Contents

1 12.02.20

1.1 Provisioning Services

- Products obtained from ecosystems
- Pharmaceuticals
- Fruits and vegetables
- Fish and game
- Timber, fiber, fuels

1.2 Plants as food

- 400,000 species described
- 14 species provide most of our food
- 3 crops (corn, wheat, rice) account for half of the world's calorie consumption

1.3 The Green Revolution

- Normal Bourlaug - Father of the Green Revolution
  - Selective breeding increased crop yields throughout the world in the 1960s

  - Won many different prizes (National Medal of Science, Congressional Gold Measure, Public Welfare Medal, Nobel Peace Prize, Presidential Medal of Freedom)

- Shortly after the 20's and the rise of higher crop yields, the dust bowl and great depression hurt agriculture significantly
- The 1960s Green Revolution increased food supplies worldwide

1.4 The Basis of the Green Revolution

- Nitrogen and phsphorus fertilizer, irrigation and pesticide use are unsustainable
- Production increased during the green revolution even though the area under cultivation remained approx. the same
- Production leveld off in the 1980s, only to rise again at the turn of the century, where genetic engineering technologies were used to develop new crop varieties

1.5 Feeding the Global Population

- Global pop expected to reach 10B by 2050
- Experts say we will need to produce twice as much food
- Eventually crop productivity reaches a limit

1.6 Green Revolution Impacts, Limits, Future

- Povery and food insecurity persisted despite advances
- Nutrition: Calorie availability increases but micronutrient intake is lagging
- Environmental impacts have been mixed
  - Positive: Less overall land used
  - Negative: Increased pesticide use
- Gains in Africa lag significanrlt but are catching up
- Green Revolution 2.0

1.7 Importance of Food Self-sufficiency

- Food self-sufficiencyL ability of an individual nation to grow enough food to feed its people
  - Africa largely overlooked by green revolution, lack food self-sufficiency
- Food sovereignty: ability for an individual nation to control its own food system
  - Africa also lacks food sovereignty

1.8 Africa & Hunger

- Industrialization and farm subsidies enabled mostly US farmers to produce vast surpluses of what, corn, and soybeans
- Global market flooded w cheap food
- Smaller countries can't compete
- Much of their farmable land used for cash crops, which are exported
  - Cash crops: Food and fiber crops grown to sell for profit rather than for use by local families, communities

1.9 Industrial Agriculture: Pros and Cons

- Pros
  - Large scale farming
  - Higher yields
  - Growth in nutrient-poor soil
  - Fewer blemishes
  - Less labor intensive
- Cons
  - Dependence on mechanization
  - Monocultures
  - Decrease in biodiversity
  - 40% of all agriculture consumed by pests/disease

1.10 Locust Outbreaks

- One of the world's most devastating pests
- Can swarm to 80M, eat 2+ grams/day

2 11.30.20

2.1 Human Impacts on the Phosphorus Cycle

- inc fetrilizer use increases phosphorus runoff into waterways, increases eutrophication
- all farmers need phosphorus, but 5 countries control ~85% of world's remaining phosphate reserves
- phsophorus critical to fertility, high crop yields, overall necessary to food production
- phosphorus quickly becoming more expensive

2.2 Major Issues Assiciated with Current Phosphorus Usage

- Inefficient global food system
  - 4/5 of phosphorus is lost/wasted in the supply chain from mine to field to fork
- Cheap fertilizer
  - Farmers need access to phosphorus, yet up to 1B farmers lack access to fertilizer markets
- No Monitoring
  - Currently no international or national policies, guidelines, or organizations responsible for ensuring long term availability and accessibility of phosphorus of food production

2.3 Phosphate Prices

- temporary phosphorus price spikes in 2008 affected farmers from Australia to Ethopia, leading to farmer riots and suicides - was a wake up call to the fragility of the world food sitation

2.4 Sustainable Phosphorus Measures

- Much of phosphorus is lost in waste, can be recycled and recouped
- Critical to maintain a more sustainable diet

2.5 Soil & Soil Dynamics

- Critical Concepts:
  - Physical and Chemical Weathering
  - Erosion
  - How long do soils take to form?
  - Soil loss & conversion

2.6 Physical and Chemical Weathering

- Weathering = breakdown of rocks, soil, minerals often done by water or organisms
  - Physical weathering = simply breaking down rocks
  - Chemical weathering - changing the chemical structure of rock, soil, etc
- Makes up ~50% of the soil
- Takes an extremely long time

2.7 Soil Complexity

- Diverse organisms contribute to soil structure
- Soil is often linked between the different spheres of the world and supports biodiversity significantly
- Climate effects soil in different ways
  - Tropical forest: generally infertile due to heavy rainfall and decomposition rates
  - Temperate forest: usually fertile and neutral to slightly aciding
  - Temperate grassland: neutral to slightly basic, high to moderate fertility

  - Desert: low fertility and organic magter, often high in salt content

- It can take 500+ years for 2.5 cm of soil to form
- Poor land use practices cause soil erosion

2.8 Weathering vs Erosion

- Weathering: the breakdown of rock to soil (creating soil)
- Erosion: the movement of soil, minerals, etc to another place (taking away soil)
- Overgrazing: removal of plant matter by livestock exposes soil to erosion
- Deforestation exposes soil to loss
- Desetification: Semiarid range land becomes permanently less productive when overgrazed

2.9 Summary

- There are biotic and abiotic components of ecosystems
- Global biogeochemical cycles are essential to supportiong biology and the economy
- Phosphorus is especially important. It is distributed heterogeneously and limitation of it may compromise agricultural production. An excess of phosphorus is a major quatic pollutant
- Access to elements will govern patterns in economic and technological development
- Soils are complex and take extremely long times to form. Soils are strongly influenced by climate.
- A variety of activities compromise soils.

