc.) bind together to form dozens of *minerals* including mica, quartz, gypsum, calcite, dolomite, and feldspar. These are the building blocks of rocks, combining in myriad ways to create the enormous variety you see in the field. Geologists identify the minerals that compose particular rocks by using measurements including hardness, color, and fracturing qualities as the basis of their classifications. A good rock identification book will give you the information you need to do this, too, and you might find that the delights of being a rock hound are as satisfying as being able to identify trees, animals, and cloud formations.

To simplify matters, geologists have divided all rocks into one of three categories, depending on their origins—*igneous*, *sedimentary*, and *metamorphic*. Every rock bears clues of the process that formed it. By deciphering those signs, you can not only learn how certain rocks came into being, but also perhaps better understand the makeup of entire landscapes.

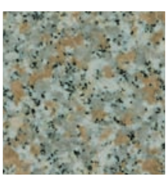
Quartz



Gypsum

Calcite

Dolomite



Feldspar

Igneous Rock

Igneous rock forms from cooling molten rock. When magma stays beneath the Earth's surface, it cools slowly, forming crystals. The slower the cooling process, the larger the crystals. Magma thrown up by a volcano is an *extrusive* igneous rock, meaning it cools on the Earth's surface. Since it cools quickly, the crystals are very small—you might need a magnifying glass to see them. Obsidian, for example, is magma that cooled so rapidly it became a kind of glass that can be black, green, gray, or even red in color. Basalt is another extrusive igneous rock. Granite, on the other hand, is an *intrusive* igneous rock, meaning it cooled slowly under the surface of the Earth. The crystals in granite are large and very easy to see and identify.

Igneous rock

Sedimentary Rock

Sedimentary rock forms as eroded particles settle out of the water in which they have been transported. Layers of sediment piling on top of one another become compacted, and moisture percolating through the sediment may deposit calcium carbonate, silica, or iron oxide, which binds the particles. Limestone is among the most common sedimentary rocks, often composed of the skeletal remains of ancient plants and animals. Grains of sand can become sandstone. Pebbles and larger stones can become cemented together to form layers of *conglomerates,* while shale primarily is composed of silt and clay particles. With a sharp eye you often can find tiny, beautifully preserved fossils in sedimentary rock.

Sedimentary rock

Metamorphic Rock

Igneous and sedimentary rocks are sometimes heated enough or put under enough pressure for their minerals to take on new forms. The rocks that result are said to be *metamorphic*. For instance, shale can metamorphose into slate, and limestone into marble. Granite might change into banded gneiss. Under tremendous pressure, graphite can be transformed into diamonds.

Metamorphic rock

Soils

Soil is so familiar to us we seldom give it a second thought. "As common as dirt," goes an old saying, but there is nothing common about soil. It is an ecosystem composed of a complicated combination of mineral matter (a mix of silt, sand, and clay), water, air, and organic material (plant roots, bacteria, fungi, nematodes, protozoa, arthropods, earthworms, etc.).

Decomposing organic matter breaks down into phosphorus, nitrogen, sulfur, and other compounds that vegetation must have in order to thrive. As plants and animals die, their decomposition refreshes the organic material of the soil, making possible one of the environment's most important energy cycles.

Those who study soil classify samples according to a variety of measurements:

- *Composition*—the ratio of sand, silt, and clay
- *Water-holding capacity*—the ability of a soil sample to absorb moisture
- *Biotic contents*—the amount and kind of organic material found in a sample

Another useful measurement for identifying a particular soil is its color, classified by its hue (degrees of red, yellow, green, blue, and purple), darkness or lightness, and strength of color (known as *chroma*). In general, darker soils contain more organic matter, and thus are more fertile, than soils of lighter color. Darker soils also are less likely to erode.

Erosion

Coupled with the creative forces of plate tectonics is the relentless power of erosion. Without erosion, the Earth's mountains would be extremely high. There would be no streambeds, no canyons, and little soil. Without erosion, life as we know it could not exist.

The primary agents of erosion are water, chemicals, ice, gravity, and wind. Moisture seeping into rock fissures expands as it freezes, gradually breaking stone apart. The rocks of talus and scree slopes on mountainsides probably were shattered by frost. Chemicals carried by water can dissolve rock or eat away the crystals that hold it together, allowing it to crumble into particles. Limestone is especially susceptible to chemical weathering, as evidenced by old limestone tombstones whose eroded letters have become almost unreadable, and by the formation of sinkholes and caves.

Rain washes away bits of loosened stone that will act as abrasives as they are carried along. Trickles of water combine to form rivulets, rivulets unite into streams, and streams join into rivers, all patiently cutting channels into the Earth. The steeper the grade of the land, the faster and more erosive

River deltas and weathered rock are both results of erosion.

the movement of the water and the sediment in it. When the grade lessens and streams lose momentum, particles suspended in the water settle to the bottoms of lakes or help create deltas at the mouths of rivers. Floodplains are formed by the deposition of sediment during flooding.

Glaciers are among the most spectacular agents of erosion. A glacier is a long-lasting body of ice formed when yearly accumulations of snow exceed the amounts that melt. The weight of new snow compresses that below it, eventually turning it into ice. As more snow falls on the upper reaches of a glacier, it pushes the ice field downhill in a motion much like that of a very slow river.

Stresses upon glacial ice cause fractures called *crevasses* that can be hundreds of feet deep. When a glacier pushes its way down a steep valley or over a cliff, it creates an *icefall,* a chaotic tangle of frozen walls and pillars known as *seracs* that can topple without warning. If a glacier reaches the ocean, as do many in Alaska and Antarctica, great chunks of ice shear away and drop into the sea. Called *calving,* this glacial activity is a primary source of icebergs.

As a glacier moves across the land, gravel and rocks trapped beneath the weight of the ice scour the surfaces over which they travel. Glaciers can reshape the sharp, V-shaped canyons cut by streams into broad U-shaped valleys. Melting glaciers can leave behind *moraines*—distinctive ridges of rock, boulders, cobbles, and sand they might have pushed along for many miles.

Erratics are boulders carried along by glaciers and deposited in a new location.

Scientists believe that when the climate of the Earth cooled, continental glaciers crept down from the Arctic to cover much of North America. When the weather warmed and the glaciers retreated, they left behind thick deposits of soil and, here and there, solitary boulders known as *glacial erratics*. Much of the rich American prairie was formed by *loess,* windblown soil deposits in glaciated areas. Alpine glaciers continue to cloak the summits and high basins of many mountain ranges in Canada and the United States.

The power of erosion is astonishing. Over the eons it has carved the Grand Canyon, worn down the Appalachian Mountains, and helped shape every landscape you've ever hiked. In fact, you'll find the effects of erosion everywhere you look, but it must be seen in perspective. Erosion plays an essential role in the creation of the soil in which forests, grasslands, and crops can take root, but it has an insatiable appetite. Poor management and abuse of natural resources can allow erosion to take away soil far more quickly than it can be formed.

For more on the effects of erosion and ways to avoid its negative effects, see the section titled "Leaving No Trace." For ways to repair landscapes harmed by erosion, see the chapter titled "Being Good Stewards of Our Resources."

Wisely Using Our Resources

Our Earth has countless resources, including minerals, water, forests, wildlife, oil, and open land, to name a few of them. Minerals are extracted for making metals used in construction, factories, heavy equipment, and automobiles. Water is used for human consumption, crop irrigation, manufacturing, hydroelectric power, and recreation. Oil is used to heat and light our homes and offices, as well as for powering machinery and automobiles. Forest lumber is used to construct buildings, homes, and furniture. Land is used for housing and business development; for raising crops, grazing cattle, building highways, and recreation; and for preserving species of plants and animals.

Human beings have many needs and wants. We are responsible for determining how and for what we will use our resources—decisions that have enormous consequences for our daily lives. We can set aside a river for recreation, or we can build a hydroelectric dam that will generate electricity to light hundreds of thousands of homes—but that same dam also might affect the fish habitat of the river. The consequences of our action or inaction need careful consideration based on all of our needs and wants so that we do not act rashly or do something we might come to regret. Alternative uses of resources need to be carefully researched to achieve a solution that serves the most people and the most significant needs. When you learn about a controversy regarding the environment, take time to educate yourself about each of the alternatives and listen to other people's perspectives before reaching a conclusion. There are no easy answers.

As members of the BSA, we have pledged ourselves to be thrifty. As residents of the planet and consumers of its resources, we must be leaders in doing our part to care for the Earth.

We can pitch in and do plenty of good work repairing environmental damage near our homes, in Scout camps, and in parks and forests we enjoy using. We can recycle. We can be smart about what we purchase and what we consume. We can stay informed and become involved in the political processes that lead to many decisions about how the people of our communities, states, and nation will use and protect natural resources.

Other chapters of the *Fieldbook* have emphasized the importance of practicing Leave No Trace principles during outdoor adventures. The chapter titled "Being Good Stewards of Our Resources" suggests many hands-on projects that can make a real difference in the quality of the environment. With hard work, we can protect the places where we camp and hike. With enthusiasm, patience, and dedication, we can extend our efforts to care for all of the Earth.

"The miracle of soil, alive and giving life, lying thin on the only planet for which there is no spare. We need a renewed stirring of love for the Earth."

—David Brower (1912–2000), American conservationist and first executive director of the Sierra Club

CHAPTER 30

Monitoring Weather

"Joy comes from simple and natural things, mists over meadows, sunlight on leaves, the path of the moon over water. Even rain and wind and stormy clouds may bring joy."

—Sigurd Olson, American nature writer, founding father of the Boundary Waters Canoe Area, and recipient of the 1974 John Burroughs Medal, the highest honor in nature writing

The atmosphere swirls above us like a great, restless sea. Jet streams streak across the sky at hundreds of miles an hour. Polar air masses spill off the ice fields and roll toward warmer climes, while hot tropical air can be so still that a ship's sails can hang limp for days. Chinook winds sweep off the mountains, and thunderheads billow over the prairies, while high peaks seem to produce their own storms.

Thunder and silence, drought and rain, the seemingly random effects of weather are everywhere. Yet weather is not a series of isolated events. It is a constantly changing whole that is as remarkable for its thousand-mile bands of storms and calm as for the narrow paths of tornadoes and lightning bolts. As you travel the outdoors, you'll want to piece together the weather clues you see, hear, and feel so that you can predict the conditions to come in the next few hours and days. To do that, it helps to understand the big picture.

The Atmosphere

Breathing it throughout our lives, feeling it blow against our faces, and watching it move smoke, dust, sailboats, and clouds, we usually take the air around us for granted. The air we call atmosphere, composed primarily of nitrogen (78 percent) and oxygen (21 percent), rises some 60 miles above Earth's surface, thinning until it vanishes into the vacuum of space. The atmosphere presses down on us at sea level with a force of about 14.7 pounds per square inch, but we are so accustomed to feeling that weight we seldom realize it is there unless we are changing elevations. Climb a mountain, though, and you will find the air getting thinner as you go higher. You might feel light-headed and short of breath. When you make an alpine camp, you also might notice that water on your backpacking stove boils at a lower temperature than at sea level.

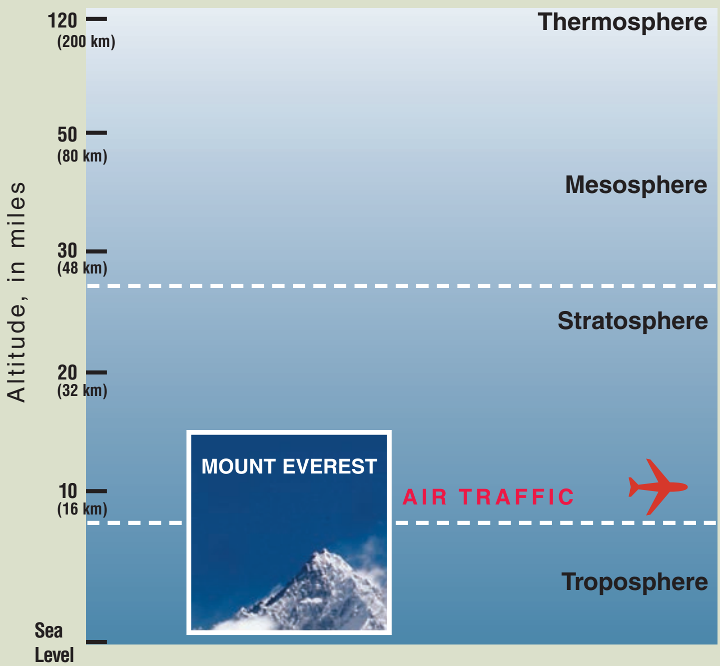
Water's Boiling Point

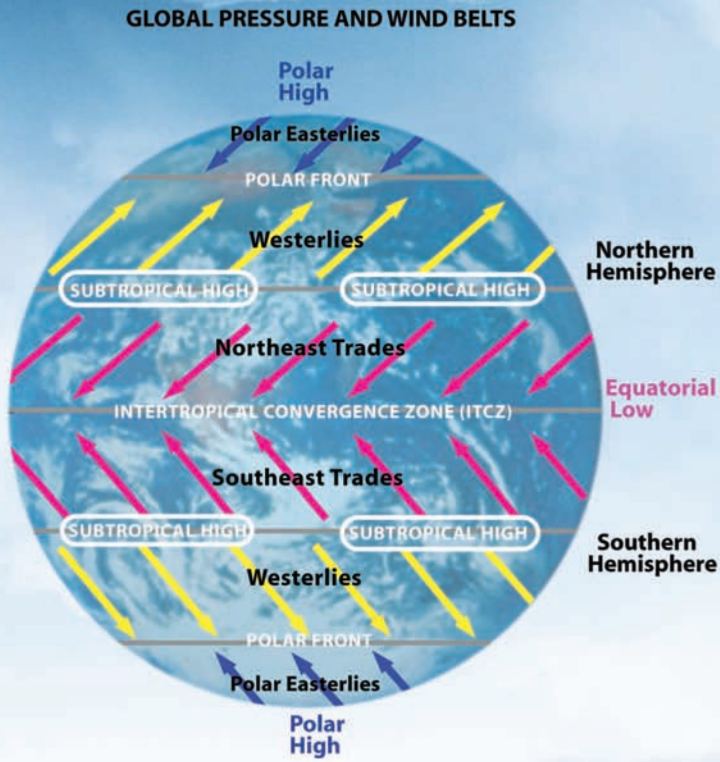
ELEVATION	DEGREES FAHRENHEIT
Sea level	212
1,000 feet	210
5,000 feet	202
8,000 feet	196
10,000 feet	192
12,000 feet	188
14,000 feet	184

Atmospheric Strata

The layers, or *strata,* of the atmosphere are the *troposphere, stratosphere, mesosphere,* and *thermosphere.* Nearly all weather occurs in the troposphere, the level closest to Earth's surface. The troposphere varies in depth from 4 miles at the North and South Poles to about 10 miles at the equator.

The boundary between the troposphere and troposphere is the *tropopause,* a lid on the weather-filled troposphere. The stratosphere above it is ideal for jet travel, since aircraft at that altitude are above most atmospheric disturbances.





Air Pressure and Atmospheric Temperature

The sun is the engine that drives Earth's weather systems. Solar radiation warms Earth, which in turn heats the envelope of air nearest Earth's surface. The sun's rays are more direct, thus more intense, closer to the equator, making the tropical latitudes warmer than the North and South Poles. The temperatures of large bodies of water change more slowly than the temperatures of land masses. The surface of bare soil heats and cools faster than forested regions at similar latitudes and elevations. The seasons affect rates of heating and cooling, too. All these factors result in wide temperature variations around the globe.

As hot tropical air lifts into the sky, cooler air from temperate latitudes is drawn in to fill the void. In turn, that air warms and rises, drawing in even more cooler air. Meanwhile, heated air migrating toward the Poles cools and descends. Warming and rising, cooling and sinking, the cycle goes on and on, producing and affecting patterns of weather all over the planet.

Cold, dense air is associated with higher pressure while lower pressure is the realm of warmer, lighter air. This fact partially explains the presence of semipermanent belts of high and low pressure that power large-scale wind circulations including the westerlies in the midlatitudes carrying storm systems from west to east across the United States.

Embedded in the prevailing westerlies are *jet streams,* fast currents in the flowing rivers of air. A few miles wide and some 30,000 feet above Earth, jet streams move along at several hundred miles an hour. Aircraft pilots traveling east across America sometimes seek out these persistent winds to help them speed their planes toward their destinations, though when they are traveling the other way they are careful to avoid the head-on force of a jet stream.

If Earth were smooth and made up of equal areas of land and water, the prevailing winds would blow in predictable patterns. However, the surface of the globe is irregular both in shape and composition. Mountain ranges jut into the sky, while plains and deserts lie flat. Some areas are heavily forested, others bare, some light in color, some dark. As a result of these variations, the atmosphere warms and cools unevenly, and the speeds and directions of the prevailing winds are altered by the drag of friction and by the physical barriers they encounter. Dividing, combining, weakening, and gaining strength, air masses swirl this way and that, responding to local temperature and terrain and to the presence of other air masses.

Highs and Lows

When warm, high-altitude air cools and sinks, it can form an area of high pressure known simply as a *high.* The barometer rises as a high takes shape, indicating an increase in atmospheric pressure. The dense air in a high-pressure region can keep other weather systems at bay, and the skies generally will be clear.

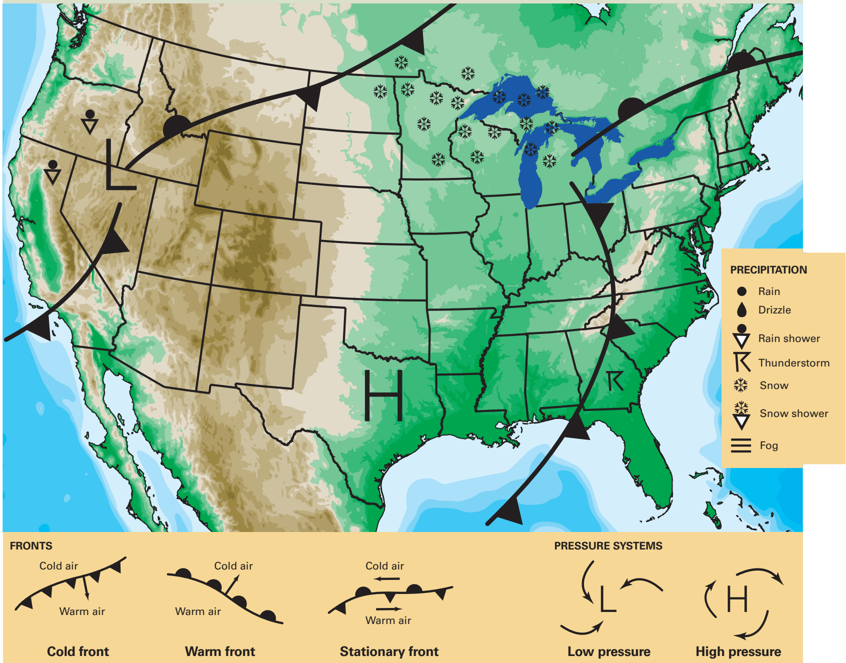
However, there is only so much atmosphere blanketing Earth; if the air is more concentrated in high-pressure areas, other parts of the sky must be areas of low pressure, or *lows.* As indicated by dropping barometric readings, the air in a low is less dense than that in a high, so it tends to draw in winds laden with moisture. As a result, lows are less stable, cloudier, and stormier than highs.

Polar air masses can bring cold, northerly air into the American heartland. When they collide with moist air masses drifting in from the Pacific Ocean and Gulf of Mexico, much of the country can expect rain or snow. Warm air near the equator tends to rise rather than move horizontally, creating great areas of calm called the *equatorial doldrums* and the *horse latitudes.* Sailing ships of old could languish in calm weather for weeks, waiting for a breeze to fill their slack canvas.

Meteorologists chart the sizes and shapes of highs and lows by preparing maps with lines connecting points registering identical pressure readings. While a topographic map shows variations in terrain by using contour lines to connect all points in an area that are the same elevation above sea level, a weather map uses lines called *isobars* to indicate the relationship of locations reporting the same barometric pressure. Just as contour lines ring a mountain, isobars encircle regions of high pressure, decreasing in value as they move away from the center. Likewise, isobars show low-pressure areas as valleys and sinks in the atmosphere in much the same way contour lines indicate valleys and lowlands on maps of dry land.

Weather Maps

You can access weather maps for any area of the globe via the Internet. Maps of your area can be found in daily newspapers and on televised weather reports. Satellite images show cloud movement across the United States and much of Canada.



The Coriolis Effect and Prevailing Winds

While Earth's great air masses are flowing from polar regions toward the tropics, the globe is rotating beneath them. As a result, the winds do not appear to travel in straight lines, but rather bend to the right in the northern hemisphere and to the left south of the equator. This phenomenon, named the *Coriolis effect* in honor of its 19th-century French discoverer, causes prevailing weather patterns to curve as they flow across the globe, and at times to overlap, collide, and mesh with one another.

Weather watchers have known about these patterns of air motion for centuries. Sailors since Columbus' time have traveled near the equator to let the trade winds of the tropical Atlantic Ocean push their ships west to America, and then returned to Europe in the westerlies farther north. Today's transcontinental bicyclists know they are more likely to have the wind at their backs when they pedal from the Pacific toward the Atlantic, but if they go the other way, they might fight head-winds much of the time.

Beaufort Scale

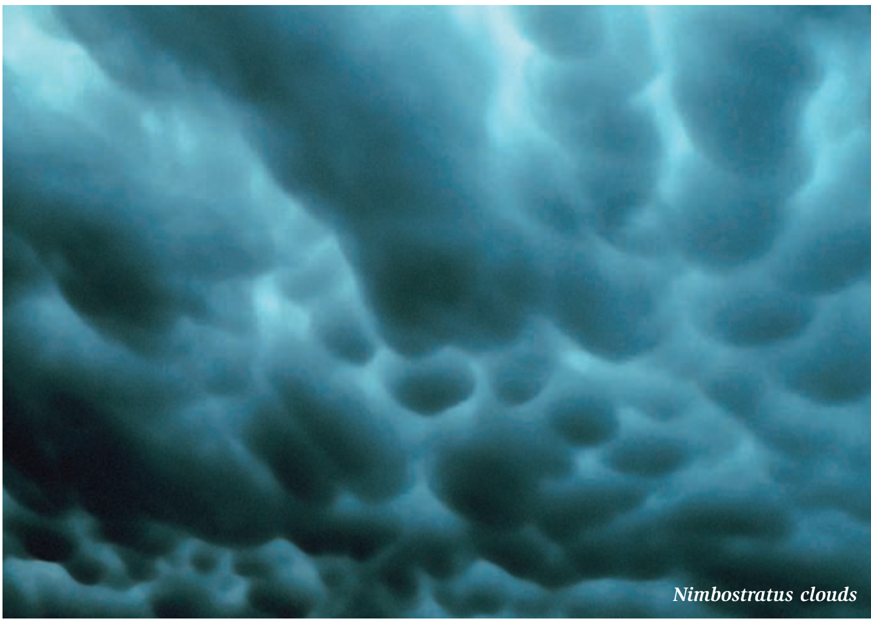
Developed in the 1800s for the British Royal Navy by Rear Adm. Sir Francis Beaufort, the Beaufort scale is a tool for estimating the force of the wind.