3 11.23.20

3.1 Tomato Agriculture

- Tomato is one of the most valuable crops in the world
- Originally from S America, transported to Europe by early 17th century, back to N America in 18th century
- Annual production > 175M tons, 85B USD
- Important plant model
  - 15,000+ known varieties
  - Member of important Solanaceae family

3.2 Ecosystems

- The provisioning of ecosystem services is dependent upon functioning ecosystems
- Biosphere: the total area on Earth where living things are found; the sum total of all biomes
- Ecosystem: all of the organisms in a given area + the physical environment in which, and with which, they interact
- Community: all the populations (plants, animals, other species) living and interacting in an area
- Population: all the individuals of a species that live in the same geographic area and are able to interact and interbreed
- Ecosystem ecologists: study how ecosystems work in relation to their biotic and abiotic components
- Population ecologists: study how populations change over time and space
- Community ecologists: investigate the factors that influence biodiversity, community structure, and the distribution and abundance of specie

3.3 Energy and Matter

- All ecosystems function through:
  - Matter cycles: movement of life's essential chemicals/nutrients through an ecosystem
  - Energy flow: the one-way passage of energy through an ecosystem
- Earth is materially closed but energetically open
- Biomass can't enter or leave the system, but energy can
- Energy enters as sunlight through either heat or light
- Photosynthesis: the chem eraction done by producers to convert energy of the sun using carbon dioxide and water -> sugar and oxygen

3.4 Biomes

- Biomes: specific portions of the biosphere determined by climate and identified by the predominant vegetation and organisms adapted to live there
- Biomes are divided into three main categories
  - Terrestrial
  - Marine
  - Freshwater

3.5 Limiting Factors & Distribution

- Limiting factor: the critical resource whose supply determines the population size of a given species in a given ecosystem
- Range of tolerance: the rande, within upper and lower limits, of a limiting factor that can limit population size
- Limiting factors determine the distribution and size of populations
- Variability increases a population's range of toleration, expanding its distributoin and increasbing the chance that it will be able to adapt to changing conditions

3.6 Review

- Food insecurity is global and heterogeneous
- There are 4 types of ecosystem services
- Biophysical charactersistics of systems govern what and how much of a crop can be produced into a region

3.7 Matter

- Matter cycles that move nutrients through ecosystems depend on living organisms and abiotic sinks of those resources
- Biotic: the living, organic components of an ecosystem
- Abiotic: the non-living compoenents of an ecosystem, important for nutrient cycling
- BiogeochemistryL the ways in which an element or compound moves between its various living and nonliving forms and locations in the bioshphere
- Elements required for life: Carbon, Hydrogen, Ditrogen, Oxygen, Phosphorus, Sulfur
- Biogeochemical Cycles:
  - Water cycle
  - Carbon cycle
  - Nitrogen cycle
  - Phosphorus Cycle

3.8 Carbon Cycle

- Photosynthesis: Plants and other photosynthetic organisms produce sugars
  - Utilize sunlight and CO2, produce oxygen
  - Photosynthesizers known as producers
- Cellular respiration: Organisms break down sugar to release energy
  - Utilizes oxygen, produces CO2, known as consumers

3.9 Nitrogen Cycle

- Nitrogen is the most abundant gas in the air but has a very tight bond, bond must be broken (fixed) before use by producers
- Nitrogen cal also be released back into the atmosphere
- Nitrogen Cycle: a continuous series of natural processes by which nitrogen passes from air -> soil -> organisms -> air/soil
- Nitrogen enters ecosystem through nitrogen fixation
- Nitrogen exits the ecosystem when other bacteria convert nitrate back to molecular Nitrogen
- Humans are disrupting the nitrogen cycle
  - Fertilizers and emissions are doubling availbility of nitrogen
  - While nitrogen is no longer a limitng factor for plant growth, the additional notrigen can disrupt the ecosystem

3.10 Phosphorus Cycle

- Different than other cycles because phosporus doesn't exist in the atmosphere
- Only found in solid, liquid form
- Phosphorus cycle: a series of natural processes by which phosphorus moves from rock -> soil, water -> living organisms -> soil

4 11.20.20

4.1 What does it take to grow a tomato?

- Nursery (Water, energu, materials, presicides, etc)
- Nursery to farm transport
- Cultivation (Pesticides, land use, tillage, etc)
- Farm to Packaging-House transport
- Packaging (Energy, water, packaging)
- Transportation (Freight ship route, truck route)

4.2 Ecosystem Services

- Provisioning Services (Prodicts obtained from the ecosystem)
- Regulating Services (Benefits from regulation of ecosystems)
- Cultural Services (non-material benefits obtained from ecosystems)
- Life on earth depends on ecosystem services provided by natures
- Recognizing the value of rhese services may motivate us to protect them

4.3 Nutrition

- Currently produce 1/3 more calories than needed
- UN 2013, 842M people (12% of the world) suffers from undernutrition (not enough calories)
- Civil war and Climate change contribute to a significant increase in recent famine
- Although we produce enough food to feed everyone, nearly 1B people don't have access to enough nutritious food
- The rise of industrial agriculture and the Green Revolution helped fight hunger in the 20th century but came w some unintended consequences
- Employing a variety of agricultural methods and addressing socioeconomic drivers of poverty necessary to fight hunger