WIND SPEED IN MILES PER HOUR	EFFECTS
Less than 1	Smoke rises straight up; air is calm.
1–3	Smoke drifts.
4–7	Wind is felt on the face; leaves rustle.
8–12	Leaves and twigs constantly rustle; wind extends small flags.
13–18	Dust and small paper are raised; small branches move.
19–24	Crested wavelets form on inland waters; small trees sway.
25–31	Large branches move in trees.
32–38	Large trees sway; must lean to walk.
39–46	Twigs are broken from trees; difficult to walk.
47–54	Limbs break from trees; slight structural damage (chimney posts and shingles are blown off roofs); extremely difficult to walk.
55–63	Trees are uprooted; considerable structural damage occurs.
64–74	Extensive, widespread damage; seldom experienced inland.
75 and up	Hurricane: extreme destruction, severe and extensive damage.

Fronts

Study weather maps for several days in a row, and you'll see that the North American continent can contain a number of air masses, some dominated by high pressure, some by low. Some might be moving very fast, perhaps pushed along by prevailing winds out of the west. Others might remain stationary for several days. Those pushing in from the Gulf of Mexico or the Pacific Ocean can be loaded with moisture, while cold, high-pressure air masses moving into the prairies between the Appalachians and Rockies are likely to be dry.

As you examine the isobars on a weather map, pay special attention to the areas where different air masses meet. These boundaries are known as *fronts,* and it is along fronts that many changes in weather occur. For instance, a region of cold, dry air overtaking a warm, moist air mass will wedge under the warm air. As the warm air rises, it cools, and the moisture it carries can condense and fall as rain. Observers on the ground probably will notice a shift in the direction of the wind and a variation in temperature as the front moves through and the new air mass establishes itself overhead. They also can watch changes in the shapes of clouds. If they know what to look for, they can predict a change in the weather several hours or even a day before it occurs.



Nimbostratus clouds

Clouds have long fascinated observers, both for the beauty of their shapes and for what they can tell us about changes in the weather.

Clouds

Rising air often lifts moisture into the atmosphere. If it encounters microscopic particles of dust, smoke, or other condensation nuclei, moisture will attach to the particles and form clouds. There are three basic forms of clouds described by their appearance and given their Latin names—*cumulus* (heap), *cirrus* (curl of hair), and *stratus* (layer).

The term *nimbus* (Latin for "violent rain") describes any cloud from which precipitation might fall; thus, a *nimbostratus* is a layer cloud capable of producing rain. The prefix *alto-* indicates that a cloud is in the middle altitudes of the lower atmosphere, between 6,500 and 23,000 feet above Earth's surface. An *altocumulus* is a fluffy heap cloud floating between 1 and 4 miles overhead.

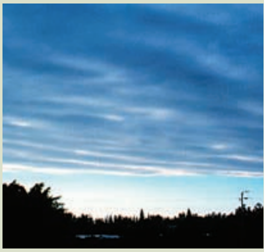
The International System of Cloud Classification

Beyond identifying the basic shapes of clouds, meteorologists have devised a system for classifying 10 principal cloud types. Arranged by the clouds that form highest in the atmosphere, they are:

- **Cirrus**—thin, whispy clouds sometimes described as mare's tails or curls of hair
- **Cirrocumulus**—small cloudlets that resemble ripples or grains
- **Cirrostratus**—thin veil of cloud that covers the sky
- **Altocumulus**—globs of clouds in patches or layers
- **Altostratus**—thin cloud sheets or layers that appear bluish or gray
- **Nimbostratus**—dark layers of ragged clouds, usually carrying rain
- **Stratocumulus**—sheets of lumpy clouds, usually with some dark patches
- **Stratus**—uniform, low layers of clouds that cover the entire sky
- **Cumulus**—large, individual puffy clouds that appear in heaps
- **Cumulonimbus**—large, towering clouds associated with thunderstorms

Cumulus

Cirrus



Stratus

Using Clouds to Predict Weather

The movement of a frontal system often is heralded by a procession of different cloud types, each signaling a greater likelihood that local weather conditions are about to change. The first sign of an approaching storm might be the appearance in a clear sky of high, feathery cirrus clouds known as *mare's tails.* Over the course of several hours or days, they will thicken until the sun is hidden behind a thin cirrostratus veil. A gray curtain of altostratus clouds comes next, followed by a moist blanket of dark stratus clouds rolling close to Earth. Finally, nimbostratus clouds, black and threatening, bring the rain.

Of course, not all clouds signal bad weather. Cirrus clouds detached from one another indicate that the weather will stay fair for a while. A mackerel sky formed by cirrocumulus clouds that look like the scales of a fish usually promises fair weather, but it also might bring unsettled conditions with brief showers. Outdoor groups eager for dry trails welcome the sight of cumulus clouds. On hot days, however, travelers are wise to keep an eye on swelling cumulus clouds and take cover if those clouds develop into dark cumulonimbus thunderheads, the breeders of violent storms.

For information on preparing for different kinds of weather in the backcountry, see the chapter titled "Planning a Trek."

Thunderstorms

A thunderstorm bearing lightning, heavy rains, and strong winds can be a menace to anyone in its path. The danger increases if the storm also generates hail or spawns tornadoes.

A thunderstorm begins when cumulus clouds surge into the sky, gaining thousands of feet of elevation in a few minutes. The surge is powered by solar heat churning the atmosphere and by winds converging and forcing moisture-laden air upward. Air will continue to rise, carrying moisture with it, as long as it is warmer than the atmosphere around it. When the moisture begins to cool and condense, cumulus clouds transform into cumulonimbus clouds. These thunderheads can billow to altitudes of 60,000 feet where the boundary of the troposphere prevents further ascent and horizontal winds flatten the tops of the clouds to create the distinctive anvil shapes of fully developed thunderheads.

Eventually the rising air can no longer support all the moisture lifted high into a thunderhead, and the moisture will rush back to Earth as rain and sometimes hail. The descending precipitation drags air with it, and that might create strong winds near the ground. Heavy precipitation also drains the energy from a thunderstorm. Within half an hour of the start of rain, a storm is often over. If it is part of a broader weather front, it might give way to steady rain.

Heat generated as the sun beats down on prairie regions provides the energy driving the formation of thunderstorms. In mountainous zones, warm air rising up alpine slopes can encounter instability in the atmosphere above, generating thunderstorms in the afternoon, even if the morning skies were clear.

Hail

A pellet of ice descending through a thunderhead might grow as it is coated with freezing moisture. Some pellets are caught in a cycle of updrafts and descents, increasing in size as they swirl through the clouds until they become too heavy for the winds to keep aloft.

Lightning

Lightning kills about 90 people each year in the United States. Charged with 100 million volts of electricity and traveling at 31,000 miles per second, lightning heats a narrow pathway of air to 45,000 degrees Fahrenheit. The resulting violent expansion and subsequent rapid collapse of the air causes a clap of thunder.

The basic electrical charge of Earth's surface is negative, while that of the upper troposphere is positive. Lightning forms when electricity moves between areas of opposite electrical charge. When the weather is clear, there is nothing between the ground and the sky to conduct electricity, but when a thunderhead forms, positive and negative charges build within its parts, allowing lightning to travel within a cloud, between clouds, or from a cloud to the ground.

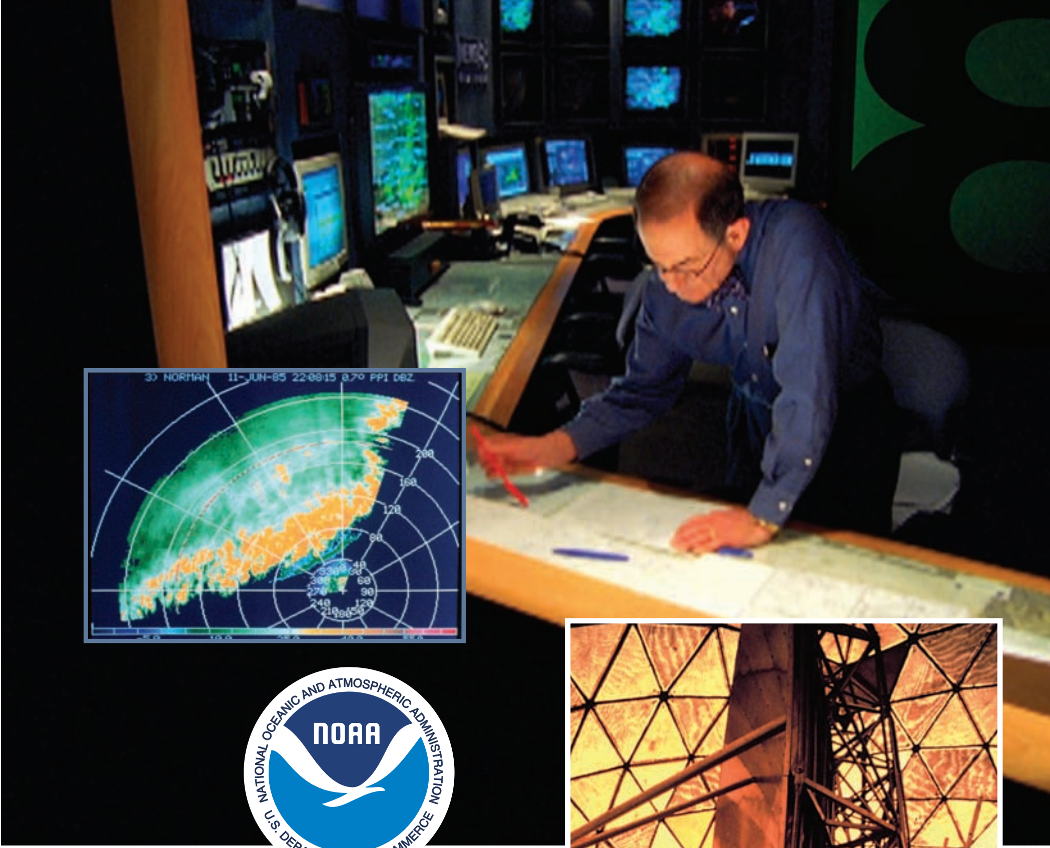
The instability of electrical charges within a cloud is heightened by collisions of ice crystals and hail, and by differences in air temperature at different altitudes. When the imbalance becomes great enough between negatively charged and positively charged areas of clouds, or between a cloud and the ground, electrons form a pathway called a leader and flood from one zone to the other. If that connection includes Earth's surface, electrons will take the path of least resistance—through a solitary tree, perhaps, or the summit of a mountain—and a lightning strike occurs.

For information on protecting yourself and others from lightning, see the chapter titled "Managing Risk."

Local Weather

Despite the broad application of basic principles of meteorology, weather conditions in your area might not match the overall patterns of prevailing winds, highs and lows, and fronts. That's because the weather in each part of the country is influenced by local terrain, bodies of water, and a host of other variables. For instance, coastal regions might be cooler and moister than territory a few miles inland. A mountain range might force warm air to rise, wringing out its moisture as snow and rain. Prairies can allow fronts to roll unimpeded for hundreds of miles.

Learning the patterns of weather in your part of the country can be very satisfying and useful. Glance at the sky whenever you are outdoors and notice the kinds of clouds you see, the direction of the wind, and the sort of weather you're having. Gradually you can build up enough observations to realize that winds from a certain direction usually indicate rain, and that clouds of a certain type mean the skies will clear soon.



Resources for Forecasting Weather

Radio, television, and newspaper weather reports and forecasts can give you some guidance as you prepare for a trek adventure. So can Internet sites devoted to meteorology. Up-to-the-minute weather information is also available from the National Oceanic and Atmospheric Administration (NOAA). NOAA Weather Radio, operating on high-band FM frequencies, transmits updates that can be received by special receivers and by AM/FM radios equipped with a weather-band feature.

Meteorologists have many tools for gathering information. Among the most effective is Doppler radar, capable of showing squall lines and other weather features moving through an area.

Learn the historical weather extremes for the area you plan to travel, and prepare for somewhat worse conditions than the norms. If extreme weather does occur, you will be able to cope with it.

Traditional Weather Signs

There is plenty of folklore connected with weather. “Red sky at morning, sailor take warning,” goes one old saying, often true since the brilliance of a sunrise can be caused by moisture in the air that later in the day turns to rain. As for “Red sky at night, sailor’s delight,” a brilliant, red sunset usually indicates that there is clear, dry air to the west, the direction from which most storms come.

Animals also play a role in weather lore. Perhaps you’ve heard old-timers base their predictions of the severity of an upcoming winter upon the woolliness of caterpillars or the thickness of squirrels’ coats. Birds, their hollow bones especially sensitive to changes in atmospheric pressure, might alter their flying habits to match certain changes in the weather, and many other animals are thought to become restless and seek shelter long before humans are aware of an approaching storm.

Regardless of whether there is sufficient scientific data to support the claims of folklore adages, old sayings and beliefs provide a fascinating glimpse into the way weather predictions were made before the development of accurate measuring devices. Consider these ages-old indicators of fair weather and foul listed on the following page.

Signs of Fair Weather

Expect pleasant weather when you see some of these signs:

- "Red sky at night, sailor's delight." The dust particles in the dry air of tomorrow's weather produce a glowing red sunset.
- "Swallows flying way up high mean there's no rain in the sky." Swallows are birds that catch and eat flying insects. In the high air pressure that comes with fair weather, insects can be carried aloft by air currents.
- "If smoke goes high, no rain comes by." Campfire smoke rises straight up when there is no wind. Still air is generally stable and won't move moisture into an area.
- "When the dew is on the grass, rain will never come to pass." Dew forms when air moisture condenses on cool leaves and grass. That happens especially during the cool, clear nights that come with good weather and high pressure.

Signs of Stormy Weather

The following signs suggest bad weather is on the way:

- "Red sky at morning, sailor take warning." Dry, dusty air is moving away from you toward the east. Clouds and moist air might be coming in from the west.
- "Swallows flying near the ground mean a storm will come around." The low air pressure that pulls in stormy weather causes insects to fly close to the ground on heavy, moist wings. Swallows feeding on them will follow.
- "If smoke hangs low, watch out for a blow." Low air pressure can prevent campfire smoke from rising very high.
- "When grass is dry at morning light, look for rain before the night." On a cloudy night, grass might not cool enough for dew to form.

"The weather is always doing something . . . always getting up new designs and trying them on the people to see how they will go."

—Mark Twain (1835–1910), American author and satirist

CHAPTER 31

31

Plants

"The earth's vegetation is part of a web of life in which there are intimate and essential relations between plants and the earth, between plants and other plants, between plants and animals."

—Rachel Carson (Her 1962 book *Silent Spring* questioned the use of pesticides and aroused worldwide concern for protecting the environment.)

Shade. Nourishment. Beauty. Breath. Life. The contributions of plants and plant communities are vital to existence. Vegetation is so universal that it is easy for us to overlook what is all around us. When we take notice, though, we can begin to see the astonishing diversity of the plant kingdom. In size, shape, aroma, texture, and means of adapting to their settings, plants are remarkable members of ecosystems, connected with all other species on the planet.

You can find plant life almost anywhere. Deserts, prairies, shorelines, and urban parks abound with a stunning variety of vegetation. Plant communities thrive in the mountains, too, and bring richness and variety to wetlands, woodlands, tundra, and forests.

Plants pump oxygen into the atmosphere and cleanse it of carbon dioxide. They offer shelter and food for wildlife. Vegetation forming ground cover slows the runoff of rain, allowing it to seep into the earth. Roots prevent soil from washing away. Decaying leaves and other plant matter enrich the soil. In their simplicity and grandeur, members of the plant kingdom are key elements in the cycles of nature, and essential components of all ecosystems. Two plant communities of particular interest to outdoor travelers are forests and prairies.

31

Forests

From the highest branches to the deepest roots, a forest forms a belt of life up to several hundred feet thick composed of thousands of species of plants and animals. Broad-leaved forests dominate the eastern United States, while conifer forests cover much of the West. These great stands of vegetation shield Earth from the forces of wind, rain, and sunlight. They slow erosion, act as watersheds, and provide havens for animals. Photosynthesis—the process by which most plants manufacture their food—produces oxygen and removes carbon dioxide, which continually freshens the air.

A mature forest consists of levels, or *strata,* all of them essential to the health of a forest ecosystem. Typical forest strata are the canopy, understory, shrub layer, herb layer, and litter layer.

Canopy

The branches and leaves forming the highest reaches of a forest—the canopy—capture maximum sunlight. They also provide shelter and shade for the strata below. Formed by the largest and oldest trees, the canopy is home to birds, climbing mammals, and insects.

Understory

Smaller and younger trees thriving in the broken shade beneath the canopy form the understory of the forest. As canopy trees die, some in the understory will grow to take their places.

Shrub Layer

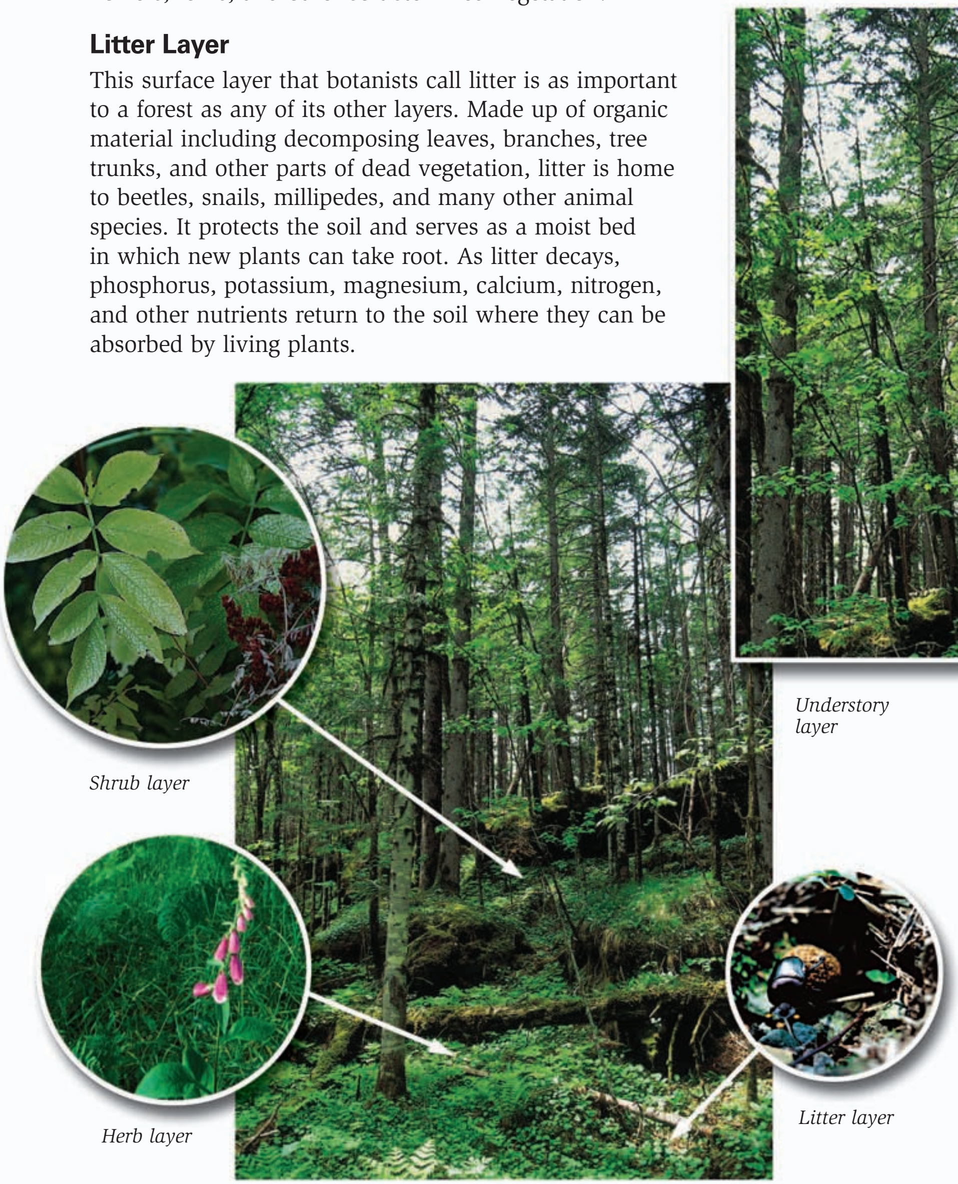
Bushes and thickets of plants with woody stems form the shrub layer, which rises above the ground to about shoulder height. It is this layer that can pose a serious challenge to off-trail travelers when dense vegetation makes hiking difficult.

Herb Layer

A forest's herb layer is composed of the dense ground cover of grasses, flowers, ferns, and other soft-stemmed vegetation.

Litter Layer

This surface layer that botanists call litter is as important to a forest as any of its other layers. Made up of organic material including decomposing leaves, branches, tree trunks, and other parts of dead vegetation, litter is home to beetles, snails, millipedes, and many other animal species. It protects the soil and serves as a moist bed in which new plants can take root. As litter decays, phosphorus, potassium, magnesium, calcium, nitrogen, and other nutrients return to the soil where they can be absorbed by living plants.



Nurse Logs

Long after their deaths, trees falling to the ground play an important role in the life of a forest. Termites, beetles, worms, and other creatures burrow into the wood, allowing moisture to seep in. Fungi and mosses take hold, softening the wood and creating an inviting germination bed for larger plant species. Covered with young vegetation and slowly decomposing into the forest floor, these old trees act as "nurse logs" that help ensure the health of future generations of vegetation. They also provide important cover for small mammals, reptiles, and amphibians.

Prairies

Grasslands cover nearly a fourth of Earth's land surface, creating ecosystems that rival forests in complexity and importance. The steppes of Asia, the savannas and veldts in Africa, and the pampas of South America all are vast grasslands. In North America, the term for extensive grasslands is prairie.

Just as trees are the most noticeable members of a forest community, prairies are dominated by grasses. Storms batter them, animals trample and graze upon them, droughts dry them out, and fires consume them, but grasses endure, recovering quickly from nearly all abuse to thrive again.

Like a mature forest, a fully formed prairie is made up of distinct layers. Big bluestem and similar grasses tower above other species to form a prairie's tallest stratum. Interspersed among the grasses are wildflowers—pasqueflowers, prairie goldenpea, shooting stars, wild roses, and many others. As prairie grasses and flowers die, they mat down to create a dense, tough ground cover. The roots of plants extend deep below the surface, creating stability and guarding the soil from erosion.

Various species of animals thrive upon different levels of the prairie, from antelope, bison, and other mammals grazing on the grasses to earthworms, prairie dogs, and moles finding shelter underground. Many find cover in riparian zones—borders of trees and other woody vegetation growing along the moist banks of prairie streams. By shading the water, the trees of riparian zones can make streams more inviting for fish and other aquatic species. Isolated trees and prairie brush also serve as home for birds and other wildlife.

Old-Growth Forests and Native Prairies

Forests that have never been felled and prairies that have never been plowed are mature ecosystems with finely tuned cycles of growth and decay. Large numbers of plants and animals are interwoven to create a rich diversity that makes these environments very stable. As with wilderness, old-growth forests and native prairies are important for their biological diversity and as reminders of the astonishing ways in which nature functions when left undisturbed by people.

Forest Fires and Prairie Fires

Most fires in forests and prairies are naturally occurring events caused by lightning. Such a fire might burn thousands of acres of timber and sweep across miles of prairie. To those who liked the prairie and the forest as they were, a fire might seem like a great waste. However, the flames that char the trees also consume much of the brush and dead wood choking the understory of the forest, releasing nutrients into the soil and providing a fertile bed for new growth.

Mature trees often can withstand the heat of occasional fires because their bark is dense enough to prevent them from being seriously damaged. The cones of some pines open only after they have felt the heat of a fire, germinating in the ashes and sending up saplings as a new forest begins. Animals can move more freely through land opened by fire, and can browse on the newly sprouted vegetation. Even when large trees are completely burned, the land is left ready for the process of forest succession to begin once more.

Likewise, fire has always been a part of healthy grassland ecosystems. Fire burns away dead prairie vegetation and fire-intolerant invasive plants, releasing nutrients that can be absorbed by the root systems of existing plants and by germinating seeds. The prairie is refreshed and able to thrive again.

Much modern concern about fires results in part from our efforts to manage forests. Forest management practices that seek to eliminate all fires and timbering can allow fuel loads to build up on forest floors, leading to infrequent fires that are hotter and more destructive than might have occurred if the natural cycles of fire and regeneration had been allowed to play themselves out.

For more on ways to help protect the outdoors, see the "Leaving No Trace" section of this book and the chapter titled "Being Good Stewards of Our Resources."

Plant Divisions

There are hundreds of thousands of known species of plants. Botanists organizing vegetation into understandable groups have classified all complex plants as members of one of five divisions—mosses, club mosses, horsetails, ferns, and seed plants.

Mosses (Bryophytes)

Mosses are small, nonflowering plants generally not more than a few centimeters tall that grow in rock crevices, on forest floors and tree trunks, and along the banks of streams. Many have a small spore capsule at the end of a stalk that rises above a leafy base. Haircap moss, apple moss, and the closely related liverworts and hornworts typify this group. Most of the mosses and their close relatives live in moist areas on land.

Moss

Club Mosses (Lycopsids)

Despite the name, club mosses differ from true mosses because they are vascular—that is, they have veins. Club mosses play a small role among today's plants. Eons ago though, they included vast forests of trees up to a hundred feet tall, forests that scientists believe were to become many of the coal deposits of Europe and North America.

Ground pine

Horsetails (Equisetophytes)

Horsetails are an ancient group of plants, relatively unchanged for eons. These plants with hollow, jointed, and usually grooved stems reproduce with spores rather than seeds, and thus have no flowers. Strobili, cone-shaped structures atop the horsetail stems, produce the spores. Horsetails have been used for medicinal purposes and as scouring brushes for cleaning pots.

Horsetail

Ferns (Pteridophytes) and Their Allies

Although they share with seed plants the presence of chlorophyll and vascular tissues, ferns reproduce without seeds. Ferns often have lacy leaves called fronds. Uncurling in the spring, the fronds of some ferns resemble the decorative ends of violins, and thus are called fiddleheads. Ferns are most abundant in the shade of moist forests. Fern allies include closely related whisk ferns, horsetails, quillworts, club mosses, and spike mosses.

Fern, showing a fiddlehead

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Giant sequoia

Seed Plants (Spermatophytes)

The great majority of Earth's plants are those that produce seeds. Among them are the most ancient living beings on the planet, including 4,000-year-old intermountain bristlecone pines, and the largest, including giant sequoias that can achieve a mass of more than 2,500 metric tons.

Seed plants are divided into two groups: nonflowering plants (gymnosperms), such as conifers, ginkgos, and ephedras; and flowering plants (angiosperms), such as wildflowers, grasses, and flowering trees and shrubs.

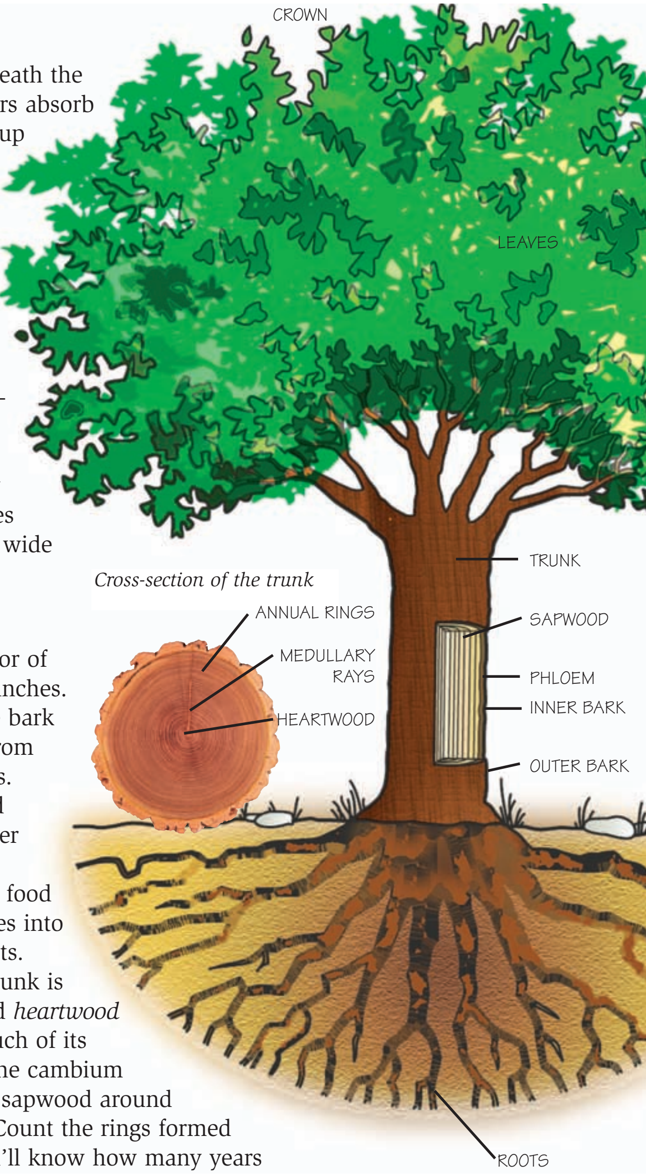
Trees

Many thousands of species of trees grow in North America, and thousands more flourish in other parts of the world. Trees are characterized by their size (usually taller than the height of a person) and by the fact that each usually has a single woody stem, or trunk. (Shrubs, on the other hand, have multiple woody stems, and seldom grow much beyond 8 to 10 feet in height.)

Anatomy of a Tree

Roots

Much of a tree is beneath the ground. Tiny root hairs absorb moisture and send it up into the tree. A root system also is the anchor that holds a tree upright, even in high winds. Some trees have taproots that extend deep into the earth. Others, especially those growing in thin or rocky soils, have roots that spread out just below the surface, sometimes achieving a radius as wide as the tree is tall.



Trunk and Bark

Bark is the outer armor of a tree's trunk and branches. Sapwood beneath the bark transports moisture from the roots to the leaves. Between the sapwood and bark is a thin layer of tissue called the *phloem* that channels food produced by the leaves into the trunk and the roots. In the center of the trunk is hardened wood called *heartwood* that gives the tree much of its structural strength. The cambium grows a new layer of sapwood around the trunk each year. Count the rings formed by the layers and you'll know how many years a tree was alive.

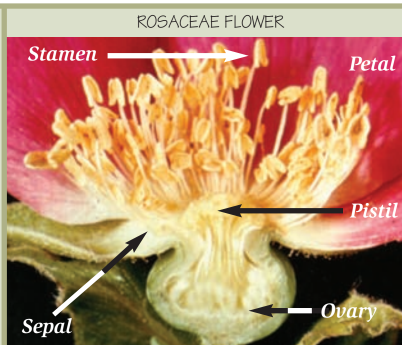
Leaves

Chlorophyll, a chemical compound in leaves, draws power from sunlight to convert carbon dioxide and water into plant food. This process, called *photosynthesis,* also returns oxygen to the atmosphere. Green plants produce the oxygen that supports all of Earth's animal life, humans included.

Conifers

Conifers are a type of gymnosperm—plants with naked seeds tucked inside the cones. Exposed to the elements, conifer ovules can be fertilized directly by windblown pollen. Rather than relying on insects to aid in pollenation, conifers release pollen that blows from tree to tree, an ideal transport mechanism in alpine regions and other settings where there are plenty of breezes but perhaps not many bugs. The compact Christmas-tree shape of pines, firs, spruces, and other conifers helps them shed rain, snow, and wind.

Conifers are particularly well-suited to high elevations and northern latitudes where growing seasons are short. The needlelike leaves of most conifers don't fall off, allowing those trees to spur growth as soon as the days begin to warm in the spring. (There are a few deciduous conifers, including cypress, larch, and tamarack, that do lose their leaves.)



Conifers and Broad-Leaved Trees

The two large groups of trees are conifer trees and broad-leaved trees. Broad-leaved trees bear flowers, and most are deciduous—they shed their leaves, typically in autumn, and grow new ones in the spring. Many fruit trees, including the apple, apricot, and plum, are of the rosaceae family. Its flower contains the stamens, pistil, ovary, petals, and sepals, all of which are crucial to reproduction.

Conifers, also known as evergreens, are cone-bearing trees with needlelike or scalelike leaves that stay on many of the trees for several years. The seeds of a pine tree will remain inside the cone for up to two years until the cones open, allowing the seeds to fall out.

Broad-Leaved Trees

Broad-leaved trees are angiosperms—flowering plants with ovules protected inside ovaries. Fertilized ovules develop into seeds. Unlike the cones protecting the seeds of conifers, seeds of broad-leaved trees are enclosed in fruits such as nuts, or some other forms of seed cases.

As their name implies, most of these trees have wide, flat leaves. Many broad-leaved trees have trunks that branch out into round, airy shapes. They do well where conditions during the growing season are not harsh. Everything about them, from leaf shape to the orientation of branches, plays into their survival and their ability to adapt to their environments. Losing their leaves in the autumn, for example, helps protect branches from breaking under the weight of winter snows.

Why Leaves Change Color

Each autumn, the foliage of many broad-leaved trees turns from green to brilliant red, orange, or yellow, and then brown. In fact, those bright hues were in the leaves all summer, hidden beneath the green of the chlorophyll. As the growing season comes to an end, a tree's food production drops and so does the amount of chlorophyll in the leaves. The green fades, allowing the fiery colors to show through.

Another change causes a layer of cells at the base of the leafstalk to cut tissues holding the leaf on the tree. The leaf falls to the ground where it will decompose, returning nutrients to the soil.

Identifying Trees

You don't have to know the names of trees to appreciate them. "The biggest tree in our campsite" might be all the identification you need to share information with friends who have pitched their tents in the same place.

Knowing the name of the tree can open a world of information to you. If you discover that the tree is an ash, you can easily research its geographic range, qualities of the wood, the tree's fruiting bodies, its life span, and ways in which it interacts with other species.

Identifying a tree can be simple. "You can tell a dogwood by its bark," the old-timers say, and they're right. The appearance of the bark is one of several important pieces of evidence that can lead to discovering the name of a tree. Other characteristics to notice are its shape, leaves, and the way it fits into its environment.

Tree Shape

A tree's silhouette can be as distinctive as a fingerprint is for a human. Some trees spread great branches of leaves toward the sky to absorb as much sunlight as possible. Other trees have shorter, tighter shapes that help them endure storms and shed snow. Here are some of the most common tree shapes:

Pyramid

Column

Palm

Weeping

Round

Cone

Irregular

Oval

Vase

Bark

Tree bark is notable for its variations in shape and texture. Some varieties are shown here:

Peeling

Plated

Smooth

Flaked

Furrowed

Leaves

While shape and bark reveal much about a tree, its leaves probably are the most commonly used clues for determining its identity. For starters, leaves of conifer trees are in the shapes of needles or scales. Those of deciduous trees are broad, and might appear singly, in various combinations, or in sets that alternate on a branch or are opposite one another. Basic leaf shapes of broad-leaved trees include the following:

Narrow

Lobed fan

Egg-shaped

Heart-shaped

Veined fan

Long pointed

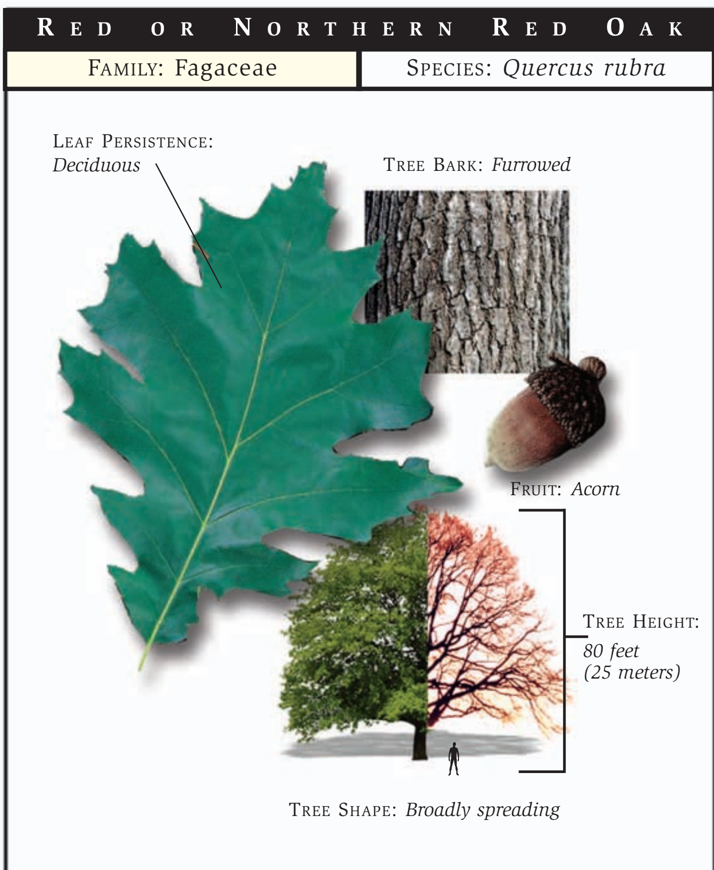
Nomenclature of Trees and Other Plants

Plant naming can be very specific, using Latin terms to describe each species. This system of using standardized names, or *nomenclature,* allows botanists and others who study plants to share accurate information about particular plant species.

Plant Keys

The most useful tools for studying plants are plant keys, which group plants based on similarities they share. Plant keys are available both as books and as interactive Web sites.

A powerful aspect of a plant key is its ability to guide you step-by-step to the identity of a plant species. Each plant key addresses particular kinds of vegetation (trees, for example, or mushrooms or wildflowers), and may be further focused on a specific region (the trees of North America, for instance, or the mosses and ferns of the Pacific Northwest).



Using a Plant Key

Plant keys typically are constructed with an either-or format, asking you to answer a series of questions that will steadily narrow your choices until you come upon the specific description of the plant you want to identify. A typical sequence might lead you this way:

1. Needlelike leaves or broad-leaved?
   If broad-leaved, then . . .
2. Compound leaves or simple leaves?
   If compound, then . . .
3. Thorns or spines present, or thorns or spines absent? If without thorns or spines, then . . .
4. Are leaves smooth, toothed, or lobed?
   If lobed, then . . .
5. Are leaves arranged opposite each other on the twigs, or do they alternate? If opposite, then . . .
6. Are leaves heart-shaped or oval? If oval, then . . .

Identification keys are available for trees, shrubs, flowers, and many other plants, as well as for mushrooms and animals.

Once you have identified a plant, the plant key can provide a wealth of information about the species, often including its normal geographic range, its general size and shape, and descriptions of fruiting bodies, leaves, and bark.

Plant identification is most effective when it is done in a plant's natural setting where you have a wide range of clues to help you—appearance, aromas, and evidence of the interaction between a particular plant and other species of plants and animals. You also can observe the full array of leaves and determine whether they are staggered, opposed, or in clusters.

Identifying Dormant Trees

Most conifers look much the same in the winter as they do in the summer; however, dormant broad-leaved trees will have lost their leaves, and also will be missing color, aroma, and other clues useful in determining their identity. You might be able to make an accurate identification using the tree's bark, shape, and orientation of branches and twigs. A leaf picked up from the ground beneath the tree also can be a strong clue, though there's a possibility it is from a different tree, blown there by the wind. Make your best winter guess as to the identity of a tree, then come back in the spring or summer and see if your guess was right.

A Sampling of North American Conifers

Pines

Many species of pine trees thrive in North America, each finding an ecosystem for which it is particularly well-suited.

The white pine, found throughout the Northeast, is recognizable by its smooth, tight bark and leaf clusters of five needles each. It is the tree featured on the state flag of Maine. Other pines common in the Eastern states include the pitch pine with three needles per cluster, and the jack and red pines with two needles. In the Southeast, the longleaf and loblolly pines have three needles to a cluster, while slash and shortleaf pines display two.

The largest pines grow in the mountains of the West. Sugar pines can reach a height of 200 feet. Look for five needles in each of its leaf clusters. The heavy cones of sugar pines can be 18 inches long.

Jeffrey pines have long needles in groups of three. Get close to the bark of a Jeffrey or ponderosa pine and you might smell a pleasant vanillalike aroma. Ponderosa and knobcone are other Western pines with three-needle clusters. Lodgepole pines, named for the straight, clean trunks some American Indian tribes used to set up their tepees and lodges, have clusters of two needles each.

Conifer forests can be found in many parts of the United States.

Lodgepole pine

Ponderosa pine

Red cedar

Redwood

Colorado blue spruce

Many conifers have the Christmas-tree look of an inverted cone.

White spruce

Balsam fir

Larch

Tamarack

Eastern hemlock

Douglas fir

Spruces

The needles of spruce trees are four-sided in shape. The Engelmann spruce, found in Southwestern states and in the forests of the Rocky Mountains and the Pacific Coast, has soft needles with a blue-green hue. The blue spruce, growing primarily in New England, the Rockies, and Southwestern states, has needles that are stiff. The tallest American spruce is the Sitka spruce of rain-drenched Pacific Northwest coastal forests.

Firs

Fir needles are flat and flexible, and appear to be arranged in orderly rows along the sides of branches. The needles are dark green on top, while the undersides show two white lines. Fir cones grow upright on the upper branches of the trees. The balsam fir of the East and the white fir of the West are stately, fragrant representatives of these evergreens.

Larches and Tamaracks

The soft needles of the larch grow in tufts out of old-growth bumps on the branches. Unlike those of most other conifers, larch and tamarack leaves fall off in the winter. Larches are tall, slender trees with small cones.

Hemlocks

Hemlocks are large evergreens identified by short, flat needles with dark green tops and silvery undersides. The small cones hang from branches that can droop in the shape of a graceful pyramid.

Douglas Firs

Douglas firs are found primarily in the western United States. Also known as the Douglas spruce, red fir, and Oregon pine, the tree actually is of the pine family, as are spruces, firs, larches, and tamaracks. Its flat needlelike leaves spiral around the branches, giving them the appearance of bottle brushes or squirrels' tails.

Sequoias and Redwoods

The world's largest trees are the redwoods and giant sequoias of California. Redwoods can grow to over 300 feet in height, and sequoias to a diameter of more than 25 feet. Some of these trees reach several thousand years of age.

Cedars, Junipers, and Cypresses

The leaves of cedars are tiny, bright-green scales arranged like small shingles on flattened twigs.

The western red cedar is, in fact, a juniper. Junipers have two kinds of leaves. Some are scaly and flat like a cedar, while others are prickly. Juniper cones look like moldy blueberries.

The bald cypress of the South drops its needles each winter, and some kinds of cypress grow in swamps; portions of their roots exposed above the water are called *knees.*

Bald cypress

Identifying Firs, Spruces, and Pines

As a quick rule of thumb to determine some of the larger groups of conifers, examine their needles and note their shape, then apply these identifications:

Flat needles = fir

Square needles = spruce

Pairs or clusters of needles = pine

Scaly, shingled needles = cedars

Aspen trees

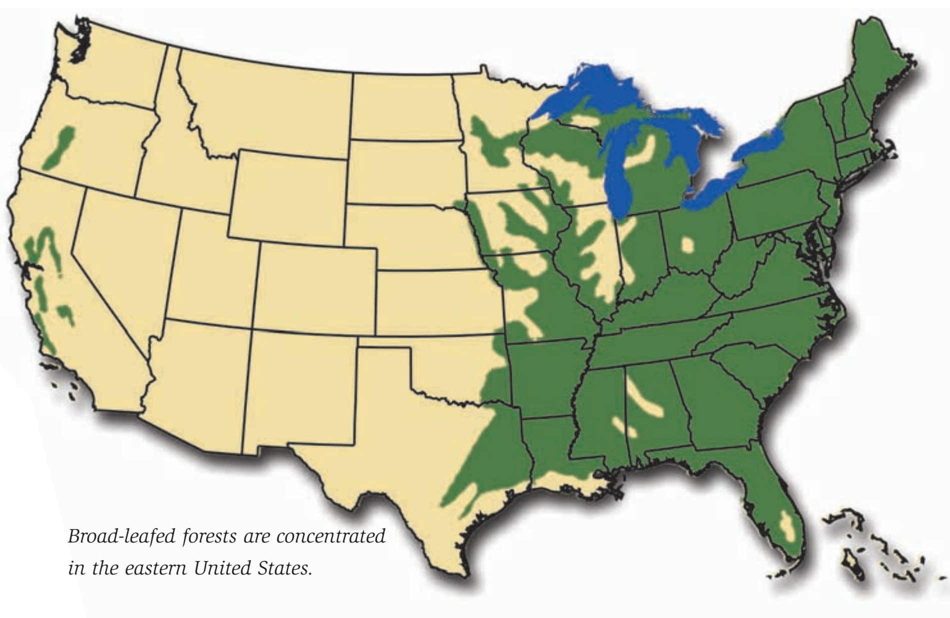
Pussy willows

A Sampling of North American Broad-Leaved Trees

Willows and Aspens

The pussy willow takes its name from its furry flower clusters that resemble tiny kittens clinging to the willow's long, straight branches. The sandbar willow often is one of the first plants to grow on new ground formed by shifting river currents.

Aspens thrive on sunlight. They take root quickly on mountain slopes burned by fire, protecting the soil from erosion and providing browse for deer, elk, moose, and other animals. As slower-growing conifers mature, they tower above the aspens and eventually create so much shade that the aspens must give way.



Broad-leafed forests are concentrated in the eastern United States.

Pistache

Western catalpa

American elm

White oak

Paperbark maple

Deciduous trees flourish in the temperate climate of the Northeast.

Nut Trees

Walnuts and hickories have compound leaves, each made up of a number of leaflets. A hickory leaf has three to nine leaflets, while the leaf of a walnut tree might have more than a dozen. Walnuts and hickory nuts are the seeds of their trees. Both are good to eat, as are the nuts of pecan trees. Mockernut, bitternut, and pignut trees have small, bitter kernels.

Bitternut hickory

Walnut

The Birch Family

This family of broad-leaved trees includes birches, hornbeams, and alders. The trees are most commonly found in the East and Northeast. Their oval leaves have jagged edges and shiny surfaces.

Birch

American Indians used sheets of white bark from the paper birch to build their canoes. The bark of yellow birch peels away from the trunk in curls. Gray and black birches have much tighter bark.