4.4 Food Security

- Food security: having enough physical, social, and economic access to sufficient safe and nutritious food
- Food insecurity is a problem due to
  - Inadequate distribution of food
  - Inadequate funds to buy food
- Undernourishment: When a person does not have enough to eat
- Worldwide, 1/4 children experiences stunted growth due to undernutrition

- Malnutrition: a state of poor health that results from a nutritional imbalance due to a lack of essential nutrients
  - can serve as a prelude to many duseases
  - UN est that the cost of treating malnourishment in children under 2 is double of the cost to prevent it in the first place
- Overnutrition: the consumption of too many calories
  - considered a form of malnutrition
  - affects 1.5B people
  - increases susceptibility to diseases
  - problem of both the wealthy and poor
- Protein deficiency -> Kwashiorkor
- Calorie and protein deficiency -> wasting disease
- Vitamin deficiency -> many diseases

4.5 Food Deserts

- 13/30 of athens census tracts are labeled as food deserts, 33% of residents live 1+ mile from a grocery store

5 11.11.20

5.1 Cannabis & Sustaibaility

- Now that cannabis legalization is sweeping North America, we need to better understand its impact on freshwater systems
- 2/3 of Americans believe that marijuana should be legalized

5.2 Cannabis & The Economy

- Cannabis may be key to economic recovery, potentially post COVID, similar to how ending prohibition helped end the Great Depression
- 10s to 100s of Millions made off of Marijauna tax revenue
- California is the biggest producer with nevada as the runner up for marijuana

5.3 Cannabis & Society

- Many states are no decriminalizing Marijuana and allow for medical Marijuana use
- Without legalization, marijuana feeds non-violent offenders into the prison system, perpetuates mass incarceration, and disproportionately affects POC
- California was the first state to allow medical use of Marijuana, many states have created laws since then

5.4 Cannabis and the Environment

- California case study, Pot takes up very significant amounts of water, no regulation
- Groundwater use has triggered conflicts across areas of California
- Water rights are a large concern in the Marijuana industry, especially for California because unlicenced growers often steal other's water
- US DEA est. that 60% of cannabis consumed nationwide is grown in California
- Bulk of that comes from three upstate counties of the Emerald Triangle: Mendocino, Humboldt and Trinity.
- This is because the conditions there are perfect for Cannabis growth but this comes with problems for the environment, waterways, and wildlife
- Creek Diversions threaten fish habitats
- Road building erodes soil, streams
- 1 marijuana plant growing in a national forest uses 900 gallons of water per growing season
- In 2017, 1.25 Million plants were found growing in CA national parks
- Illegal marijuana growth therefore uses 1.1 Billion gallons of water

5.5 Tristate Water Wars

- For 30 years, GA, AL, FL have fought over the sue of water in the Apalachicola-Chattahoochee- Flint River Basin (ACF) which is heavily infleunced by the US Army Corps of Engineers' operation of Lake Lanier's Buford Dam. Lanier lies within Chattahoochee's headwaters, north of Atlanta
- 70: the number of attorneys on retainer by GA
- 4 Million: Pages of documents produced by GA agencies, universities and non-profits requested by FL.
- 660,000 emails give to GA by FL
- 45 people deposed by both GA and FL

6 11.02.20

6.1 Triple Bottom Line

- An assessment of the cost of a good or service should include more than just the economic costs; it should also include the social and environmental cost
- IPAT Equation: I = P * A * T; I = Impact, P = Population size, A = Affluence(products/person), T = Tech Usage (impact/product)

6.2 Assumptions of Mainstream Economics

- Environmental economists argue that mainstream economics will fail in the long run because it makes some assumptions that are inconsistent with the way nature operates

1. Assumption:
    - Natural and human resources are infinite, substitutes can be found as necessary
    - Economic growth will go on forever
    - Something that benefits/harms us today is more important than something that ight do so tomorrow
2. Impacts:

- Linear economic production models use inputs and produce waste without regard to sustainability; circular systems depend on renewable resources and see waste as a useful inp
- Cradle to Cradle mentality creates sustainability whereas crade to grave increase the amount of overall waste

6.3 Market solutions

- Alternatve: Command and Control
  - Command = estbalishment of performance standards by a govt authority that must be complied with
  - Control = negative consequences that could result from non-compliance
- Performance Standards
- Tradeable permits
  - Important to consider the effect on environmental justice

Economic Incentives

- Seek to reduce or eliminate negative environmental externalities (such as pollution) by incorporating the external cost of production.
- The general focus is prevention rather than remediation
- Payment for Ecosystem Services
  - NYC protecting its water supply

6.4 Environmental Policy

- Environmental policy = A course of action adopted by a government or organization intended to improve the natural environment and public health and reduce human impact on the environment
- Collective action undertaken to manage natural resources and human impacts on the environment.
- Things like: – Laws – Regulations – International agreements – Funding decisions

6.5 Why is Environmental Policy Challenging

- Many environmental problems trasncend boundaries
- Lots of WICKED problems, very complex with mulitple stakeholders
- Lawmakers must juggle many factors
  - Effectiveness of the policy
  - Negative tradeoffs
  - Cost burden (internal, external costs)
  - Flexibility of the policy to accomodate changes
- Many times, voters and lawmakers don't agree that they are necessary