The wood of the smooth-barked American hornbeam is so tough that the tree is sometimes called ironwood. The trunk resembles a person's muscular arm.

Alders grow in moist ground throughout the country. They have broad leaves, stalked buds, and small, conelike fruits.

American beech

Beeches and Chestnuts

You can identify an American beech tree by its smooth, pale gray bark. Like those of the birches, each beech leaf has a strong midrib and parallel side veins. Its burrlike fruit contains two triangular nuts.

The chestnut was once common in forests of the eastern United States until the appearance of the chestnut blight, a fungal disease that killed so many of the trees you would probably have a hard time locating an American chestnut today.

Acorns

Oaks

Wood from America's oak trees has long been prized by carpenters and cabinetmakers. Oak timbers are slow to rot, even if they are wet. The Revolutionary War ship USS *Constitution* ("Old Ironsides") was made of oak, and hand-hewn oak beams were used in many Colonial homes.

The acorn is the fruit of an oak. Most oaks have notched leaves. The lobes on the leaves of some oaks are rounded, while those of others come to sharp points. One exception is the live oak; its leaves have smooth edges and no lobes at all, but its acorns help you identify it as an oak.

Elms

Elms are large, graceful shade trees found at one time in towns and cities throughout the nation. The leaves of American elms and slippery elms are egg-shaped and lopsided with saw-toothed edges. Leaves of American elms are shiny and smooth. Despite the name, the leaves of the slippery elm have dull, rough surfaces. Dutch elm disease, caused by a fungus, has wiped out the elm populations in many parts of the United States.

American elm

Magnolias

Magnolia trees are found in the southeastern United States. Their large, distinctive leaves are shiny dark green on top and pale underneath. One magnolia, the cucumber tree, bears a mass of many small, elongated pods.

Another member of the magnolia family is the tulip tree, a very tall tree named for the tuliplike appearance of its flowers. The tulip tree is one of the few members of the magnolia family that is native to North America. It once flourished throughout the continent, but now grows only in the eastern United States.

Magnolia

Papaws and Sassafras Trees

The common papaw belongs to the custard-apple family. It is found in forests of the East and Midwest. The fruit of the papaw looks and tastes like a chubby, overripe banana.

Tea made from the dried root bark of the sassafras tree is an old household remedy for colds. On the same tree you can find leaves of many shapes—some oval, some like three-fingered mittens.

Papaw

Gums and Sycamores

The sweet gum tree has star-shaped leaves that turn a brilliant red in autumn. Its fruits look like spiny balls.

The fruit of the sycamore has a similar shape, but doesn't have the spines. The bark of a sycamore gives the trunk a distinctive patchwork of large blotches of white, green, and yellow.

American sycamore

Sweet gum

Plums and Cherries

A dozen varieties of wild plum trees grow in the eastern United States. Look in the woods for small trees with shiny oval leaves and purple or reddish fruits. The hard pit inside each fruit contains the seed of a new tree.

Wild bird cherry or pin cherry are small trees with tiny red fruits in clusters of two or three. Other wild cherries have fruits arranged in bunches.

Plum

Wild cherry

Maple

Maples

The leaves of maples are arranged in pairs opposite each other on the branch. Their main veins come out like fingers from the base of the leaf. Fruits of maple trees, called *samaras,* each have a "wing" attached that causes them to twirl through the air.

Buckeye

Buckeyes

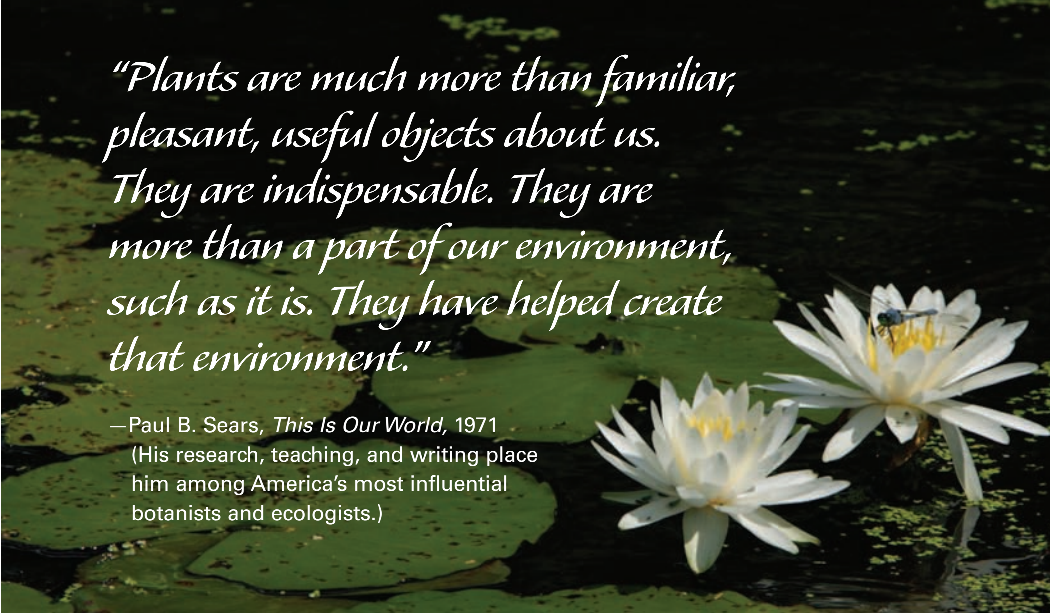
Inside a tough, spiny burr is the fruit of the buckeye. Its size and shiny brown surface make it look something like the eye of a deer, and thus its name. Leaves of buckeyes have five long leaflets. Ohio, the Buckeye State, takes its nickname from this tree.

Ashes

Many ax handles and baseball bats are made from the hard, smooth wood of the ash tree. Each ash leaf is made up of many leaflets that grow in pairs on either side of the stalk. The leaves are in pairs, too, and so are the branches of the tree.

Flowers

Flowers are the reproductive parts of many plants. The shapes and bright colors of flower petals attract insects and other animals that spread pollen among the plants. The male part of the flower, the *stamen,* produces pollen. The female part of the plant, the *pistil,* receives the pollen. The pistil often is shaped like a stalk with a knob on top. Insects, bats, and birds pollinate many flower species as they move from plant to plant.



Native Plants, Exotics, and Weeds

The role of vegetation in ensuring the diversity of an ecosystem is starkly evident when desirable native plants are pushed out by weeds. The cause of these disruptions often is human activities. Solutions also can rest with our actions.

Native plants are those that are the natural inhabitants of an area. A nonnative plant is one that has been introduced to an area. Whether native or nonnative, plants that spread aggressively and push out species important for a healthy ecosystem often earn the designation of weeds.

A noxious or invasive plant is a weed designated by law as undesirable and requiring control. These plants usually are nonnative and highly invasive; some examples are passion flower, Scotch broom, purple fringe, and spotted knapweed. Weeds crowding out native vegetation can create a monoculture, an area dominated by a single species. When that happens, plant diversity is lost.


Yellow star thistle

Many native plants have fibrous root systems that provide soil cover, stability, and water infiltration while many weeds have narrow taproots that leave bare soil exposed to erosion. Other weeds have roots that penetrate deeper than those of native plants, allowing them to tap more water and thus crowd out native vegetation.

Weed seeds can be spread by wind, water, livestock, wildlife, vehicles, and people. Outdoor users traveling with horses, mules, or other livestock often carry hay that is specially treated to prevent the seeds of weeds it might contain from taking root and competing with native vegetation.

For more on using livestock without leaving a trace, see the chapter titled "Riding and Packing." For more on ways to improve the environment by controlling weeds, see the chapter titled "Being Good Stewards of Our Resources."

CHAPTER 32

Wildlife

"Knowing the names that humans have given to other creatures or things is far from the most important lesson you will teach."

—Rachel Carson (1907–1964), American ecologist and writer

A cocoon warming in the sunlight slowly breaks open, and a majestic butterfly emerges, greatly changed from the caterpillar it once was. A salmon hurls itself against a thundering cascade, fighting upstream to lay its eggs. Bats swirling from the mouth of a cave find their evening meal of flying insects by carefully monitoring the echoes of their high-frequency clicks. A bullfrog watching a newly hatched butterfly dry its wings flicks out its sticky tongue, and the butterfly is no more.

The world's animals are profound in their complexity, astonishing in their variety, and fascinating in their activities and habits. Wildlife thrive almost everywhere—from the depths of the sea to the highest mountain ranges, from the driest deserts to the wettest rain forests, from a city park near your home to the wilderness areas of national forests and parks. By gaining an understanding about animals, you can begin to see how species interact with one another within their ecosystems.

Salmon swimming upstream

No matter what habitat is home—desert, alpine, forest, prairie, aquatic—every animal needs food, water, shelter, and space. Changes in the combination of an ecosystem's basic resources (and changes are constant) affect all species and their abilities to thrive.

A badger and a mountain lion settle a territory dispute.

Adaptations

Exploring what an animal eats—and what might eat it—is a good starting point for discovering a species' particular traits. An animal's diet and efforts to keep from becoming part of another creature's diet can influence everything from its color and shape to its body covering, ways of perceiving the world, and manner of enduring winter.

Herbivores eat vegetation. Bison and elk are herbivores with mouths adapted for grazing and four stomachs for digesting grasses. Worms, caterpillars, grasshoppers, and thousands of other insects devour the leaves of trees and shrubs. Hummingbirds, nuthatches, and many other birds feed exclusively on plants.

Carnivores eat other animals. They might have talons, claws, or fangs shaped for capturing and tearing apart their prey. Many spiders build elaborate webs to capture insects, and many insects feast on other insects.

Omnivores eat both vegetables and animal matter. For example, grizzly bears dine on berries but also eat grubs, small animals, salmon, and the carcasses of larger beasts. Humans are omnivores, though some people choose to follow a vegetarian diet.

Color and Shape

An animal's adaptation of color or body shape can be surprisingly obvious—once you are aware of it. For example, the walking stick is an insect whose body mimics the surrounding twigs, camouflaging its approach upon tiny insects that become its food. Likewise, the walking stick's natural disguise keeps it hidden from most birds that would feed upon it.

Many fish have dark backs and pale bellies, which naturally blend from above with dark lake or pond waters and from below with the bright sky, so no matter what a predator's position, it will have a tough time seeing the fish in water. A deer's tawny shades allow it to blend into the underbrush, and a fawn's spots enhance its natural camouflage. Some lizards and tree frogs gradually shift color to match their surroundings. The ptarmigan is a grouselike mountain bird whose brown summer plumage begins to turn white with the first snow. Also white in the winter, the snowshoe hare's fur takes on the tundra's earthy hues when summer rolls around.

Not all animals blend with their backgrounds, however. Many birds display brilliant plumage, and some insects are very colorful. The bright red, yellow, and black bands of the poisonous coral snake serve as a warning to the curious.


Snowshoe hare


Cardinal

Body Covering

Some animals' bodies have adapted to physically protect them from predators. A turtle cannot easily flee danger, but it can draw itself into the protection of its shell. A porcupine does not move quickly, but its quills will discourage all but the most persistent predators. An armadillo can curl into a ball, hiding its soft underbelly and presenting an attacker with nothing but bony armor plate.

Body covering also can help protect animals from the elements. Mammals' fur, for example, provides insulation against the cold. Waterfowl are covered with warming layers of down and outer feathers rich with natural oils that shed moisture so the birds stay dry. Scales on snakes' underbellies allow them the traction they need for motion, and the sleek hides of beavers, seals, and other aquatic mammals help them slip smoothly through the water.

To realize the degree to which animals have adapted to their environments, think of an animal outside its natural role. For example, imagine a hummingbird diving out of the sky to snatch a fish in its claws and lift it to a nest on a distant cliff. Now imagine the impossibility of a bald eagle hovering motionless above a field of flowers, sipping nectar from the throat of a blossom.

Perceiving the World

Animals use a variety of strategies to gather information about their surroundings. Humans use combinations of five senses—sight, sound, touch, smell, and taste. Other species use those senses and a range of others not available to humans.

Seeing

Some animals see extremely well, while others are nearly blind. A soaring hawk notices the slight movement of a ground squirrel far below, and a falcon diving on a smaller bird can identify its prey at a glance and gauge its altitude and speed.

Most animals see the world in shades of black rather than in color, which is why game animals like deer and elk do not notice hunters' fluorescent orange hats and vests. Many insects have compound eyes that gather data from a wide arc of vision. Animals with eyes on the sides of their heads can find it difficult to focus both eyes on a single object and might not be able to judge distances well. Moles and bats are blind, at least in the conventional sense of the word, forcing them to rely on organs other than their eyes.

Smelling

Some animals, like wolves, coyotes, bears, sharks, and snakes, have a very keen sense of smell. A faint scent in the breeze or water is all it takes to alert them to danger or lead them to carrion and other food sources.

Sharks' sense of smell does not work like mammals' noses, but they can perceive the presence of blood in the water from great distances. Similarly, many insects can detect odors through specialized organs in their antennae and bodies.

A snake's tongue ranks among the most remarkable sense organs of the animal world. Flicking out in search of predators and prey, a snake's forked tongue delivers particles of air, soil, and water to the roof of its mouth, where a specialized organ called the *Jacobson's organ* interprets the particles much like the human sense of smell.

Hearing

Many animals such as rabbits and owls have ears that are large in proportion to their body size, which can help them pinpoint the sources of faint sounds that give them an early warning of danger or help them locate prey.

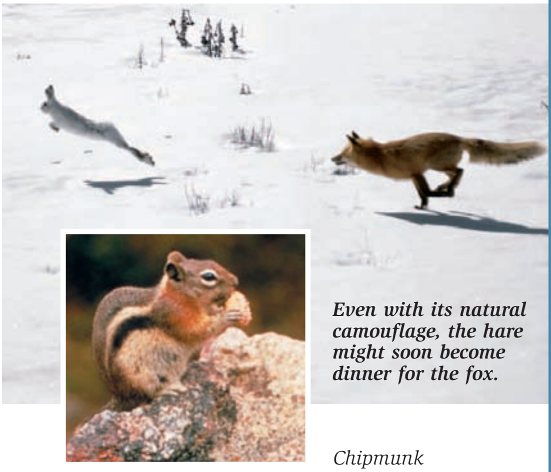
Humans can be so accustomed to city noises that the silences of the outdoors can be startling. Listen carefully, though, and you might hear the songs of birds, the splash of water, and the rustle of leaves in the wind. Unique sounds like the snort of a deer, the rhythmic beat of a woodpecker, or the slap of a beaver's tail may help you locate and identify wildlife you might not have noticed otherwise.

Touching

Whiskers, tongues, feelers, antennae, toes—animals rely on all manner of body parts to touch the world around them. Fish have a sensory organ along a lateral line of nerves and pores on their sides that picks up small vibrations in the water and alerts them to changes in their surroundings. When you walk along a stream bank, fish might dart away even if they can't see you; their lateral lines alert them to the weight of your footsteps upon the ground.

Surviving Winter

Perhaps the most profound changes in an ecosystem are driven by Earth's tilt and orbit as it makes its annual trip around the sun. Each season of the year offers wildlife challenges and opportunities, but for many species a central focus of survival is preparing for, and then living through, winter.



Even with its natural camouflage, the hare might soon become dinner for the fox.

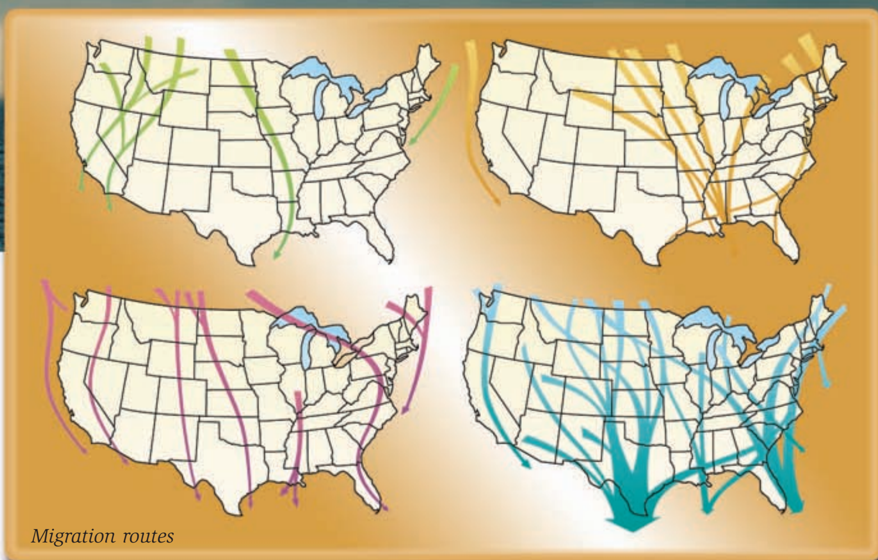
Chipmunk

Some animals remain active year-round, foraging and hunting despite cold, snow, and shortages of browse and prey. Bison use their large heads to push away snow to reach frozen grasses. Foxes stalk hares and birds that increase their chances of winter survival by turning white when the first snows cover the ground.

Another strategy for winter survival is stockpiling food. Squirrels spend much of summer and autumn hiding nuts in tree hollows or burying them in the ground in hopes of finding them later. Honeybees build up surpluses of comb honey. Ants gather grass and leaf clippings. Bears and chipmunks preparing to hibernate eat voraciously through the summer to add fat to their bodies before they bed down in their dens and burrows. By the time they awaken in the spring, they might have lost up to a third of their body weight.

Mammals are not the only animals that hibernate. As a pond's water temperature drops in the autumn, frogs burrow into the mud beneath the water. Buried deep enough to be safe from freezing, their bodies undergo complex physiological changes that slow their metabolism, circulation, and other processes until they are expending just enough energy to stay alive. Frogs pass the winter in deep slumber, emerging from the mud only when the temperatures of spring have risen enough for them to again thrive in the water and on land.

Canada geese



Migration routes

- **Seabirds, gulls, and terns**
- **Shore and wading birds**
- **Waterfowl**
- **Land birds and birds of prey**

Migration

An ecosystem is habitable for a species only while conditions remain within certain bounds. In the winter, many animals cannot endure the cold and snow of alpine meadows. However, as the drifts melt and plants make the most of the short growing season, deer, elk, mountain goats, and bighorn sheep in search of good grazing will move up from the shelter of the forests. With them come the predators that feed upon them—mountain lions, cougars, bobcats, and others. Vultures, ravens, magpies, and other scavengers drift higher, too, waiting to pick at the remains of the carnivores' meals.

Some animals migrate tremendous distances. Ducks and geese wing their way from summer breeding grounds in Canada and Alaska to winter havens in the southern United States, Mexico, and South America. Monarch butterflies migrate, too, as do whales, bluefish, and salmon, which swim from the ocean back to the streams where they were hatched to lay and fertilize their own eggs.

Animal Classification

Every species has traits that set it apart from all other animals. Each species also shares characteristics in common with certain others. Zoologists and biologists use those similarities and differences to organize animals into a classification system. All creatures, for example, can be divided into one of two large groups—*vertebrates,* which have backbones, and *invertebrates,* which do not. Mammals, birds, reptiles, amphibians, and fish are vertebrates. The other 95 percent of the planet's creatures, including worms, spiders, insects, and crabs, are invertebrates.

As the classification process continues, vertebrates and invertebrates are sorted into increasingly specific groups until only one kind of animal—one *species*—fits a description. The American black bear, for example, is classified this way:

Kingdom—*Animal.* There are five kingdoms: animals, plants, fungi, protists, and monerans.

Phylum—*Chordata,* which includes all animals with backbones

Class—*Mammalia,* which includes all mammals

Order—*Carnivora,* which includes carnivorous mammals

Family—*Ursidae,* which includes all bears

Genus and **Species—***Ursus americanus,* which includes only American black bears

By comparison, grizzly bears share so many similarities with American black bears that they are members of the same kingdom, phylum, class, order, family, and genus. The grizzly bear's classification is *Ursus arctos horribilis,* differentiating it from every other creature on Earth.

An animal's genus is always capitalized; the species is not. Together, genus and species are shown in *italics.*

***Grizzly bear,* Ursus arctos horribilis**

American black bear, Ursus americanus

Opossum

Elk

Dolphin

A Sampling of North American Animals

Mammals

What do a field mouse and a grizzly bear have in common? For one thing, they are both *mammals*—warm-blooded animals that have backbones, fur or hair, and mammary glands for feeding their young. More than 400 species of mammals are found in North America, many of them sharing the same landscapes where humans hike and camp.

Watch mammals closely to figure out what they are eating, how they find shelter, and the ways they defend themselves. A chipmunk, for instance, scurries among the grasses in search of nuts and seeds. When startled, it relies on speed to carry it to a safe hiding place.

Rabbits also use bursts of speed to escape predators. Powered by muscular hind legs, they scamper from danger in a zigzag course that larger animals cannot easily follow. Rabbits and mice use their smaller front legs to hold the grasses on which they feed.

Squirrels' long tails provide balance as they run along branches, and their claws allow them to grip tree bark. Like chipmunks, they can fill their cheeks with nuts and grains to stash in trees or in the ground, returning to these caches when other sources of food are scarce.

The opossum does not share the rabbit's speed. Instead of fleeing when threatened, it lies limp and still until danger has passed. Close relatives of Australia's kangaroos, opossums are *marsupials*—pouched mammals. A mother opossum carries her newborns in a pouch formed by a fold of skin on her abdomen.

When crowded too closely, the porcupine slaps its tail to drive quills into an attacker's flesh. Skunks can spray an attacker with a chemical that stings the eyes and leaves a foul, long-lasting odor. Omnivorous skunks, close relatives of weasels, feed on insects, reptiles, eggs, and small rodents.

As you hike along a stream, you might notice the stumps of trees cut by beavers. They eat the bark of smaller branches and use some of the wood for constructing and improving their dams. The pond formed behind a dam gives beavers quiet water that is deep enough for swimming and feeding. They build dome-shaped lodges from sticks and mud. Although a beaver's teeth are worn down by chewing through tree trunks, they continue to grow throughout the beaver's life.

Ponds also are home to muskrats, which use sticks to build lodges just as beavers do. The entrances are beneath the water so that the animals can slip in and out unseen, while the interior room is above water level.

Beaver dam

Beaver dams often are important to an area's natural succession. Slowed by a beaver's dam, a stream will drop its silt. The beaver pond eventually fills with silt and dries, becoming land where grasses and trees can take root.

Otters dig burrows in the banks of lakes and streams. Strong, sleek swimmers, they prey on fish. You may come upon an "otter slide" where otters have been tobogganing on their bellies down stream banks and into the water. Otters once were found throughout much of America, but they were hunted and trapped so aggressively for their fur that today they are rarely seen.

In the damp soil along a stream, tracks that look like small hands with five long fingers are the marks of a raccoon. Usually traveling at night, raccoons come to the water to feast on frogs and crayfish. Raccoons also are expert climbers, and many live in hollow trees.

Bears have a varied diet that includes berries, grubs, fish, and small animals. Black bears are good tree climbers and can be found in much of North America, weighing as much as 500 pounds. Despite their name, black bears range in color from black to light brown.

Grizzly bears grow to be much larger than black bears and require more territory in which to roam. They once ranged throughout the western United States, but the development of farms, ranches, and cities has led to severe reductions in grizzly bear populations. Most grizzlies now are concentrated in Canada, Alaska, and an ecosystem that stretches from the Grand Tetons north through Yellowstone and Glacier national parks.

Wolves have highly developed social structures and cooperative hunting strategies that can involve up to a dozen members of a pack. Feeding on small animals and on old and sickened deer, elk, and caribou, wolves help keep animal populations in check. Although wolves have been vital members of numerous food chains, they have been driven almost to extinction in much of the nation. Today many land managers are working to return wolf populations to some of our national parks.

Bobcats, mountain lions, and cougars also have suffered from humans' actions. Each must have plenty of open space in which to thrive, and each can be a tempting target for hunters. Their disappearance from America's forests is a reminder that the ways we choose to conduct ourselves in the outdoors can have a dramatic impact upon entire species.

"We're not just afraid of predators, we're transfixed by them, prone to weave stories and fables and chatter endlessly about them, because fascination creates preparedness, and preparedness, survival. In a deeply tribal sense, we love our monsters."

—E. O. Wilson, Eagle Scout, entomologist, and Pulitzer Prize–winning author

Deer live in almost every part of North America. As their names suggest, white-tailed deer can be identified by their distinctive coloration. The larger mule deer, a native of the Rocky Mountain foothills, has a white tail tipped with black and has longer ears.

Moose are the largest members of the deer family. They range through the northern forests of the United States and far into Canada. Like all deer, a moose is a *ruminant*—an animal with four stomachs for digesting grasses, leaves, and twigs.

Wapiti is an Indian name for the American elk, another large deer that makes its home mostly in the western United States. Like other members of the deer family, male elk grow antlers each year, shedding them in the autumn after the mating season.

Caribou, found in Alaska and northern Canada, are unusual deer in that both females and males grow antlers. In herds as large as several thousand, caribou migrate long distances to find food. Caribou calves are able to run soon after they are born, which helps them keep up with the herd and evade predators during migration.

Although deer can kick with their sharp hooves, most flee their enemies rather than trying to fight. Pronghorn antelope are the fastest land animals of North America, able to reach speeds of more than 60 miles an hour.

Mountain goats and bighorn sheep are surefooted enough to scale steep mountain cliffs, while American bison can be seen grazing on the lower grasslands.

Elk

Moose

Pronghorn antelope

Mountain goat

Plankton—masses of tiny organisms drifting in the water—serves as food for small sea life and also for some whale species, the largest animals on Earth. Whales strain water through their mouths, trapping food in bristled screens called *baleen.*

Plankton

Captive killer whale giving birth

Although they spend their lives in seawater, whales are mammals, not fish. They are warm-blooded and breathe with lungs rather than through gills, coming to the ocean's surface to inhale fresh air. Instead of laying eggs as fish do, whales bear their young alive and nurse them with milk.

Reptiles

Reptiles such as snakes, lizards, alligators, and turtles have backbones like mammals do, but they are cold-blooded and do not have fur. Their bodies are covered with scales or plates, and they reproduce by laying eggs. More than 300 species of reptiles are found in the United States.

Iguana

Reptiles and people have had a stormy history. Humans often look more kindly upon furry and feathered animals than they do upon cold-blooded, scaly creatures. Despite their appearances, reptiles play important roles as both predators and prey in their ecosystems.

The secret to a snake's forward motion is *lateral undulation*—the way it makes S-shaped bends with its body and then pushes against the ground. Snakes prefer to use their mobility to get away from a potential threat rather than confront it.

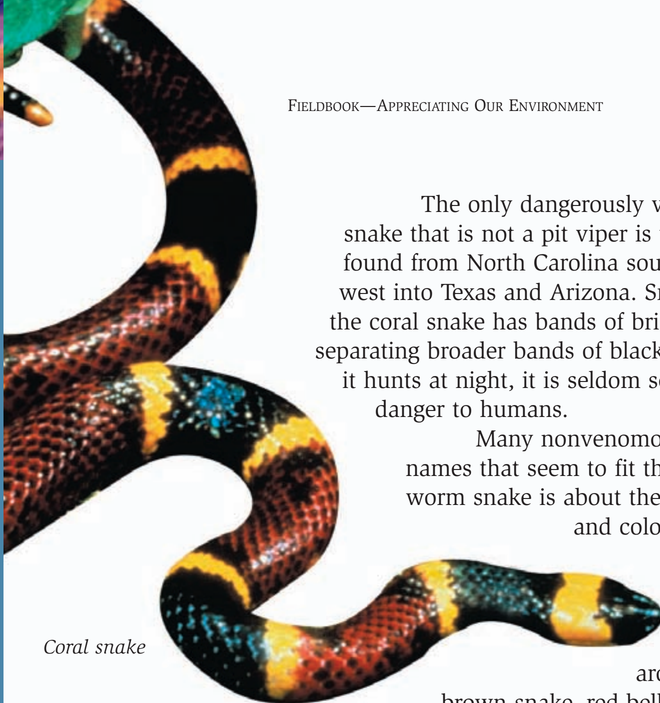
Rattlesnakes, copperheads, and cottonmouths are all pit vipers—snakes that have a distinctive pit beneath each eye that locates prey by detecting small differences in the temperatures of warm-blooded animals and their surroundings.

Perhaps the best known of venomous snakes, the rattlesnake has a tail equipped with dry rattles that sound a warning. Rattlesnakes live throughout much of the continental United States, Mexico, and some parts of Canada.

The copperhead snake can be found in woodlands and rocky outcroppings in the eastern half of the nation. You can recognize it by its copper-brown color with darker, hourglass-shaped cross bands.

Sidewinder

The cottonmouth, also known as the water moccasin, lives in streams and marshes of southern states. A chunky, muddy-brown snake, it sometimes rests in tree branches that hang low over the water. Its name comes from the cotton-white color of the inside of its mouth.



Coral snake

The only dangerously venomous American snake that is not a pit viper is the coral snake, found from North Carolina south to Florida, and west into Texas and Arizona. Small and slender, the coral snake has bands of bright yellow scales separating broader bands of black and red. Because it hunts at night, it is seldom seen and rarely a danger to humans.

Many nonvenomous snakes have names that seem to fit their appearance. The worm snake is about the same size, shape, and color as an earthworm. The ring-necked snake is black to steel gray, with a light-colored ring around its neck. The brown snake, red-bellied snake, and green snake take their names from their colors. The hognose snake, or puff adder, is named both for the shape of its head and for its habit of puffing itself up when frightened. Like all snakes, their jaws are hinged so that they can swallow prey larger than their heads.

Among the larger American snakes, the king snake eats rats, mice, and other snakes. The common king snake is black with white or yellow bands, while the bright red, yellow, and black bands of the scarlet king snake make it look much like the venomous coral snake.

The black racer of the eastern states has a smooth, black back. The coach whip snake of the South and the striped whip snake of the West are the racer's close relatives.

Bull snakes are one of the largest nonvenomous snakes in the United States. They are grayish brown with large patches on their backs. An eastern variety is often referred to as the pine snake, and a western form is called the gopher snake.

For guidelines on treating a snakebite, see the chapter titled "Managing Risk."

Lizards share many similarities with snakes, but they differ by having legs, moveable eyelids, and small ear openings on their heads. Many lizards make their homes in arid regions. The thick, rough skin of the horned lizard protects it from its enemies and helps it conserve moisture. Collared lizards and swifts are desert dwellers, whose speed and long, slender tails set them apart from their sluggish neighbor, the Gila monster. Covered with raised round scales that look like beadwork, the Gila monster is America's only venomous lizard.

Gila monster

A turtle's shell, composed of hard scales attached to a cagelike skeleton, encloses the animal's vital organs and protects its head, legs, and tail. Some turtles spend most of their lives on dry land, while others dwell in ponds, streams, and marshes. A few thrive in the open sea.

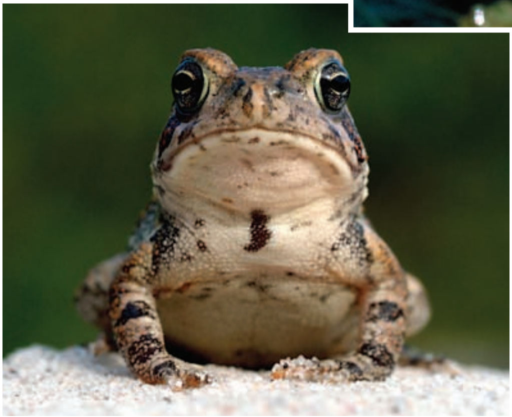
Turtles have no teeth, but the edges of their jaws are tough enough for them to feed on insects, snails, and small aquatic animals. The snapping turtle settles to the bottom of a pond and lies with its mouth open. A worm-like appendage on the floor of its mouth lures fish close enough for the turtle to catch them.

Amphibians

Frogs, toads, newts, and salamanders are all amphibians, and about 4,000 species of amphibians can be found worldwide. The name *amphibian* comes from two Greek words—*amphi,* meaning "both," and *bios,* meaning "life." After hatching from eggs laid in the water, most amphibians live in the water as *tadpoles,* swimming and eating a vegetarian diet. As they mature, they develop legs and begin spending some of their time on land where they feed on plant and animal matter. Frogs and toads lose their tadpole tails by the time they become adults, while salamanders keep theirs.

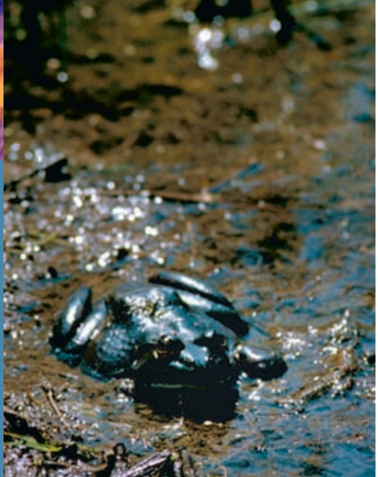
Frogs and toads look a lot alike, but frogs' skin is moist and smooth while toads' skin is bumpy and dry. Frogs and toads use their powerful hind legs to propel themselves over the land and through the water.

Frog



Toad

Toads are less mobile than frogs because of their shorter legs and heavier bodies, but as a defense, some toads can secrete a poison that irritates their predators' eyes and mouths.

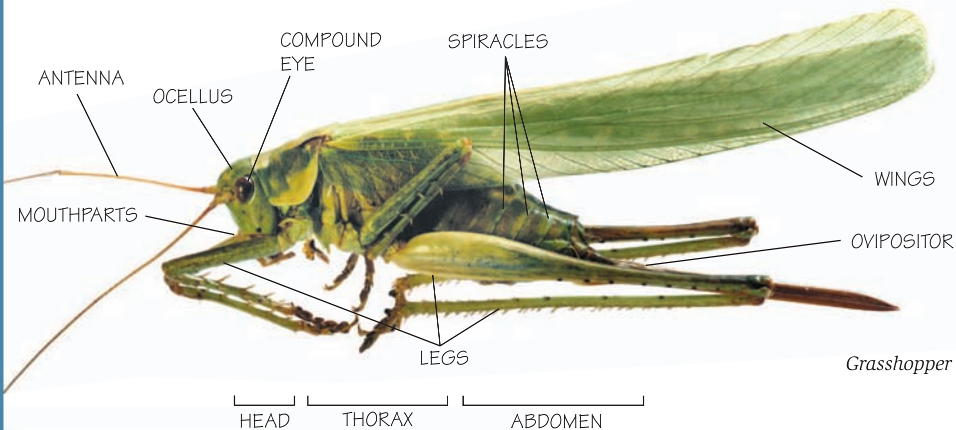


Bullfrog

The croaking you hear near a pond may be a bullfrog, the largest American frog. Seldom away from water, it eats insects, spiders, snails, and crayfish, and is the prey of snakes, birds, and many mammals.

Spring peepers and tree frogs have sticky pads on their toes that allow them to hang onto branches and leaves. Some tropical tree frogs lay their eggs in pockets of water in tree knots, and the tadpoles that hatch then mature high above the ground.

Adult salamanders live both in and out of water. While the bodies of salamanders and newts resemble that of a lizard, salamanders and newts have smooth, naked skin—not scales.



Grasshopper

Spiders are sometimes confused with insects, but they are *arachnids*—animals with eight legs and two body parts.

Insects

In terms of sheer numbers, insects rule the world. Five out of six animals are insects. Some insect species fly, some swim, and some scurry across the ground. They eat everything from leaves and flower nectar to blood, dead animals, and each other. Many display brilliant hues, while others are drab in color and are shaped like dried leaves or twigs. All insects have six legs and a body with three sections—head, abdomen, and thorax.

Tarantula

Butterflies and moths have four broad wings covered with scales so tiny they appear to be fine dust. At rest, butterflies tend to hold their wings upright, while moths keep theirs flat or curled around their bodies. Butterfly antennae are shaped like tiny clubs; those of moths look more like feathers.

Irregular color patterns on moths' and butterflies' wings can play tricks on their predators' eyes, making the insects harder to see. For example, wing spots that look like eyes might cause birds to perceive these insects as much larger animals that should be left alone.

Polyphemus moth

Many species of ants, bees, and wasps live in nests or hives. As a community member, each insect carries out duties that help feed, defend, and maintain its home. Some ants look after tiny insects called *aphids.* When stroked on the back, the aphids produce a sweet liquid that the ants feed to their own larvae. Other ants are farmers, preparing soil in their nests and raising small fungi for food. Some species of wasps feed on insects. Bees collecting nectar for honey aid in plant fertilization by scattering pollen among the flower blossoms.

Forty percent of all insects are beetles. Ranging in size from the 1/4-inch-long snout beetle to the stag beetle which, with its great pincers, can be several inches long, beetles are distinguished from other insects by having two pairs of wings—a back pair used for flying and a protective front pair covering the abdomen.

Stag beetle

The ladybug is a very beneficial beetle able to eat many times its own weight in other insects. Many other beetles are scavengers that devour dead plants and animals, helping to continue the energy cycle.

The firefly is one unusual beetle. A chemical reaction in an organ near its tail creates a glowing light, allowing it to flash signals into the darkness as part of the mating ritual.

Flies and mosquitoes each have just two wings. The mosquito has a long *proboscis* that can pierce a mammal's skin and draw blood. The fly's mouthparts are like a sponge made for lapping up liquids. Mosquitoes lay their eggs in still water, while

Grasshopper

flies often leave their eggs in dead and decaying matter. While important to ecosystems, flies and mosquitoes can carry diseases harmful to humans.

Grasshoppers, crickets, and their relatives are among the musicians of the insect world. Grasshoppers click and whir when they fly, and sometimes they make a raspy sound by stroking their wing covers with their hind legs. Male katydids rub their front wings together to produce a rhythmic buzzing. Cicadas do the same by vibrating a timbrel organ in their abdomens.

Cicada nymphs hatch from eggs laid in trees. The young insects burrow into the ground and suck sap from roots, staying buried for up to 17 years. When they do come back out they crawl up trees, shed their old shells, and emerge as full-grown adults ready to lay eggs and keep the cycle going.

Many people call all insects *bugs,* but true bugs form a definite group. Like a beetle, each bug has four wings, the front pair serving as a shell over the abdomen and flight wings. Where a beetle's shell halves form a straight line down its back, though, those of a bug fold into an X shape. All true bugs also have mouthparts made for sucking.

One member of the bug group is the spittlebug, the larvae of which hide in frothy spittle they hang on plant stalks. The water strider is a bug that hurries along the surface of the water, as do the back swimmer and the water boatman.

Elephant beetle

Water strider

Fish

Fossil evidence suggests that fish were thriving in Earth's oceans before animals with backbones walked on land. Fish have endured for so many eons because they are well-suited to their environment. With more than 30,000 kinds of fish alive today, they also are the most numerous vertebrates. You can find them in nearly every body of water except for very salty, alkaline waters such as that in Utah's Great Salt Lake, or in water that has become badly polluted.

Rather than lungs, fish have gills through which they absorb oxygen from the water. Inside the fish is an air-filled organ called a *swim bladder* that provides buoyancy. Fins help the fish stay upright, move forward, turn, and stop. The long, sleek shapes of many fish allow them to swim fast enough to catch their prey and to escape being devoured themselves.

A fish's many sense organs help it find food, escape predators, and locate mates. Most fish can see, smell, hear, taste, and feel, and they use sensory organs running the length of their bodies to pick up vibrations in the water.

Many fish rely on coloration for protection. Perch, bluegills, and other fish that live among underwater plants sport a camouflage of stripes. Catfish and other bottom-dwellers might be colored so much like a streambed that, when lying motionless, they seem almost to disappear.

Catfish

Catfish have mouths designed for vacuuming food from the bottoms of rivers and lakes, and long, whiskerlike organs on their faces for feeling their way through murky waters. Thin, sharp, flesh-tearing teeth allow muskellunge, pike, and barracuda to feed on other fish. Trout, crappie, and similar fish with a diet of insects can get along with less fearsome teeth.

Frigate birds on Johnson Island in the Pacific Ocean

Birds

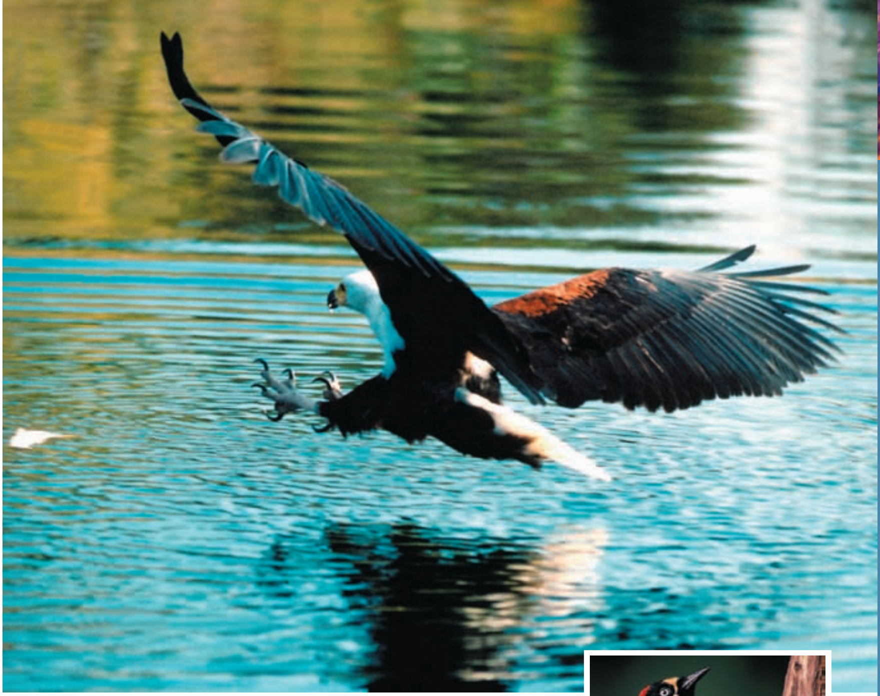
Today there are more than 9,000 species of birds spanning nearly the entire globe. Birds are differentiated from other warm-blooded animals by the fact that they have feathers.

Contour feathers make up the visible plumage that gives a bird its shape. Down feathers next to the skin provide insulation to keep a bird warm.

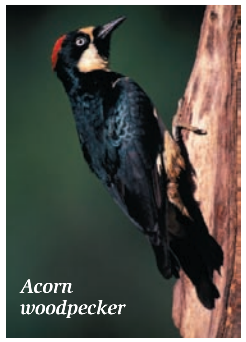
All birds lay eggs, but the different species are as unique as those of any other animal class. Some birds swim, some spend their lives walking on land, and some rarely come down from the sky. Diets, reproductive strategies, and migratory habits also can help define bird species.

Birds that fly have thin, strong, lightweight bones. Their wing shapes help determine how they maneuver in the air. The hummingbird's small, short wings enable it to hover and move both backward and forward. Soaring birds have broader wings to catch updrafts so they can hang in the sky with little motion. With pointed wings, peregrine falcons are able to dive faster than a hundred miles an hour and maneuver quickly to attack airborne prey.

Small birds must eat often. Hummingbirds expend so much energy that they are engaged in feeding activities much of the day and might be so weakened after a night without nourishment that they need the help of the sun to warm them enough to fly. Larger birds can go longer between meals but still are almost constantly in search of food for themselves and their offspring.



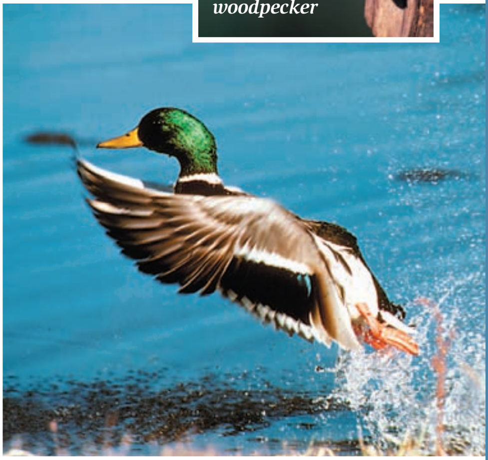
Bald eagle



Acorn woodpecker

The bills of birds offer clues as to their diets. Woodpeckers have beaks that can be used as chisels. Birds that eat seeds and nuts have short, thick beaks and powerful jaw muscles, while those eating grasses and water plants have wider bills adapted to foliage. Some shorebirds use their long, slender bills to probe the waters for small fish, and other fish-eating birds have sharp, hooked beaks.

The legs and feet of birds are other indicators of diets and mobility. Waterfowl have webbed feet that are perfect for swimming, and the talons of raptors are just right for grasping prey. Birds that perch tend to have long toes and short legs, while those that walk on the ground have both long legs and toes. Penguins and other cold-water birds have short legs and compact feet that are adapted for keeping them warm and helping to steer.



Mallard drake

Birds are not the first animals to have flown, nor are they the only flying creatures today. Paleontologists have found evidence of *pterosaurs*—prehistoric winged reptiles. The *archaeopteryx* had feathers rather than scales, so it is considered the first true bird.

Oil spills can be disastrous to all kinds of wildlife.

Wildlife Protection

Ecosystem changes cause animals to adapt to new conditions, migrate to more hospitable locations, or suffer reductions in population. Fires moving across woodlands and prairies alter the habitats of many creatures. An early winter storm might catch many animals unprepared for migration or hibernation. Floods can wash away beaver dams and fish spawning grounds. Drought can reduce food for grazing animals and, in turn, for species that depend on those animals for food. While natural changes affect many animals, they often are important to maintaining a healthy balance of wildlife populations. Unfortunately, the same cannot always be said for the disruptions caused by humans.