6.6 History of Environmental Policy

- Before 1960's
  - How best to use resources
  - Pollution not key objective
  - Primerily dealt with at the state level
  - Environmental problems addressed after the fact through litigation, favored the pollutor
- Changes
  - As industry, pollution inc, pollution crossed state lines
  - Massive outcry in the 60's and 70's lef to federal legislation
  - Performance standards let to a prevention-focused regulation

6.7 Who Makes Environmentla Policy?

- Elected Officials
- Federal and State Agencies
- Local departments: planning and zoning, public works, etc/
- Courts
- Corporations and other businesses

6.8 NEPA

- NEPA's key feature is the Environmental Impact Statement (EIS)—a report that details the likely impacts (positive and negative) of a proposed action.
- The goal of an EIS is to identify problems before they occur so that stakeholders can choose the most acceptable course of action.
- The findings are made available to everyone (citizens, policy makers, and special interest groups)—this keeps the process transparent and everyone is given a chance to respon

6.9 Policy Decision Making Process

- Identify problem -> Consider options -> Formulate Plan -> Adopt Law -> Implement Law -> Evaluate effectiveness
- Statutes:
  - Provide policies, goals
  - Typically mandate an agency to promulgate regulations according to staturoy standards and enforce them
  - Often authorize states to enforce them
  - Often dictate funding allocations
- Regulations:
  - Regulation = rule = administrative law
  - The actual technical and programmatic standards for environmental protection
  - Standards usually in regulagtions instead of statutes because of ease of amendment
- Court Decisions
  - Rule on constitutionality of statute, regulation, or other deferal action
  - Rule on application of statue or regulation
  - Rule on meaning (language/intent)
- Executive Orders

  - Presidential directives to do something
  - Often involve internal affairs, Development of amendments to regulations

6.10 Misc

- Most environmental regulation passed between the 70's and 90's, no significant regulation since
- Enforcement and Definitions absolutely essential
- Trump and Environmental Policy
  - Treaties

  – Paris Climate Agreement
  - Agency heads, federal judges
  - Agency directives –rules/regulations
  - Rule rollbacks
  - No new rules or policies
  - More state authority

7 10.26.20

- Disease cases frim infected mosquitoes, ticks, and fleas have tripled in the last 13 years

7.1 Malaria

- Vector: Mosquito
- Transmission: Bite from infected mosquitoes
- Prevalence: Est 219M cases of Malaria, cases are mostly children w 660k Deaths
- US Prevalence: An average of 1,500 reported cases of malaria in the U.S. each year

7.2 Dengue Gever:

- Vector: Asian tiger mosquito (in 36 US states)
- Transmission: Bite from infected mosquito
- Prevalence: 100M cases worldwide, endemic in the Americas
- Occurs rarely, but there is a small risk for dengue outbreaks in the continental United States, mainly in the Southern US

7.3 Chikungunya

- Transmitted by mosquitoes
- Mainly in Africa, Asia, Europe, Indian, and Pacific Oceans
- First found in the Americas on Carribean islands in 2013
- Beginning in 2014, reported in US travelers

7.4 West Nile Virus

- Vector: Mosquito
- Transmission: Bite form infected mosquito
- Prevalence: commonly found in Africa, Europe,Middle East, North America, West Asia
- U.S. Prevalence: Between 1999 and 2012, about 37,000 cases of West Nile Virus were reported in the U.S. Over 1,500 people died as a result.

7.5 Spread of Disease

- Increased connectivity increases rate and spread of infectious diseases across the globe
- Correlation between travel advisory and amount of travel to infected areas for Zika
- Zika most likely to be found in the Southeast because of Zika-transmitting mosquito population residence
- High poverty rates correlated with high risk of disease spread due to high population density, potential lack of good healthcare

- Warmer average temps, longer growing seasons, changes in precipiation may lead to more standing water and conditions that may be better for disease spread
- Warning temps could expose more than 1.3B people to Zika by 2050

7.6 Climate Change and Health

- Without effective responses, climate change will:
  - Water quality and quantity: Contributing to a doubling of people living in water-stressed basins by 2050.
  - Food security: In some African countries, yields from rain-fed agriculture may halve by 2020.
  - Control of infectious disease: Increasing population at risk of malaria in Africa by 170 million by 2030, and at risk of dengue by 2 billion by 2080s.
  - Protection from disasters: Increasing exposure to coastal flooding by a factor of 10, and land area in extreme drought by a factor of 10-30
- Rainfall: tranports and disseminates infectious agents
- Flooding: sewage treatment plants overflow, water sources contaminated
- Sea levels rise: Increased risk of severe flooding
- Higher temps: increases growth and survival rates of infection
- Drought: increases concentration of pathogens, hurts hygiene

7.7 Health Outcomes from Climate Change

- Some expected impacts will be beneficial but most will be adverse.Expectations are mainly for changes in frequency or severity of familiar health risks
- See Zika Climate Final for diagrams

7.8 Poverty and Disease

- Diarrhea is related to temperature and precipiatation; Diarrhea increased 8% for each 1 degree C temp increase
- Health impacts of climate change unfairly distributed, hurt mortality of developing, low-income countries, especially in Africa

7.9 Temperature Effects on Vectors and Pathogens

- Vector:
  - Survival inc/dec depending on species
  - Changes susceptibility of vectors to some pathogens
  - Changes in rate of vector population growth
  - Changes in feeding rate and host contact
- Pathogen:
  - Decreased incubation period at higher temps
  - Changes in transmission season
  - Changes in georgraphical distribution
  - Decreased viral replication

7.10 Percipitation Effects on Vectors

- Survival: increased rain may increase larval habitat
- Excess rain can eliminate habitat by flooding•Low rainfall can create habitat as rivers dry into pools (dry season malaria)
- Decreased rain can increase container-breeding mosquitoes by forcing increased water storage
- Heavy rainfall events can synchronize vector host-seeking and virus transmission
- Increased humidity increases vector survival and vice-versa

7.11 IPCC

- Intergovernmental Panel on Climate Change, intl body for assessing the science related to climate change
- Set up in 1988 by the World Meteorological Organization and the UN Environmental Programme
- Provide policymakers w regular assessments about climate change, impacts and future risks, options for mitigation and adaptation

8 10.14.20

- Exam Review
  - Taxonomoc group with the most known species: insects
  - Types of biodiversity
    - Genetic
    - Species
    - Ecosystem
  - Biodiversity in the Southeast
    - Describe SE biodoviersity using the terms "richness," "endemic," and "hotspot"
  - Mussels: diversity, life history, and ecosystem service (nutrient cycling)
  - What is diversity?
- Isolation & Extinction Risk
  - Hawaii's biodiversity is vulnerable to extinction - more than 90% of native species on Hawaiian islands are endemic, one half of indigenous species face extinction

8.1 Community Ecology

- Mutualism - A symbiotic relationship between individuals where both species benefit
- Parasitism - A symbiotic relationship between individuals of two species in which one benefits and the other is negatively affected (may or may not lead to death)

- Commensalism - A symbiotic relationship between individuals of two species in which one is benefitted and the other is unaffected
- All species contribute to theur ecosystem but some are more important than others
- Keystone species influence community structure disporportionately to their abundance
  - Role: create/modify habitats, influence interactions between other species
  - Removal of a keystone species may lead to a loss of biodiversity and changes in community structure within the ecosystem
- Food web: complex and realistic representation of how species feed on each other in a community
- Food chains: a linear representation of how different species in a community feed on each other
- Producers and Consumers
  - Producers: photosynthetic organisms that capture energy directly form the sun and convert it into food
  - Consumers: organisms that gain energy and nutruents by eating other organisms
    - Animals, fungi, most bacteria, and protozoa
- Trophic level - a level in a food chain or food web
  - Primary consumer: a species that eats producers
  - Secondary consumer: a species that eats primary consumers
  - Tertiary consumer: a species that eats secondary consumers
  - Decomposers can be put practically anywhere on the food web
- Conservation Status: IUCN Designations
  - The International Union for Conservation of Nature established the Red List of Threatened Species in 1963
- Single species conservation programs focus on an individual species, successfully protecting some high-profile species but are less often used for less visible or valued species

- CITES
  - Convention on International Trade in Endangered Species of Wild Flora and Fauna
- Lacey Act: First law protecting wildlife

9 10.12.20

9.1 Definitions of Diversity

- Genetic Diversity: Variations in the genes among individuals of the same species
- Species Diversity: The variety of species present in an area; includes the number of different species that are present as well as their relative abundance
- Ecological Diversity: The variety of habitats, niches, trophic levels, and community interactions

9.2 Robust Redhorse

- Thought to be extinct until rediscovered in the Oconee in 1991
- Extripated: Extinct in a local area

9.3 Species Diversity

- Richness: number of different species
- Evenness: relative abundance of each species
- Diversity: combined richness and evenness

9.4 Endemic Species

- Because areas w high ecological diversity offer many habitats and niches, they have a large number of endemic species
- Endemic species: a species that is native to a particular area and not usually found elsewhere
  - Most commonly found in small ecosystems

9.5 Hotspots

- Biodiversity hotspots: areas that have high endemism and have lost at least 70% of their original habitat
- These areas contain a large number of endangered species (species at high risk of becoming extinct)
- The Southeast US is a global hotspot of freshwater biodiversity supporting 2/3 of the country's fish species, over 90% of the US total species of mussels and nearly half of the global total of crayfish species

9.6 Habitat v Niche

- Habitat: the physical location of an species
- Niche: the biotic and abiotic needs for a species to survive

9.7 Biodiversity Loss

- As much as 20% of the world's biodiversity may be lost in the next 30 years
- 50-66% of biodiversity may be lost by the end of the century
- Current rate of extinction is 1500 times greater than pre-human background rate

9.8 Causes of Biodiversity Loss

- Human actions are having significant impacts on biodiversity loss
- Threats include:
  - Habitat destruction
  - Invasive Species introduction
  - Pollution
  - Overharvesting
  - Climate change

9.9 Value of Biodiversity

- Provides key connections between species and their environment
- Provides direct protection against disease
- Provide food, fuel, building materials, and pharmaceuticals

9.10 Ecosystem Services

- Supportive Services:
  - Purification of air and water
  - Carbon sequestration
  - Erosion Prevention
  - Habitats for animals and Plants
- Provisioning Services: Food, resources, water, fuel
- Regulating Services: Pollination, seed dispersal, protection, biological control
- Cultural Services: Recreation, Spiritual Tourism, mental health
- Human Wellbeing:
  - Strong economic growth
  - Medicinal resources
  - Reduction in toxin exposure

9.11 Isolation and Extinction Risk

- Number of unique species increases with isolation
  - Isolation and high endemism makes remote islands particularly vulnerable to species loss
  - Human impact contributes to isolation in the form of habitat fragmentation
  - Habitat fragmentation: destruction of part of an area that creates a patchwork of suitable and unsuitable havitat areas that may exclude some species altogether