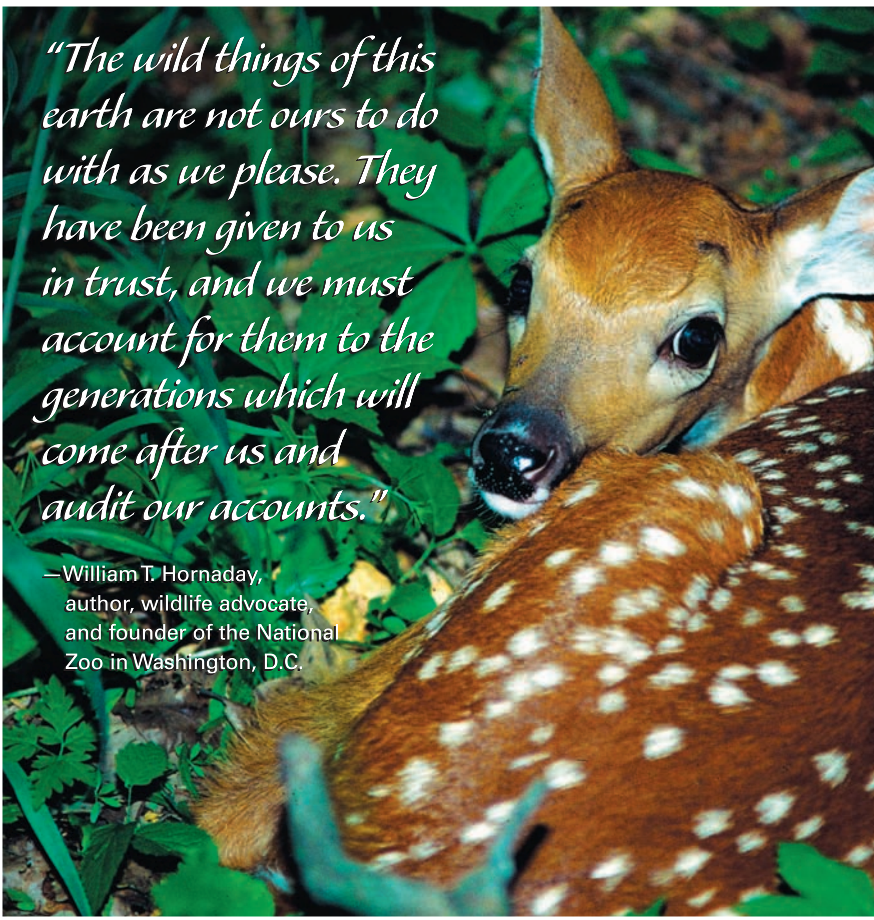
In the past, overhunting has severely reduced the numbers of many species. The passenger pigeon, a magnificent bird once thriving in the eastern United States, was hunted to extinction, and the bison of the Great Plains almost disappeared from the planet. Laws now protect endangered species, but an even greater threat to the survival of wild animals is the destruction of their habitats. Water pollution upsets entire ecosystems and lessens the carrying capacity of lakes and streams. Industrial and power plant smokestack emissions can cause rain to become acidic enough to harm vegetation and pollute water even miles away. Crop pesticides kill beneficial insects as well as those considered pests. Chemicals introduced into the environment cause some birds' eggs to become so thin that they break before the chicks are ready to hatch.

Humans' economic interests often are based on expansion and development. We transform native prairie into cropland. Our cities push into undeveloped areas, covering them with pavement and seeded lawns. Forests fall to the logger's saw. Dams and irrigation projects flood areas that once were arid and dry out those that were wet. All of these changes present wildlife with increasingly difficult challenges to their continued existence.

Fortunately, generations of Americans have had the wisdom to protect vast tracts of unspoiled land in parks, wilderness areas, forests, and wildlife habitats. As individuals come to realize the effects human actions can have on the environment, many people have adjusted their lifestyles to improve waste disposal processes, city maintenance, and land management.

Humans must adapt to change just as other animals do, including seeing with new wisdom the importance of wildlife, and then deciding to live in harmony with the environment and its animals.

For more on the role of change in ecosystems, see the chapter titled "Understanding Nature." For more on improving wildlife habitat, see the chapter titled "Being Good Stewards of Our Resources."



Chapter 33

Watching the Night Sky

"Many people tend to postpone their enjoyment of the stars because they are constantly with us, but . . . once you come to know [the stars], they never lose their appeal."

—Helen Hogg (A distinguished 20th-century Canadian astronomer, she helped popularize star study for young people.)

The view of space from planet Earth is an endlessly intriguing panorama of darkness and light, a vision shared through the ages with all of humanity.

One of the great pleasures of camping out and hiking at night is looking into the heavens. Undimmed by the lights of cities, the sky blazes with stars. Constellations parade overhead and the Milky Way forms a shimmering ribbon against the darkness. Travelers in northern latitudes sometimes watch the aurora borealis draping the sky with shadowy, luminous curtains. Watch for a while and you might see a meteor streaking through the darkness.

At first glance the night sky might seem to hold a random scattering of brilliant points of light. Look more carefully, though, and you will notice that some stars are brighter than others. Night after night, they appear in almost the same places. There is order to their locations, and by learning about that order, you will have an effective method for finding directions after sunset. You also can more fully appreciate the legacy of star study that has come down to us through the ages, for the night sky has been a subject of curiosity and fascination since the beginning of time.

Observing the Night

Make the most of watching the night sky by choosing good times and places. Of course, you won't be able to view the stars when they are obscured by clouds, fog, or mist. The brilliance of a full moon washes light across the sky. Lunar craters are most visible during lunar eclipses, which limit the intensity of light. Star fields over urban areas can be dimmed by light pollution—the glow created by streetlights, illuminated parking lots, and other sources of artificial lighting. At best, you will be lucky to make out a couple of hundred stars. Get away from cities, though, and the number of visible stars crowding the heavens can rise into the thousands.

Human vision can adapt well to darkness, but it might require up to 30 minutes to adjust fully. Your pupils will expand to capture more light, and the amount of light-sensitive pigment in your retinas will increase, allowing you to observe much more in the night sky. Your eyes can quickly lose their adaptation if they are exposed to bright white light such as that from a lantern or flashlight. If you want to illuminate a star map or find your way through the darkness, cover the lens of your flashlight with red cellophane held in place with a rubber band.

Good binoculars can take you much deeper into the universe than with eyes unassisted, revealing wonders ranging from moon craters to the colors of planets and shapes of nebulae. Telescopes, too, can increase your understanding and enjoyment of nights spent studying the heavens.

For more on binoculars, see the chapter titled "Observing Nature."

Fascinating shapes in space, such as the Eagle Nebula depicted here, can be an artist's inspiration.

What's Out There

The universe teems with nebulae, stars, galaxies, planets, moons, meteors, novas, pulsars, quasars, black holes, and many forms of matter and energy we are just beginning to understand. From space stations and communications satellites to bits of metal debris, objects created by humans also are visible as they orbit through the night. Among the most interesting of the natural phenomena are nebulae, the birthplaces of stars.

Nebulae

The largest known objects in the skies are great swirls of dust and gas called *nebulae,* taking their name from the Latin word for mist or cloud. As materials composing a nebula compress, stars are born. Many nebulae emit no light of their own, but starlight sometimes illuminates them. Others shine on their own as they condense and become superheated. From the Earth, nebulae visible to the naked eye have an appearance similar to that of stars. With binoculars or a telescope, however, they can emerge from the background of space in spectacular displays of color and shape.

Stars

Stars are gigantic thermonuclear reactors adrift in the heavens. Most are much larger than our sun, the star we know the best. Beyond the sun, even the closest stars are many light-years away. (A light-year is the distance that light will travel in a calendar year. At 186,000 miles a second, that's 5,865,696,000,000 miles a year—almost six trillion miles.)

Stars are ranked according to *magnitude*—their brightness relative to one another. The North Star, for example, is the 46th brightest star in the sky, outshone by Sirius, a first-magnitude blue giant and the brightest star visible from Earth. The color of stars indicates their temperatures, with blue burning hottest, followed by white, yellow, orange, and red. Other than the moon, the brightest nonstellar objects in the night sky are the planets Mars, Venus, Jupiter, and Saturn. Between 200 and 300 stars visible on a dark night have names. The names of most stars can be traced to antiquity, coming from Latin, Greek, and Arab language roots. Polaris, for example, the true name of the North Star, is a Latin term for "pole star." Sirius is a Greek word that means "scorching."

Scintillate, Scintillate, Little Star . . .

Rather than shining with a steady glow, stars appear to twinkle. That's because the light coming from them is distorted by turbulence in the Earth's atmosphere. Dust, heat, smoke, and smog all play roles in causing starlight to scintillate—another word for twinkle.

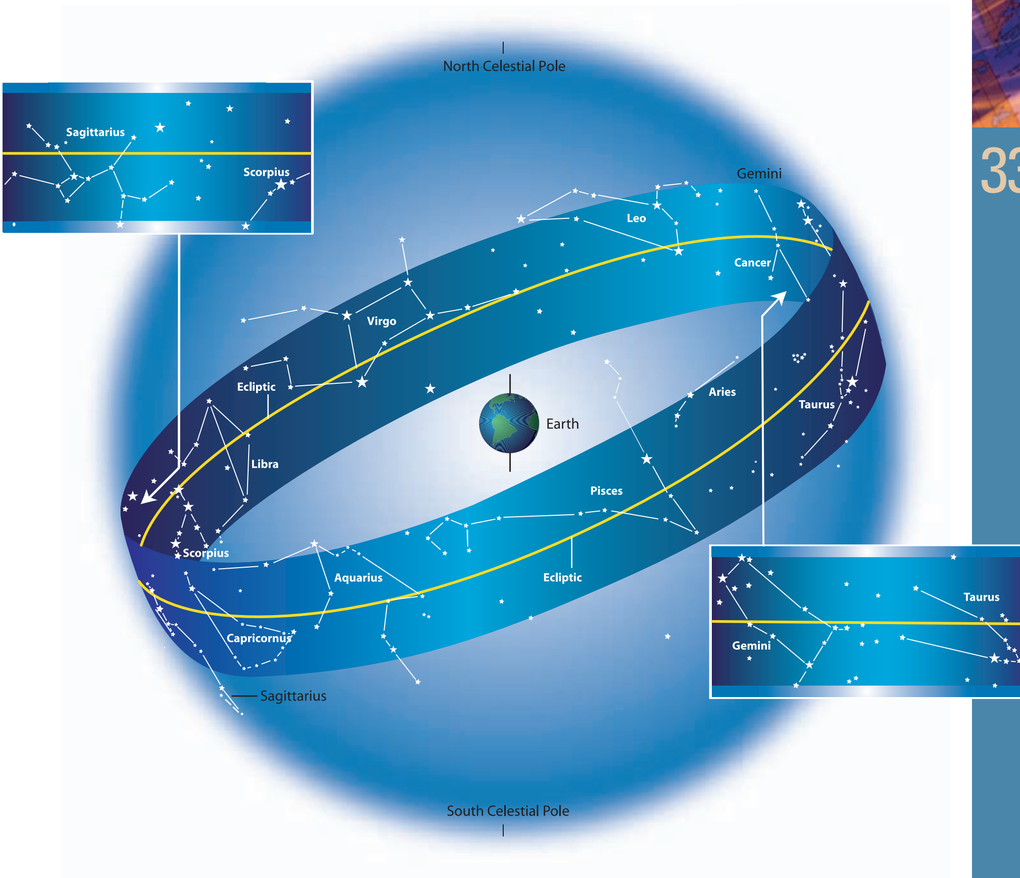
The Hubble Space Telescope's orbit high above the Earth removes it from atmospheric disturbances and allows it to produce crisp, twinkle-free images from the depths of space.

Galaxies

Many points of light we see in the sky are galaxies, great collections of stars and nebulae. Evidence from the Hubble Space Telescope suggests there might be at least 50 billion galaxies. Some are elliptical galaxies without defined shape. Others are spirals. Our solar system is part of a spiral-shaped galaxy called the Milky Way, which is composed of several hundred billion stars. It is gorgeous to the naked eye, especially on summer evenings. Seen through binoculars, it explodes with stars, nebulae, and, beyond the Milky Way, countless other galaxies. Train your binoculars on the area of sky just above the spout of the teapot-shaped constellation Sagittarius, and you will be looking into the radiant heart of our galaxy.

"What is inconceivable about the universe is that it should be at all conceivable."

—Albert Einstein, Nobel Prize–winning physicist



The Constellations

For thousands of years, people gazing at the stars have imagined them forming the shapes of people, animals, and items important to their cultures. Many of the names they gave these connect-the-dot shapes, or constellations, are with us today. Just as the starlight we see coming from stars is an echo of the stellar past, our understanding of constellations represents some of our oldest continuous knowledge, a mix of human history, lore, and belief reaching deep into the mists of time.

The word constellation comes from *con,* meaning "together," and *stella,* meaning "star." The constellations we most often identify today were formally acknowledged in 1929 by the International Astronomical Union (IAU) as a step in standardizing the mapping of the night sky. In all, 88 recognized constellations cover the heavens, with no star appearing in more than one constellation. There are 48 constellations in the southern sky and 28 in the northern sky. Another dozen constellations can be found along or near the ecliptic—the celestial pathway apparently taken across the sky by the sun, the moon, and the planets. (In fact, it is the rotation of the Earth that causes heavenly bodies to appear to move.) The 12 constellations found along the ecliptic are also known as the signs of the zodiac.

The celestial locations of constellations are determined by the time of the year and by an observer's position on the globe. Eighteen of the 88 recognized constellations cannot be viewed from the continental United States. Someone in South America, however, could see those constellations, but might not be able to view the Big Dipper or the North Star.

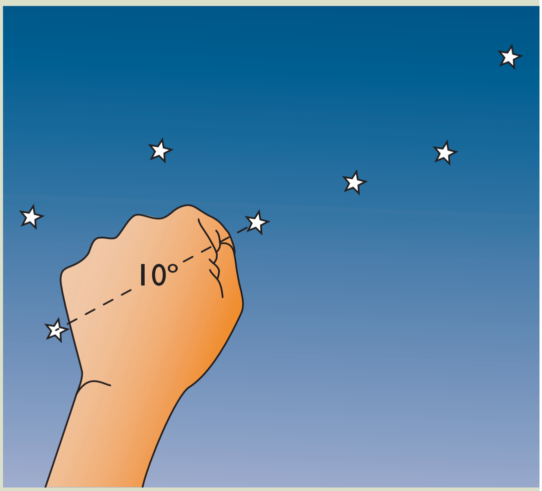
Navigating the Heavens

When giving someone directions for traveling overland to a certain location, you might use landmarks as references. "Go two miles down the Wabash Trace to the Nishnabotna River," you might say. "Waubonsie campsite is a half mile farther by the big oak tree on the left side of the trail."

You can navigate your way around the heavens that way, too, but instead of rivers, trails, and trees for landmarks, use a few easy-to-find constellations as skymarks to guide your eye to destinations overhead. Two of the most recognizable and useful constellations are the Big Dipper and Orion.

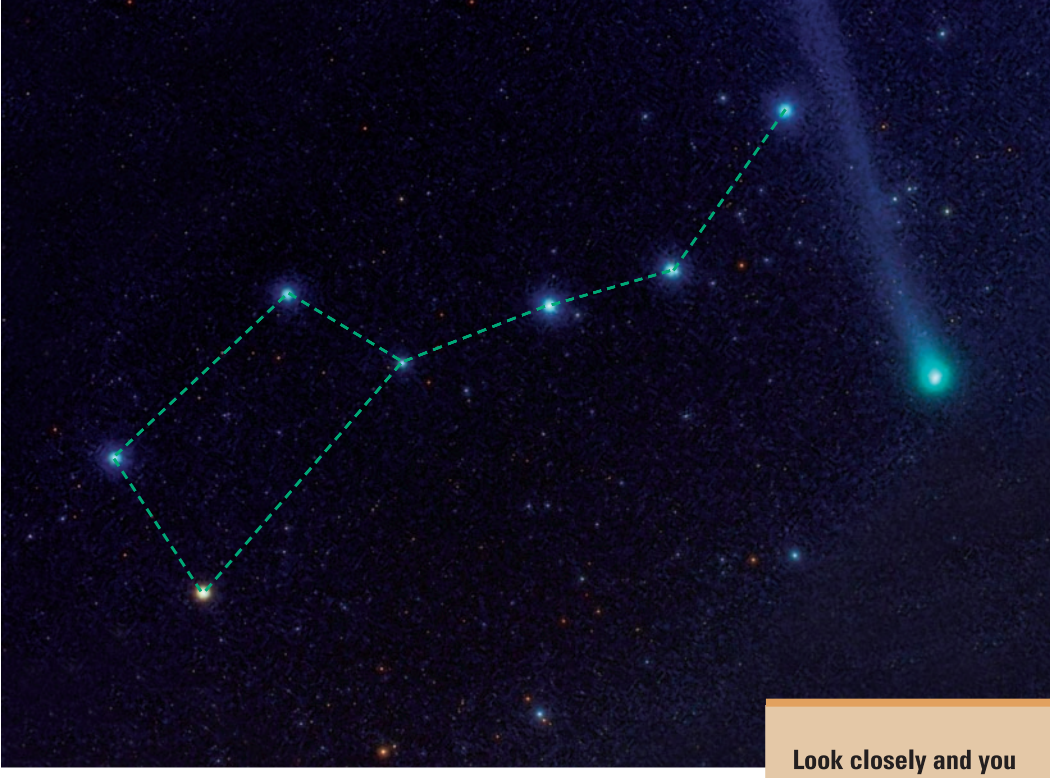
The 10-Degree Fist

Astronomers map the heavens with a grid of coordinates much like terrestrial measurements of latitude and longitude. An arc drawn across the sky from the eastern horizon to the western (or from the southern to the northern) encompasses 180 degrees—half of a complete circle. The measurement of that arc from the horizon to a point directly overhead is 90 degrees. The highest point directly overhead is known as the *zenith.*



A convenient way to measure celestial distances in degrees is to extend your arm and then sight over your hand. Viewed against the sky, your little finger represents a width of about 1 degree. Three fingers held up as if in a Scout sign are about 5 degrees in width, and your fist has a relative width of about 10 degrees. Measure 15 degrees in the sky by spreading apart your index and little fingers, and 25 degrees with the span from the tip of your little finger to the tip of your thumb.

Try a few measurements to get the idea. For example, the stars forming the rim of the Big Dipper's cup are 10 degrees apart. Viewed at arm's length, your fist should just fit between them. The width of the Big Dipper is 25 degrees; that's about two and a half fist widths, or about as wide as the span from the tip of your little finger to the tip of your thumb. The 90-degree arc from the horizon to the zenith (the point directly above an observer) can be measured with nine fist widths stacked one atop the next.



Comet Hyakutake, shown to the right of the Big Dipper, had a close encounter with Earth in 1996, when it passed within 9.3 million miles of the planet.

Look closely and you might see that the middle star of the Big Dipper's handle actually is two stars. Ancient Arab astronomers called them Mizar and Alcor. Some American Indians thought of the larger star as a horse, the smaller as its rider.

The Big Dipper

Perhaps the most familiar of all star patterns seen from North America is Ursa Major, which contains the Big Dipper. On spring and summer evenings it seems to fill the northern sky. Depending on your latitude, it might maintain its dominance in the winter heavens, too, or might disappear in part or in whole beyond the northern horizon.

Legend holds that Ursa Major, the mythical big bear, is guarding the northern territories. The state flag of Alaska features the Big Dipper, showing it along with the North Star.

A skill practiced by generations of Scouts is the ability to use the Big Dipper to find the North Star:

> To find the North Star, train your eyes on the pointer stars of the Big Dipper—the two stars farthest from the handle. Imagine a line connecting them and extending upward to a point about five times the span between the two pointers. You should see the North Star at that point. The Earth's North Pole lies directly under the North Star.
>
> —*The Boy Scout Handbook,* 11th edition, Boy Scouts of America, 1999

Northern sky

Like the sun and moon, most stars seem to move from east to west across the sky, an illusion caused by the fact that the Earth is rotating in the opposite direction beneath them. Because it is aligned with the Earth's axis, the North Star does not appear to move at all. Watch through the night and you will see Cassiopeia and the Big Dipper rotating around the northern sky with the North Star apparently motionless between them.

In astronomical measurements, the North Star can be found 28 degrees from the closest star of the Big Dipper. Use your hand at arm's length to estimate that distance across the sky. (Not only is it the North Star, it also is the last star in the handle of the Little Dipper, a portion of the constellation Ursa Minor, or the Little Bear. The cup of the Little Dipper appears to be pouring into the Big Dipper's bowl.)

With the Big Dipper as a primary skymark, similar degree measurements can lead you to other stars and constellations spangled across the northern skies:

1. Follow the arc of the Big Dipper's handle 30 degrees across the sky to the first-magnitude star Arcturus in the constellation Boötes (the bear driver).
2. Continue along the same arc another 30 degrees to Spica, a star almost as bright as Arcturus and a primary feature in the zodiac constellation Virgo (the virgin).
3. Return to the Big Dipper and trace the line through its pointer stars to the North Star. Extend the line almost the same distance again to reach Cassiopeia (named for an ancient Ethiopian queen), a constellation shaped like the letter W with its top opening toward Polaris and the Dippers.
4. Punch a hole in the ladle of the Big Dipper and go straight down to Regulus, which is also Leo the Lion's front paw.

Orion and the Southern Skies

A winter constellation south of the ecliptic is Orion, known in Greek mythology as the Great Hunter. Two bright stars mark his shoulders. Three small ones form his head and two more his legs. There are three stars in Orion's belt; the three stars hanging from the belt are his sword.

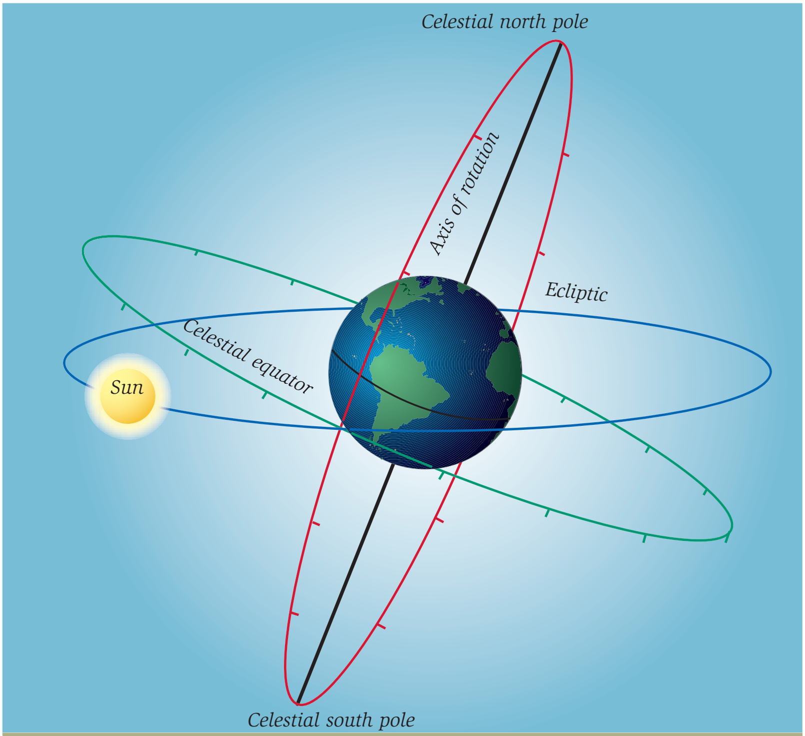
Orion is a constellation composed of wonders. Betelgeuse (pronounced *beetle-juice*), a first-magnitude red giant star emitting 60,000 times more light than our sun, forms the hunter's upper shoulder. Rigel, burning with white light and the brightest of Orion's stars, marks one of the feet. At the middle of the sword is the Orion Nebula—stellar dust and gasses compressing to form new stars. With a pair of binoculars you can begin to unlock the nebula's secrets.

As a skymark, Orion is unparalleled for locating constellations and stars in the winter. Facing south, extend a line to your left through Orion's belt, and at a distance of 20 degrees you will come to Sirius situated in the head of the constellation Canis Major, the Great Dog. Follow the line from the belt 20 degrees to the right of Orion to the first-magnitude red giant star Aldebaran, the eye in the V-shaped head of the constellation Taurus, the Bull. Stay the course for another 15 degrees past Taurus to a tight, faint

Southern sky

cluster of stars called the Pleiades, or Seven Sisters. With good eyesight you might make out six of them. Through binoculars, you might discover that the Pleiades actually are several hundred stars.

With the Big Dipper and Orion as your initial skymarks, you will be well on your way to becoming familiar with many of the features of the night sky. In seasons when those constellations are not visible or are partially obscured by the horizon, use other constellations as skymarks, especially Cassiopeia in the northern heavens and Scorpius in the southern. The star maps in this chapter can help you determine directions and distances in degrees for identifying constellations and stars relative to skymarks you already know.

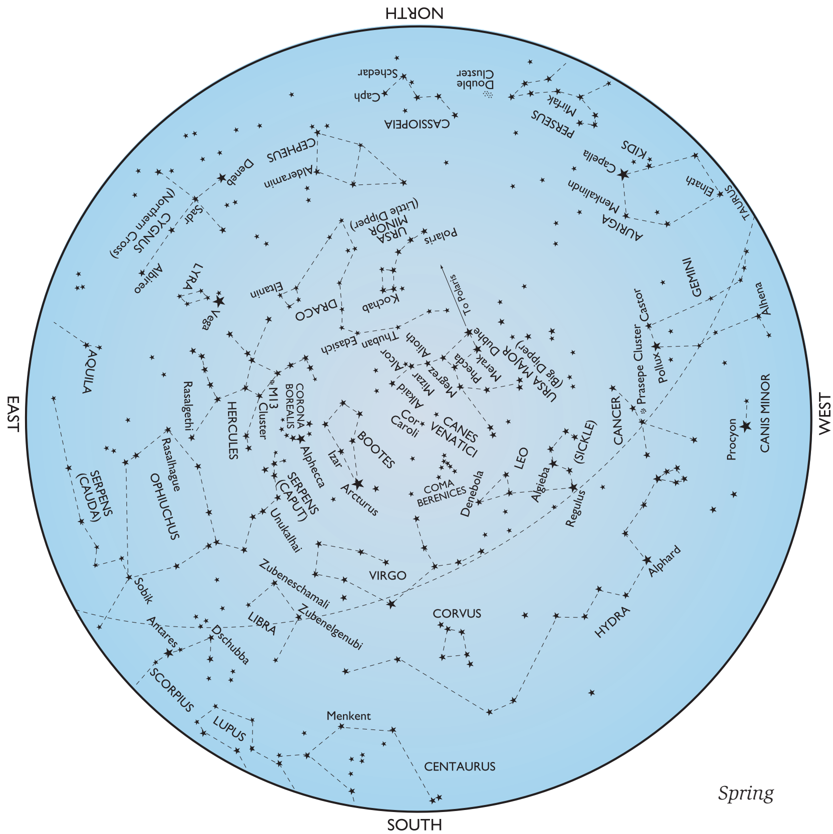


Mapping the Sky

Just as every spot on Earth can be mapped with degrees, minutes, and seconds that form a global grid of longitude and latitude, celestial coordinates are a means astronomers use to pinpoint the locations of objects in the sky.

Imagine yourself in the center of a round birdcage. The bars of the cage encircle you in the same manner that the lines of a sky map encircle you as you look up toward the heavens. The key terms of a sky map include these:

- Right ascension is similar to longitude on a map of the Earth. As with longitude, measurements of right ascension can be noted in degrees. Right ascension also can be measured in hours, minutes, and seconds, based on the fact that every 60 minutes the stars appear to move across an arc of about 15 degrees.
- Declination is similar to latitude on a ground map. Just as latitude measures the distance north or south of the Earth's equator to a point on the ground, declination measures the distance north or south of the celestial equator to a point in the sky.
- The celestial equator, located directly above the Earth's equator, bisects star maps and separates constellations into those of the northern sky and those of the southern.
- The *ecliptic* is the apparent path taken across the sky by the sun, the moon, the planets, and the 12 constellations of the zodiac.



Spring

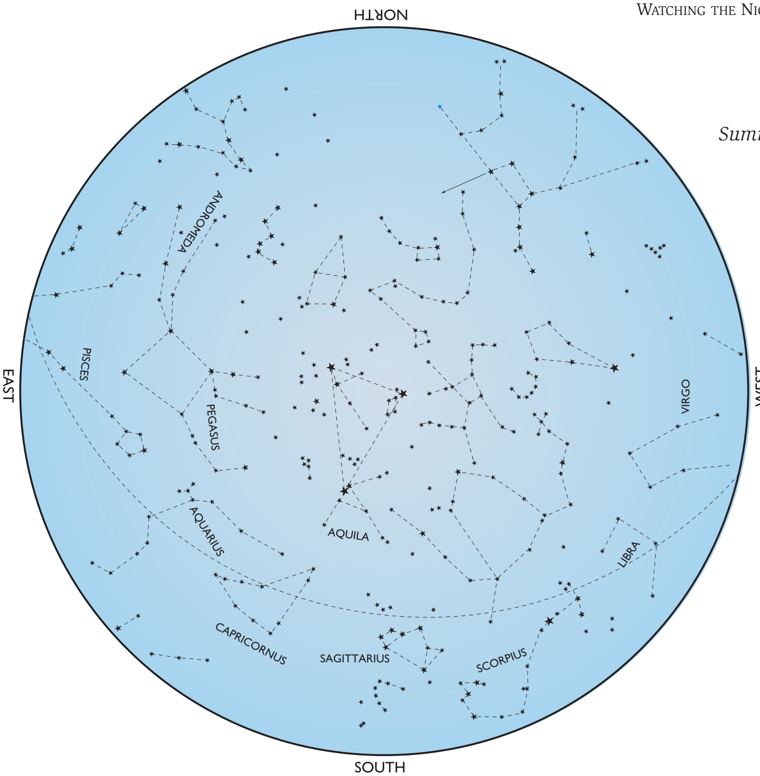
Star Maps

The angle of the Earth's axis in relation to its orbit around the sun creates the seasons, extends the hours of summer daylight, and shortens our winter days.

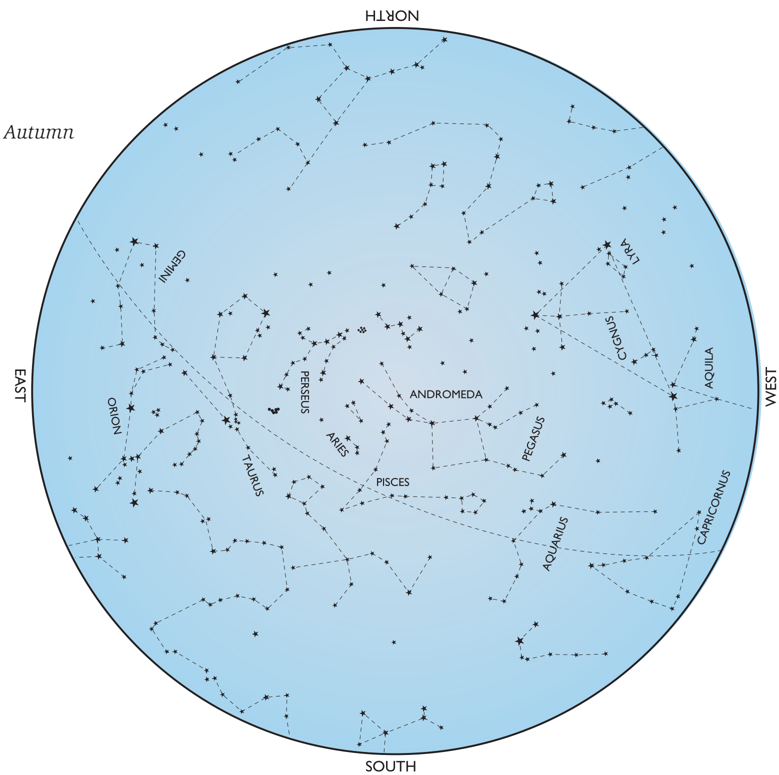
The rotation of the Earth creates the illusion that the stars we are seeing wheel across the night sky. Likewise, the annual progression of the Earth around the sun affects which stars we can observe on a given night, for we are always looking out from the dark side of the Earth—the side away from the sun. That puts us in position to view the heavens in one direction on summer nights and in the opposite direction on a winter's evening. Some constellations can't be seen at all during certain seasons, as they rise at midday and their light is obscured by sunlight. Orion is one that dominates the sky in the winter but is invisible throughout the summer.

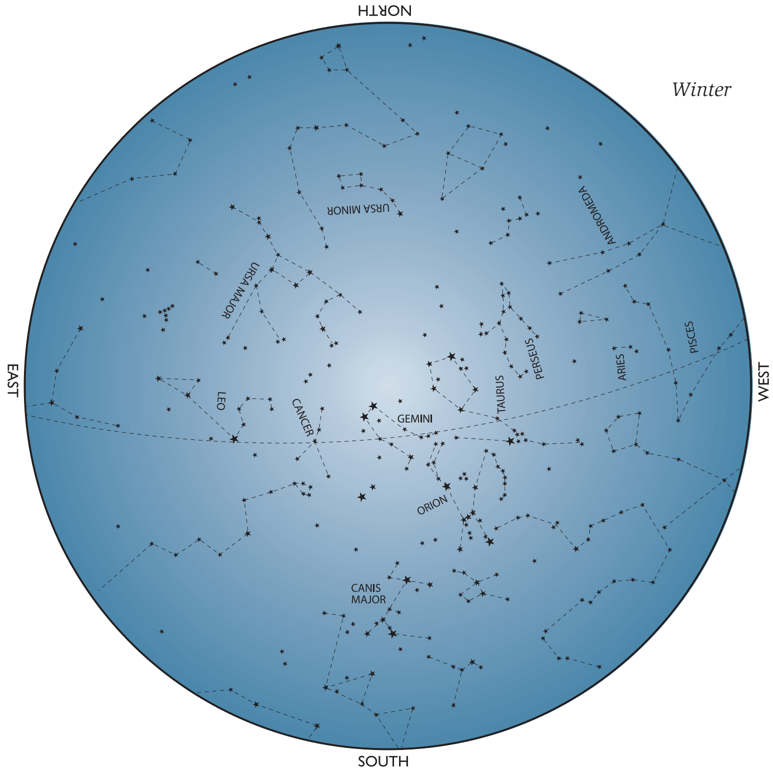
To accommodate these variations in location and time, constellation maps give the dates and hours when they best represent what you will see in the sky. The maps in the *Fieldbook* assume a viewer is in the Northern Hemisphere and is viewing the heavens between 9 P.M. and midnight.

Summer



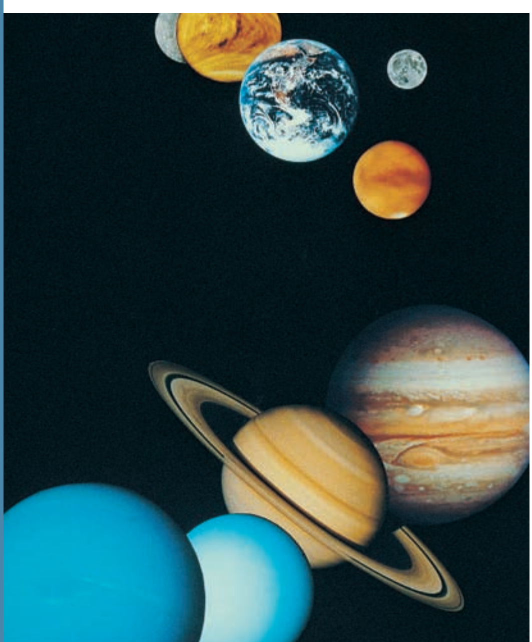
Autumn





The Planets

From earliest times, star watchers have noticed that five particular points of light did not behave like all the others. Rather than holding their positions in constellations, these five moved about among the stars. The ancient Greeks called them wanderers.



Today we know that these wanderers are planets that, like the Earth, revolve around the sun. Those visible with the naked eye are Mercury, Venus, Mars, Jupiter, and Saturn. All look like bright stars except Mercury, which, as the closest to the sun, makes faint appearances near the western horizon just after sunset. The remaining planets—Uranus, Neptune, and Pluto—can be seen only with the aid of a telescope. A small telescope enables you to view Saturn's rings, Jupiter's red spot (a giant storm), and the moons of other planets.

The Moon

Other than the sun, no heavenly body has more impact on Scout outings than the moon. Revolving around the Earth once in about 28 days, the moon waxes as more of its surface is lit by the sun, and wanes as less of its surface is lit by the sun. (If the right side of the moon, as you face it, is reflecting light, the moon is waxing. When the right side is dark, the moon is waning.)

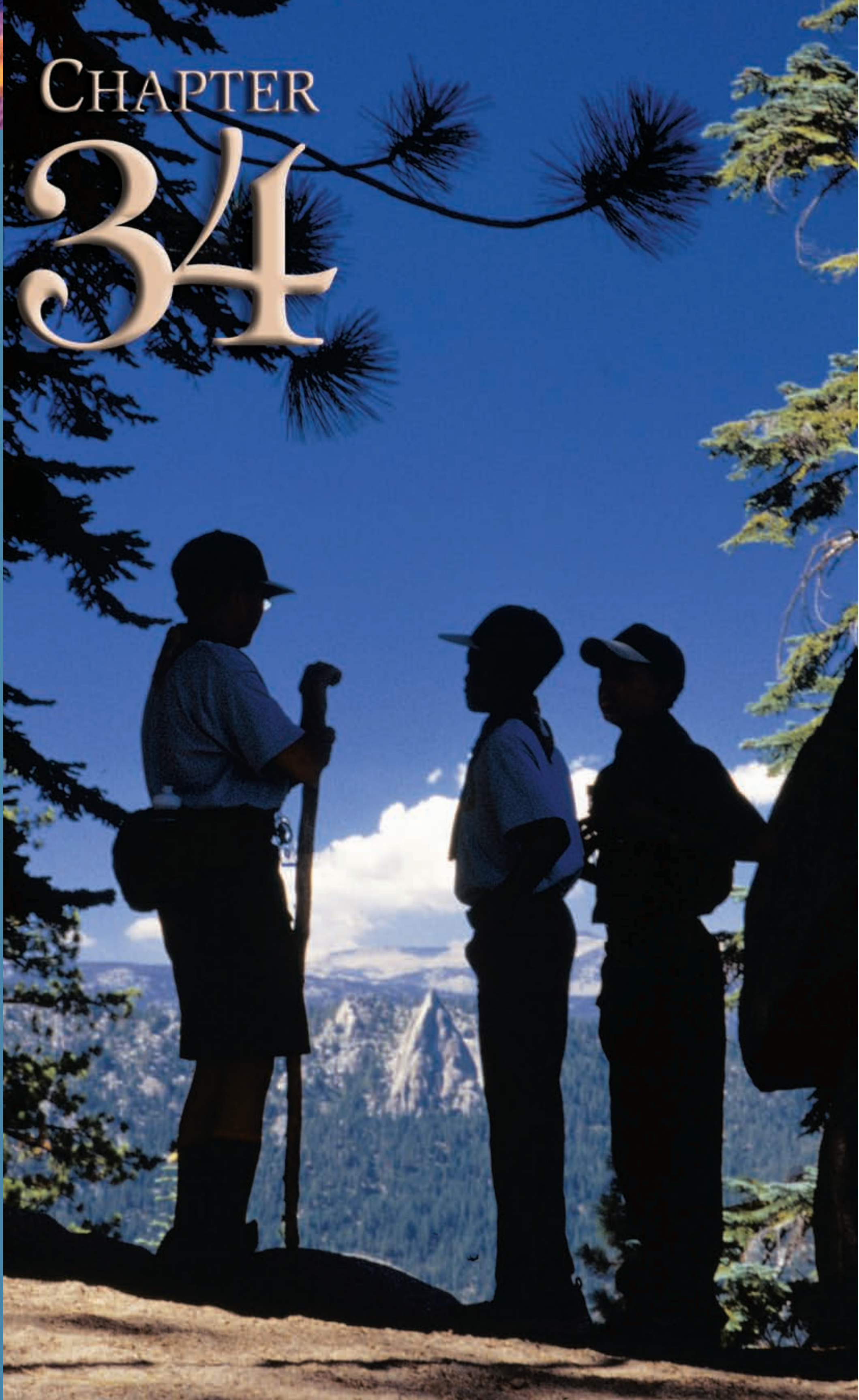
A moonlit night can be bright enough for you to observe wildlife and to move about in camp without a flashlight. A mountain travel team might schedule a trip so that they will have a full moon to illuminate their route on a summit attempt that begins long before sunrise. Sailors and sea kayakers know that the ebb and flow of tides is caused by the pull of the moon's gravity upon the Earth's oceans.

With the help of binoculars or a telescope, you can make out craters on the moon created by the impact of meteorites. A map of the moon can guide you from one terrain feature to another, and to the locations of lunar landing zones—as yet the only places beyond the Earth where human footprints can be found.

"The surface of the Earth is the shore of the cosmic ocean. From it we have learned most of what we know. Recently, we have waded a little out to sea, enough to dampen our toes or, at most, wet our ankles. The water seems inviting. The ocean calls."

—Carl Sagan, *Cosmos,* 1977 (An astronomer and teacher, he stimulated public interest in science and space through his books and television series.)

Chapter 34



Being Good Stewards of Our Resources

"Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."

—Margaret Mead, American anthropologist and author

Caring for the land is as basic to Scouting as bringing along food for the trail, and as constant as knowing which way we are going and when we will return. Much of this book has discussed terrific outdoor activities and the means to enjoy them in harmony with the outdoors. The principles of Leave No Trace are guidelines for making that happen. When we give careful thought to using a stove or a fire, to choosing appropriate campsites and travel routes, and to other means of minimizing our impact on the land, we are preventing environmental harm.

We can take our responsibilities a step further by rolling up our sleeves and pitching in to help preserve natural resources and restore damaged ecosystems. We have the power to make a difference for the Earth, and there is plenty we can do. Many projects involve stream cleanup, meadow revegetation, erosion control, and habitat improvement. Others address the needs of forests, marshes, lakeshores, campgrounds, beaches, recreational facilities, and trails.

Taking on worthwhile tasks in the field makes the importance of stewardship clear and immediate. That, in turn, helps us understand that we can be good stewards in the daily choices we make as consumers, as users of resources, and as active participants in deciding how to protect the environment.

For more on enjoying the outdoors responsibly, see the "Leaving No Trace" section of this book.

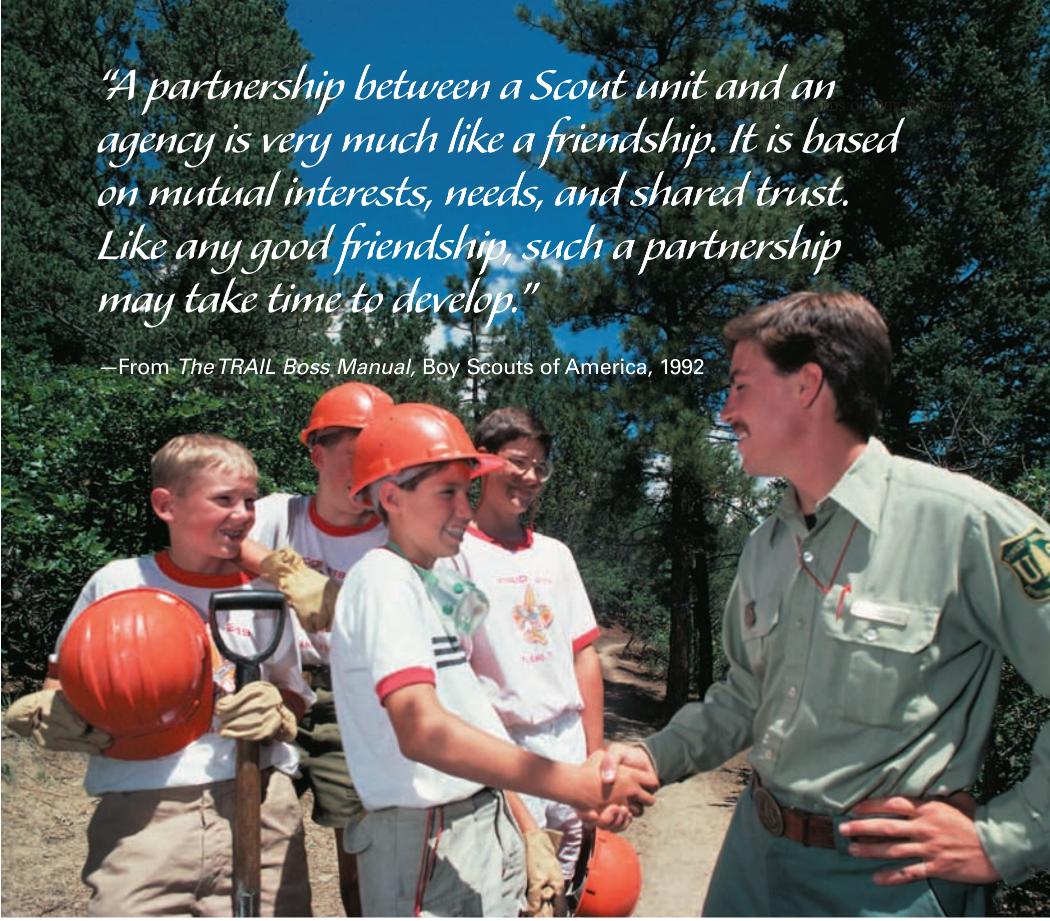
The Meaning of Stewardship

Historically, a *steward* is a person who cares for the property of others, striving to return it in comparable or better shape than when it was received. Each of us is a steward of the Earth, entrusted with the planet's care for the years we are here. The condition in which we leave it is our legacy to our children, our grandchildren, and all the generations that follow.

Stewardship is important for many reasons. It allows us to give back something important in return for what we gain from the outdoors. It makes us much more aware of the intricacies of the natural world and the ways in which our actions affect it when we see the environment in terms of maintaining healthy ecosystems rather than simply as consumable resources. It meshes with Leave No Trace ethics by providing the means to erase those traces of human activities that, over time, have injured the environment. As a means of practicing thrift and service, stewardship is an extension of the foundations of Scouting expressed in the Scout Oath and Law, the Outdoor Code, and the Venturing Oath.

"A partnership between a Scout unit and an agency is very much like a friendship. It is based on mutual interests, needs, and shared trust. Like any good friendship, such a partnership may take time to develop."