10 10.09.20

10.1 Evolution and Resistance

- Evolution happens to populations, not individuals
- Natural selection is the mechanism for evolution
- Genetic drift more likely with low population size
- The potential for antibiotic resistance to develop in bacteria is very high
- Improper waste disposal

10.2 Athens Water Quality

- 10/17 Athens watershed are impaired or unhealthy
- Athens drinking water comes from:
  - N Oconee River
  - Middle Oconee River
  - Cedar Creek
- Athens had E. Coli outbreaks in water, showing prevalence of bacteria

10.3 Gonnorhea & Resistance

- Gonorrhea treatment is done through antibiotics
- Shown increase in resistance to every drug used to treat Gonnorhea
- CDC currently recommending two-drug comination to preserve our last highly effective antibiotic
- Higher reported rates of Gonnorhea occur in SE US, on an overall upward trend with younger populations

10.4 Developing new Antibiotics

- First antibiotic developed by Alexander Fleming in 1982 after noticing the fungus penicillium could kill disease causing bacteria
- Antibiotics aren't profitable for drug companies
- Developing antibiotics are high risk, very expensive, and very difficult
- Low return on investment, development void since 1990

10.5 Post-antibiotic Era

- Currently:
  - 80% of gonnorhea infections now resistant to antibiotics- 440,000 new cases of resistant tuberculosis annually
- In the future
  - Strep throats to scraped knees could be deadly
  - Cost to treat drug resistant double that of the status quo
- Davos Declaration
  - Reducing the development of drug resistance.
  - Increasing investment in R&D that meets global public health needs.
  - Improve access to high-quality antibiotics for all.
  - Signed by 98 companies, 11 industrial associations in 21 countries

11 10.07.20

11.1 Genetic Diversity & Natural Selection

- Genetic diversity in a population is the raw material natural selection
- The larger the amount of genetic diversity, the higher probability that some individuals from that pool can survive changes to its environment
- Phenotype = expressed gene
- Natural selection acts directly on the phenotype, resulting in changes in allele frequencies from parental to offspring generations

12 10.05.20

- Following widespread usage of antibiotics on humans and animals, waste from livestock and humans is generating antibiotic-resistance bacteria
- These bacteria are getting back into the environment through out waste

12.1 Antibiotic Resistance:

- A complex problem that involves helping many actors see the big picture and not just their part of it
- Issues where an action affects (or is affected by) the environment surrounding the issue, either the natural environment or the competitive environment
- Problem whose solutions are not Obvious

12.2 Systems Thinking

- Considers the whole rather than parts of the whole:
  - Events
  - Patterns
  - Underlying Structure

12.3 Cycle of Infection

- Farm animals recieve antibiotics often, developing resistant bacteria in their gut
- This can be transmitted through produce, waste, shared environments, etc.

12.4 Bacteria

- Bacteria are single celled organisms that can grow in colonies
- Many different kinds of bacteria can grow together in similar environments

12.5 Explaining Resistance

- Antibiotics kill almost all antibiotic sensitive bacteria, leaving few sensitive and many unsensitive
- Reproduction occurs with the mostly-unsensitive remaining bacteria, leaving to many unsensitive off- spring. This increases the amonut of resistant bacteria as a whole.

12.6 Genetic Variation

- Variation in the susceptability of bacteria to antibiotics allows for the propogation of these genes in bacterial communities
- Individuals of the same species have the same basic gene
- Alleles: variants of genes that account for the diversity of traits seen in a populat
- Adaptation: traits that promote the success of a species
- An adaptive trait for one environmental condition does not mean that it is adaptive for all conditions

12.7 Genetic Diversity

- Within populations, biodiversity is measured by genetic diversity
- Genetic diversity improves survival of a population
- Outbreeding, through sexual reproduction of not closely related individuals, maximizes genetic diversity
- Inbreeding, or mating between closely related individuals, results from small populations, and increases chances of genetic diseases (e.g., hemophilia, cystic fibrosis, etc.)

12.8 Sources of Genetic Variation

- Mutation: A change in the DNA sequence of sex cells that alter a gene
  - Can be neutral, beneficial, or harmful
- Genetic Recombination: The production of eggs and sperm that results in a shuffling of alleles, creating new combinations in offspring

12.9 Natural Selection

- Constant struggle of organisms to survive and mate
- Organisms tend to produce more offspring that can survive
- Individuals of the same species are not identical
- Evidence of Natural Selection: Selective breeding (artificial selection) of dogs and cats
- Natural selection results in changes in gene frequencies
  - Some individuals will be able to obtain more resources and can produce more offspring
    - Differential reproductive success results in changes to gene frequencies

13 09.18.20

13.1 Hurricanes

13.1.1 How Hurricanes Form

- Water evaporates over the ocean and forms clouds when it touches cold air
- A column of low pressure develops at the center with winds around the column
- Speed of the wind around it increases
- Categorized based on wind speed (1-5)
- Hurrican development requires warm water and low wind shear
  - Carribean has warm water all year but also high wind shear which isn't conducive to hurricanes

13.1.2 Climate Change & Hurricanes

- Storm surge more dangerous (accoutns for 90% of hurricane deaths)
- 40% increase with a 0.5 decree C inc in temperature

- Increasing of North Atlantic hurricane season
- Climate change is expected to shift the Bermuda high westward
  - Bermuda High is a pressure system over the Atlantic
  - Has the ability to move hurricanes on the Atlantic