—From *The TRAIL Boss Manual,* Boy Scouts of America, 1992



Active Stewardship

The trails we hike and the campsites where we pitch our tents probably fall under the jurisdictions of land management agencies, conservation organizations, or the Boy Scouts of America. By becoming involved in environmental protection, maintenance, and improvement, we can enrich our outdoor experience by serving as active stewards of the places we use and enjoy. Of course, conservation projects must be done correctly or the effort will be wasted. For guidance, groups often can draw on the knowledge and support of BSA camp staffs and of land management personnel overseeing America's public and private lands.

Land managers associated with local agencies such as community parks departments might care for only a few acres. Those involved with large agencies, including the USDA Forest Service, National Park Service, Bureau of Land Management, U.S. Army Corps of Engineers, and U.S. Fish and Wildlife Service, administer tens of thousands of square miles of the American landscape.

BSA local councils and district offices might be able to refer you to agency professionals, Scout camp personnel, or other Scout groups experienced in volunteer stewardship projects on public or BSA property. Many land management agencies and organizations have designated coordinators who are experienced with stewardship volunteers, but some agency personnel might not know what to expect or what is expected of them. That's all right;

developing a conservation project partnership includes the time it takes for agencies and volunteer groups to get to know each other.

For more on land management agencies, see the chapter titled "Planning a Trek." For more on organizations involved with stewardship, see the *Fieldbook* Web site.

Involving volunteers in active stewardship is not appropriate for every local land management office or for every group of backcountry users. Some agency personnel simply do not have the time, the resources, or the need. Some groups are not sufficiently committed to the responsibilities involved in developing long-term conservation partnerships. When everyone is willing to explore the potential, though, the possibilities are remarkable.

Planning Stewardship Projects

Volunteers who take on conservation efforts are contributing their time and energy for the good of the environment and should feel pride in their important accomplishments. The following guidelines will help groups and land managers plan projects that serve the needs of the environment and ensure that those involved are using their time well.

Use Good Leadership

Venturers, Boy Scouts, and members of other groups succeed best when they are led well. Leaders can share their responsibilities by involving other members of the group in planning and then providing them with the materials, tools, and skills they require to successfully complete the project.

For more on leadership, see the chapter titled "Outdoor Leadership."

Work Closely With Land Managers

First projects with a particular agency often are as much about getting acquainted with land managers as they are about helping the land. The project should be limited in scope, lasting perhaps a few hours or an afternoon, so that participants can sample hands-on stewardship, and land managers can get a sense of a group's ability and commitment. As volunteers gain experience and confidence, projects can become more lengthy and complex. Each project must have prior approval from the land management agency or the landowner. Once a project is planned, following it through to proper completion is appreciated by land managers.

Consider Skill Levels

A demanding goal can set people up to fail and cause them to lose interest. On the other hand, the best opportunities challenge people to push a little beyond their current abilities and to master new skills. Choose a project with a level of challenge that best fits the group's skills.

Make a Difference

Effective projects allow participants to see that their efforts have meaning. They will be eager to return for future projects if they have gained a sense of pride in doing their best for the land.

Adopt-a-Site

Adopt-a-site partnerships allow Venturing crews, Scout troops, and other groups to pledge themselves to providing long-term care of a campsite or trail, and to see how their efforts protect and improve the area over the months and years.

Preproject Visit

Visiting the project site a week or two before the effort begins allows land managers and group leaders to clarify expectations and to draw up lists of tools, materials, and logistical tasks. Among the questions to be answered during a preproject visit are the following.

- Where is the project located, and how will everyone reach the site?
- What is the project's goal, and who should be included in the planning process?
- What portion of the project can the group reasonably expect to finish?
- What are the steps for completing the project?
- Is the project site safe? If not, assist the agency in eliminating any safety concerns, or move the project to another site.
- Does the group have the skills needed? If not, who can provide the information and/or training they need and help oversee the project?
- What tools and materials are required, and how will they be provided? Will there be enough tools to keep each participant busy, productive, and safe?
- Is the extent of the project comparable to the size of the group? Is leadership adequate?
- Will volunteers need special clothing or personal gear? If they might get wet or muddy, should they bring a change of clothing for the trip home?
- What activities, such as cleaning up the project site, completing evaluations, and returning tools, will effectively conclude the project?

Emergency Response Plan

As with any outdoor activity, a troop, crew, or other group planning a stewardship project should put together an emergency response plan that includes emergency contacts in case of injury or illness, the location of the closest medical facilities, and the means of transporting people to and from the project site. Make sure a first-aid kit is available and that there will be people at the project site who know how to use it.

For more on emergency response plans, see the chapter titled "Planning a Trek."

Risk Management

Address safety right from the start of project planning. Agencies often have their own safety standards and will expect volunteers to follow their guidelines. Group leaders and land management personnel should identify any hazards to be avoided and incorporate any methods to enhance safety.

A tailgate safety talk can be a standard project feature. Before the project begins, gather all participants to discuss project goals and safety concerns. In addition to the usual safety issues of being outdoors (weather, insects, sun exposure, etc.), conservation projects have some specific safety considerations:

- **Clothing and equipment.** Depending on the project, sturdy boots, hard hats, gloves, and eye protection might be needed.
- **Safe spacing.** Anyone swinging a tool should be at least two tool-lengths away from every other person.
- **Body mechanics.** Conservation projects provide great opportunities for participants to learn the right ways to lift objects, handle tools, and pace themselves through a day of outdoor activity.

Documentation

Keep a written evaluation of each project for your group's records, and provide a copy to the land managers with whom your group is cooperating. Including before-and-after photographs can provide clear evidence of the value of the volunteers' efforts. A typical evaluation answers the following questions:

- How many people were involved in the project, and how many hours did they dedicate? (To figure person-hours, multiply the number of participants by the number of hours it took to complete the project. For example, over an eight-hour day, a group of 10 volunteers has contributed 80 person-hours of effort.)
- What was accomplished? (Detail numbers and/or amounts—feet of trail cleared, number of trees planted, length of shoreline protected, percentage of a campsite repaired, etc.)
- Are there tools or skills that could improve the volunteers' efficiency? Could group leaders or land management personnel provide additional support? Add any comments and recommendations that might help everyone do a better job next time.

Recognition

The BSA honors the importance of stewardship in a variety of ways, including with patches, awards, and advancement. Agency personnel assisting volunteers in the completion of stewardship projects also deserve recognition, and they might be eligible for certain Scouting awards. A letter to an agency supervisor thanking someone for his or her help is always appreciated. Perhaps the most meaningful recognition is sincere thanks and handshakes from volunteers in the field.

The William T. Hornaday Award was established in 1914 by Dr. Hornaday, then director of the New York Zoological Park. The award recognizes BSA members and units for service to conservation and environmental quality. Other BSA awards relating to stewardship are the Conservation Good Turn Award, World Conservation Award, and the Keep America Beautiful Award.

For more on conservation awards, see the *Fieldbook* Web site.

Sample Stewardship Projects

The following is an overview of a few stewardship efforts that volunteers can carry out effectively.

Trail Maintenance

Trails are at the mercy of erosion, encroaching vegetation, and user impact. Water from rain, springs, and snowmelt gouges gullies in trails and narrows the tread with silt deposits. Brush and tree branches can make trail corridors almost impassable. Misuse by hikers, bicyclists, horseback riders, and others creates damaging shortcuts and unnecessary tread widening. Bridges, water bars, and other wooden trail structures eventually will rot away and require replacement. Steps, retaining walls, and other stone fixtures also demand occasional attention.

Nearly every kind of trail damage can be fixed. All it takes is time, skill, and enthusiasm.

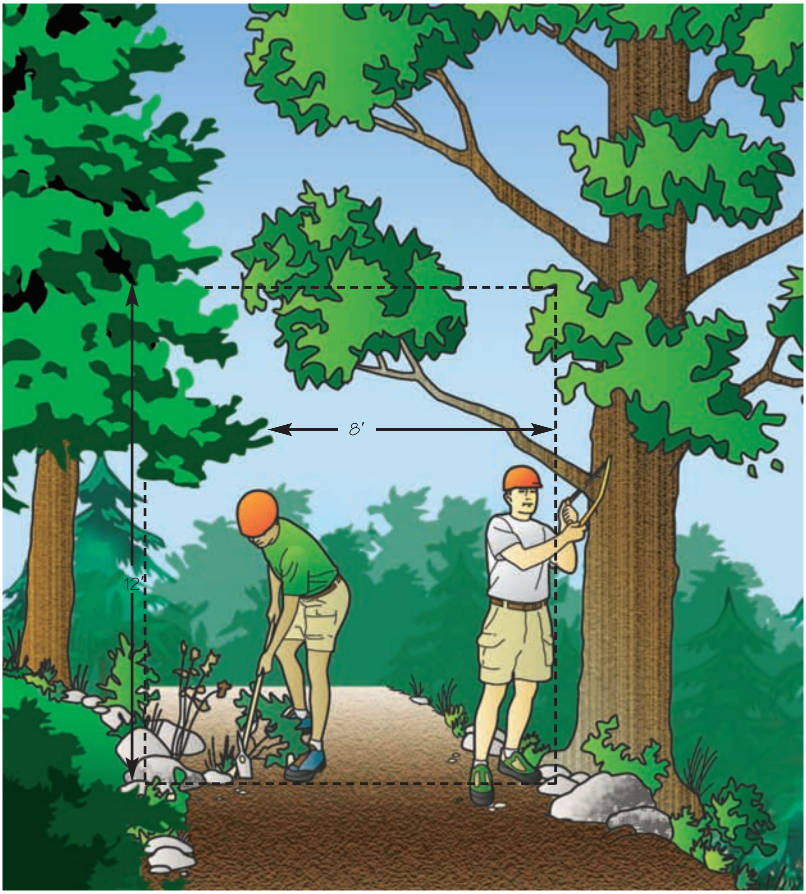
"Our ideals, laws, and customs should be based on the proposition that each generation, in turn, becomes the custodian rather than the absolute owner of our resources and each generation has the obligation to pass this inheritance on to the future."

—Charles Lindbergh, 1971 (Celebrated for his 1927 solo flight across the Atlantic Ocean, he became an advocate of stewardship and environmental protection.)

Brushing

Brushing removes branches, bushes, vines, fallen trees, and other vegetation to maintain a clear travel corridor of sufficient width and height to allow trail users to pass without difficulty. Brushing tools include loppers, bush saws, clippers, and pole saws. The following guidelines will enable volunteers to brush a travel corridor so that it looks as natural as possible.

- Cut bushes flush with the ground to avoid leaving a stump that might trip a hiker. Cut branches close to tree trunks to avoid leaving "hat racks" that might snag clothing, packs, horses, or people.
- Undercut tree branches by sawing through about one-third of their diameter from underneath, then complete the cut from above. That will prevent the falling branch from stripping the bark from living trees.
- Scatter brush and branches out of view of the trail. Cut brush and pruned branches that lie flat on the ground will decompose quickly. Do not leave piles of brush that might attract harmful insects.



Brushing and limbing for a hiking trail

Maintaining Drainage Structures

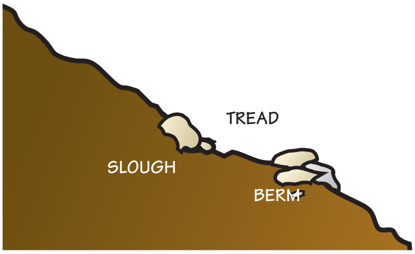
Many hillside trails deter erosion with embedded *water bars* that divert rainwater and snowmelt from the tread. Built from large rocks, logs, or lumber, water bars should be placed with enough care to withstand hard use by hikers and horses while still accomplishing their task.

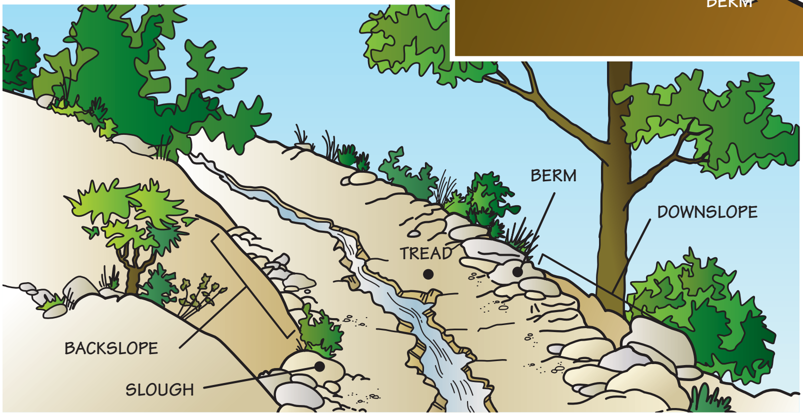
Silt building up behind a water bar can render it useless. Using a shovel, mattock, Pulaski, or even the heel of your hiking boot, scrape away the silt and restore the shape of the drainage slope so that the water bar will be effective again. Where necessary, replace rotted logs and reset loose rocks.

Maintaining Tread

A common trail concern is silt buildup on the inside edge of the tread (where it is called *slough*) and the outside edge *(berm)*. Slough and berm narrow the tread, making passage more difficult. Water trapped between slough and berm can cause erosion as it flows along the trail.

Mattocks, Pulaskis, shovels, and rakes are effective tools for removing compacted slough and berm. Loosened silt can fill in ruts along the trail or be scattered over a wide area beyond the trail.





Compaction of the tread can create a berm on the outside edge. Rainwater running from the backslope to the downslope of a trail may deposit silt on the tread. Removing this slough and berm can restore a trail's proper appearance.

"We should know the Great Spirit is within all things: the trees, the grasses, the rivers, the mountains, and the four-legged and winged peoples."

—Black Elk (1863–1950), Oglala Sioux holy man

This restored wetland near Jackson Hole, Wyoming, provides good habitat for fish and other wildlife.

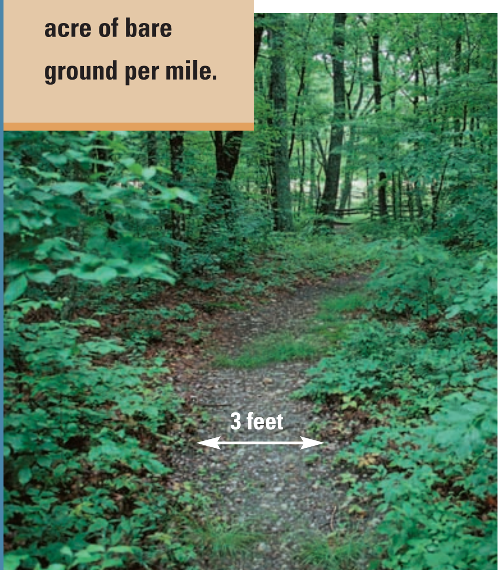
Restoration, Revegetation, and Habitat Improvement

Lakeshores, stream banks, trails, campsites, meadows, alpine tundra—all environments that humans use extensively will show signs of erosion and vegetation loss. The encroachment of nonnative vegetation also threatens many ecosystems vital to wildlife. Progress in repairing damaged sites is often slow, but groups serious about revegetation and restoration will see dramatic long-term changes.

A trail 3 feet wide represents nearly a quarter-acre of bare ground per mile.

Revegetation is the art of reintroducing plant communities to areas where vegetation growth has been discouraged. Revegetation improves an area's appearance, protects it from erosion, and enhances it as an inviting wildlife habitat. Sowing grass seed on mine tailings is a good example of a revegetation project.

Restoration is an attempt to heal the land by returning it to its natural integrity. In addition to sowing seed, restoration of mine tailings might include contouring the terrain and bringing in topsoil.



It might not be possible to restore a site to its condition before being disturbed by human activity. For example, a climax forest that has been cleared away cannot be recreated even if volunteers were to devote the rest of their lives to it. However, they can recreate the early stages of such a forest so that natural processes can move forward. Restoration gives an area a jump start on recovery, allowing the land a better chance to heal.

Erasing Inappropriate Trails and Campsites

Little will grow where the weight of many footsteps has compacted the tread's soil, so an inviting trail emerges. By concentrating use on the trail rather than on the surrounding environment, impact is limited to the tread. A planned trail is a sacrifice zone that we accept because it makes travel easier and it limits human impact to the pathway.

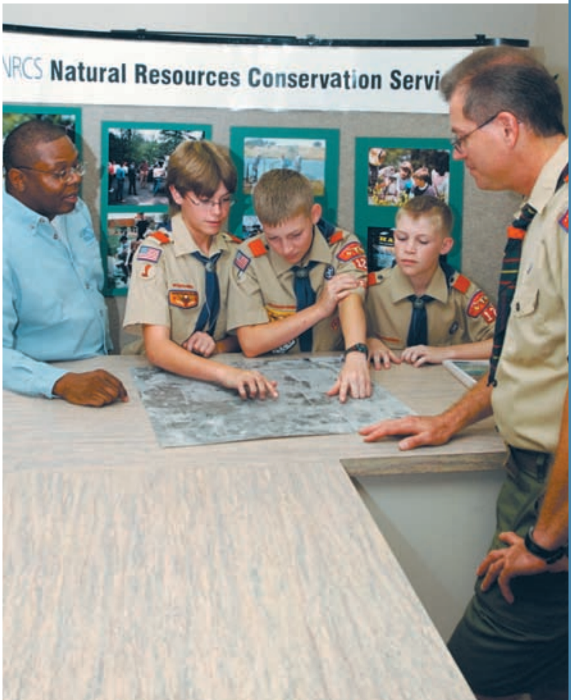
Problems arise when people stray from designated trails and, by trampling vegetation and compacting soil in other areas, create *social trails.* Many land managers try to solve that problem by selecting one route through an area, enhancing a single trail for everyone to follow, and then erasing the social trails.

Likewise, heavily used campsites often are so barren of vegetation that more camping on them will cause little further damage. Resource managers often encourage people to continue using those campsites to protect the surrounding vegetation. However, where there are too many campsites or when campsites appear in inappropriate places, it might be wise to close certain sites and restore them as much as possible.

With guidance from restoration experts and land managers, volunteer groups create visual barriers to discourage people from camping where they shouldn't. Loosening compacted soil and transplanting vegetation creates conditions that will help damaged areas recover much of their natural diversity and appearance.

Steps in Restoration and Revegetation

As with any conservation project, land managers and group leaders should do some careful planning before volunteers arrive at a restoration site. The planning process will help determine attainable goals and increase the environmental education opportunities for everyone.



Study the Area

Determine the causes and extent of the environmental damage at a site, then develop a coherent, overall plan to deal with it. Consider the soil type, annual precipitation, length and timing of the growing season, and plant communities native to the area, as well as the amount of time volunteers are willing to dedicate to improving the site.

Provide Options for Human Activity

Areas often become damaged because people use them. Efforts to restore vegetation will not be very effective if visitors continue to trample and compact repaired sites. Providing attractive alternative routes and campsites will help persuade people to avoid areas undergoing restoration.

Loosen Compacted Soil

When many people walk in the same area, their weight compacts the soil, collapsing tiny air pockets, hardening the ground, and driving out earthworms, small insects, and other creatures that enrich the soil as decomposers and aerators. Tiny root ends can no longer push through the compressed earth. Mycelia, bacteria, and other microscopic organisms essential to vegetation health might also be unable to survive.

The first step in restoring closed campsites and abandoned trails is to loosen the top 6 inches of compacted soil using shovels, garden tools, Pulaskis, and picks. Loosened soil is an inviting bed for seeds drifting in from surrounding vegetation. Scattering leaves on the disturbed area creates mulch that can protect seedlings from drying out.

Install Barriers and Camouflage

Among the most satisfying aspects of a restoration project is developing natural-looking visual barriers to discourage people from entering an area. That can give plants the time they need to become reestablished. If people can't see through a site, they are not likely to walk through it, and they will not be tempted to pitch tents there if stones and clumps of thorny bushes are covering the ground.

Restoration experts can show you how to install logs and rocks, transplant prickly native species, and then step back to examine what you have done. Can you make it look more natural? Let your efforts spill over into undisturbed areas to erase the boundary between a restored zone and the natural environment around it.

The same holds true in closing trails. Rather than simply throwing armloads of brush on the tread and ending up with an eyesore of woody debris, blend rocks and brush into the visual background to block the trail but not attract undue attention.

Transplanting

Transplanting bushes, clumps of grass, and saplings into loosened soil speeds the healing of a restoration site, but its success depends upon a project crew's knowledge of local vegetation, proper planting times and methods, and a commitment to the ongoing care of the area.

The best time to transplant usually is autumn, when vegetation is becoming dormant and will be less affected by the shock of being moved. In spring and summer, transplanting can stress plants, especially when most of their energy is going into producing flowers, seed, and roots.

Transplanted grass can thrive in new locations. Select native species from adjacent areas so that the vegetation taking root in a restored area will be the same as what was there before the damage occurred. Take plants from areas that are similar to the restoration area in terrain and amount of sunlight. If shaded plants from a moist forest floor are moved to the edge of a dry, sunnier meadow, for example, they are not likely to survive.

Before you dig up a plant, prepare the hole that will receive it by pouring in some water and perhaps a mixture of mulch and a natural fertilizer such as fish meal. Carefully remove the plant from its original location and immediately transplant it. Remove dead, damaged, and crowded limbs to shape the tree and reduce the transplanting shock to the roots. The less time fragile roots are exposed to the air, the less likely they will be to dry out. Give the transplant plenty of water after replanting. Depending on climate and weather patterns, it might require a few more irrigations in the days or weeks that follow.

Weed Control

Among the more labor-intensive challenges facing many land managers is limiting the spread of weeds. A weed is any unwanted plant. Land management agencies often approach a weed problem with a four-step plan:

Prevention—educating the public on ways to avoid transporting weed seeds from one area to another

Removal—removing weeds from an area

Restoration—helping native vegetation reestablish itself

Monitoring—diligently seeking and eliminating new weed growth

With their numbers and enthusiasm, volunteer groups can help with all four steps of weed control. Assisted by land managers, the group's plan to effectively deal with weeds in an area will clearly identify the plants to be removed and the most efficient removal methods. Considerations for a weed-removal plan include the following.

- Identify the plant. If in doubt, don't pull it out.
- Pull weeds at the right time of year, ideally before they produce and disperse their seed.
- Wear long-sleeved shirts, long pants, and gloves when working with weeds that have thorns or sap that can irritate the skin.
- Pull small infestations of weeds by hand, especially when a noxious plant has first been detected in an area. Hand pulling also is a good alternative in sites where herbicides and mechanical removal methods cannot be used.
- If weeds have deep root systems that cannot be pulled out by hand, try cutting them flush with the ground or using shovels, Pulaskis, and other tools to dig them out.
- Land managers will direct you in the best ways to dispose of the weeds you remove.

For more on weeds, see the chapter titled "Plants."

Canada thistle, Cirsium arvense, *is a troublesome perennial weed throughout the United States.*

A South Dakota rancher discusses grazing management techniques with a conservationist from the National Resources Conservation Service.

Lifelong Stewardship

Stewardship is an obvious extension of trek adventures. In fact, caring for the environment can be an adventure that lasts a lifetime and ranges wherever our travels take us. As with other outdoor skills, the more we practice active stewardship, the more easily we can find what needs to be done and the means to achieve our goals. That serves not only the well-being of the land, but also the betterment of ourselves in our appreciation, enjoyment, and protection of natural resources.

"The nation behaves well if it treats the natural resources as assets which it must turn over to the next generation increased, and not impaired in value."

—Theodore Roosevelt, United States president, 1900–1908