13.1.3 Hurricane Harvey Intensification

- Went from a tropical depression to a Cat 4 Hurricane in 57 hours
- Soil in TX affected the amount of water maintained in the Earth
- Huge economic impacts

13.1.4 General Impacts

- Storm Surge
- Extreme Rainfall
- Potential Wind Speed

14 09.16.20

14.1 Heat Waves

- Heat extremes doubled in frequency from 1980-1999 to 2000-2019
- Climate change affecting heat waves
  - Shifting the frequency of hot and cold weather, heat waves are more frequent
  - Exacerbating heat inducing droughts, dry land leads to even hotter temps
- Causes: Global warming ->
  - Large scale global circulation change
  - Atmospheric Blocking increase
  - Air mass temp increase
- Effects and Consequences

  - Decreased human productivity
  - Increased tropical disease and death
  - Environmental racism
  - Crop productivity decreases
  - Lower biodiversity
  - Decreased water availability
  - Increased fire risk

14.2 Wildfires

- Climate change is increasing the size, intensity, and frequency of wildfires
- Wildfires create more cimate change through the increase of carbon expulsion through wildfires
- Wildfires have global impacts due to smoke and temperature changes
- Wildfire season has gotten longer due to climate change

15 09.14.20

15.1 Coriolis Effect

- Deflection of an object's path due to the rotation of the Earth
- North and south poles have different deflections of wind patterns
- Little/no deflection at the equator

15.2 Air circulation

- Hottest air at the equator, moves north or south, cools, then comes back into equator

15.2.1 Cells

- Hadley cells: 0-30 degrees North and South
- Ferrell Cell: 30-60 degrees North
- Polar cells: North and South poles

- Northeast and Southeast trade winds (remember directions!)
- Westerlies: bring rain and precipitation

15.3 Surface Ocean Currents

- Ocean currents also affect the distribution of climates
- Surface ocean currents generated by wind, Coriolis effect, heat, and continents
- Heat redistribution from the Tropics
  - Trade winds push warm surface waters west
  - Water reaches continents and flows north and south
  - water cools
  - Westerlies push cooler water east
  - Water reaches continents and flows to equator

15.4 El Nino (Southern Oscillation)

- Recurring climate pattern involving changes in the termperature of waters in the central and eastern tropical Pacific Ocean.
- The ocean and atmosphere can interact to affect climate
  - Water in the eastern pacific warms up
  - Sea level pressure drops but rises in the W pacific
  - Trade winds weaken
  - Upwelling in the Pacific is reduced
  - Warmer waters - increased rainfall in Peru
  - Cooler waters, drought in Australia/Indonesia
- Critical because of its ability to change atmospheric circulation, temps, and percipitation
- Significantly hurts fisheries and developing countries

15.5 La Nina

- exacerbates normal conditions and leads to cooling in the Eastern pacific

15.6 Heat Waves

- Global warming has amplified the intensity, duration, and frequency of extreme heat and heat waves.

16 09.11.20

- Northern latitudes experience greater seasonality in CO2 concentrations
  - This is due to variation in photosynthetic activity by plants
- Greenhouse effect
  - Some incoming solar radiation is absorbed
  - Other amounts are reflected back into the atmosphere
  - Greenhouse gases capture and reradiate some heat over and over, warming the Earth
  - More gases, more heat
- Albedo: measure of the reflectivity of a surface
  - light surfaces have a higher albedo, darker surfaces have a lower albedo
  - surfaces with a low albedo release more heat into the atmosphere
- Positive Feedback Loops
  - applied to albedo:
  - temps rise -> more ice melting -> more water warming -> temps rise
- Urban Heat Island Effect
  - cities will be inc their population, inc energy and temperature
  - cities in particular have higher temperatures
  - tree cover -> cooler temperatures
- Small changes in overall global temp can cause significant changes in weather creating more extreme storms and more record temps
  - roughly twice as many heat records

  - alterations in global jet streams
  - frost comes later and begins earlier
- General climate change impacts:
  - Health impacts
  - Crop productivity
  - Coastal erosion
  - Biodiversity
  - Water availability
  - Fire risk
- Weather events getting more extreme with
  - sea levels
  - wildfires
- Need both adaptation and mitigation
  - Adaptation: Responding to warming that has already happened
  - Mitigation: Preventing further warming by addressing climate change causes

17 09.09.20

17.1 The Earth's Atmoshphere

- Climate change is a serious environmental problem impacting species, ecosystems, and the globe
- The atmosphere helps protect the Earth from the sun and keeps the temperature of the Earth cool
- Atmosphere has a significant impact on climate
- Earth's Atmosphere Composition
  - Nitrogen (78%)
  - Oxygen (21%)
  - Other - Greenhouse Gases (1%)

17.2 The Keeling Curve

- Curve developed to track atmospheric CO2 levels in Earth's atmosphere since 1952

18 09.02.20

18.1 Demographic Transition Model

- Demographers use age structure diagrams to predict future growth potential of a population
  - Pyramid structures indicate fast growth
  - House-shaped structures have moderate growth
  - Diamond structures have low/negative growth
- Development leads to smaller families
- Demographic transitions happen country by country
- Industrialization might not lead to a demographic transition in all countries
  - May not be linked to quality of life
  - Religion/Cultural beliefs
  - Social justice issue, improving the well-being of women and children key to dec. fertility

18.2 Social Justice: Education for Women

- Education of girls & economic opportunities for women are correlated with lower birth rates
- Education empowers women to take control over thri own fertility through:
  - Birth control
  - Marrying later
  - Delaying childbirth for career opportunities
- Women earning more money is correlated to lower child mortality

18.3 Environmental Impact

- Slowing population growth is critical to sustainability and reducing our population impact
- Our impact on the population is a result of (1) our population size and (2) our consumption habits - both must be addressed
- Ecological footprint: the land area needed to provide the resources for, and assimilate the waste of, a person or population

18.4 Sustainability

- A dynamic process between the economy, society, and environment
- Sustainable: The process or the activity can be mantained without exhaustion or collapse
  - Intra & Inter-generational issue
  - Capacity of a system to accomodate changes:
    - rates of renewable resource use should not exceed regeneration rate
    - rates of non-renewable resource use should not exceed rate of renewable substitute dev
    - rates of pollution should not exceed ssimilative capacity of the environment
- Sustainable development has three factors:
  - Social equity
  - Economic efficiency
  - Environmental responsibility

18.5 Worldviews

- Culture influences our beliefs through:
  - Knowledge
  - Beliefs
  - Values
  - Learned ways of life

- Worldviews are affected by:
  - Environmental Ethics

19 08.31.20

19.1 Human Populations

- 3 major sparks of growth
  - Agricultural Revolution
  - Industrual Revolution
  - Green Revolution
- With more food and technology, the population and need for more human labor increased
- The human population is rapidly increasing and the impact of humans is due to:
  - More humans overall
  - Greater growth / person
- To address population growth, we need to pursue a variety of approaches that address factors encouraging high birth rates
- Zero population growth: the absence of population growth, occurs when birth rates = death rates
  - Replacement fertility is reached

19.2 Population Ecology

- Analyze and categorize human populations using population ecology techniques
- Population Ecology: a branch of biology dealing with the number of individuals in a particular species in an area over time
- Ecologists study populations to understand what makes them survive and thrive
- Size, distribution, and growth rate is influenced by a variaty of factors and are important to understanding popilation ecology

19.3 Monitoring Population Dynamics

- Population Dynamics: Changes over time in population size and composition
- Important metrics:
  - Minimum viable population - min number of individuals that would still allow population to persist or grow
  - Carrying Capacity (K) - the maximum population size that a particular environment can support indefinitely
- Population Density - the overall desnity a particular populaiton can sustain

19.4 Exponential Growth & Populations

- Exponential growth occurs in populations when growth is unrestricted. This is, overall, unsustainable
- Growth which becomes progressively larger each breeding cycle
- Produces a J curve when plotted

19.5 Monitoring Population Growth

- Population growth rate - the rate at which a population of a species grows over time
- Growth factors - factos which assist in the growth of a population
- Resistance factors - factors which inhibit the growth of a population
- Limiting factos: resources needed for survival but that may be in short supply

19.6 Logistic Growth

- Occurs when a population nears carrying capacity (k)
  - Maximum sustainable population size
  - Determined by limiting factors

19.7 Density-dependent/ Density-independent Factors

- Density dependent factors increase as populations grow, typically biotic
  - Disease
  - Competition
  - Predation
- Density independent facts affect population growth regardless of population size
  - Storm
  - Fire/Flood
  - Avalanche

19.8 Regulation

- Tendency for populations to decrease in size when above acertain level, and increase in size below that level
- Populations can only be regulated by density-dependent factors
- Top down Regulation
  - Predation
  - Disease
- Bottom up Regulation
  - Nutrients
  - Water
  - Sunlight

20 08.28.20

20.1 What is Science?

- Science: a body of knowledge that allows us to understand the world around us
- Science is based on empirical evidence

- Science allows us to test our ideas and evaluate the evidence
- Scientific knowledge, including facts, theories, and laws, is subject to change
- Scientific claims change as new evidence is made available

20.2 White-Nose Syndrome Case Study

20.2.1 About WNS

- White-Nose Syndrome
  - 2007-2016, 6+ million bats dead as a result of White Nose Syndrome
  - The reason for the deaths was White-Nose Syndrome
- Chytridiomycosis
  - Infectious, fungal disease affecting amphibians
  - Helped understand white-nose syndrome with bats

20.2.2 Science with WNS

- Scientific Method: the procedure used to empirically test a hypothesis
  1. Observations generate questions
  2. Choose a question to investigate
  3. Consult literature
  4. Develop a hypothesis and make a testable prediction
  5. Design and carry out a study
  6. Analyze data
  7. Draw a conclusion
- Inferences: Conclusions drawn based on observations
- Hypothesis: An inference that proposes possible explanation that includes previous knowledge/observation
- Testing a Hypothesis: Hypotheses can be tested through an observational or experimental study

- Scientific Studies: A fair test with results that could support or falsify the research prediction
  - Experimental Studies: Conditions are manipulated intentionally
    - Test Group: the group in an experimental study such that it differs from the control in only one way
    - Control Group: the group in an experimental study to which the test group's results are compared
  - Observational Studies: Gather real-world data without any intentional variable manipulation
- Theory: A hypothesis that survives repeated testing by significant research can become a theory
- Correlation v Causation
  - Correlation: two things occuring together but not necessarily having a cause-effect relationship
  - Cause-Effect Relationship: the associationof a two variables that identifies one variable occurring as a result of the other
  - Observational studies can derive correlation but not causation
  - Experimental studies can derive causational relationships
- Policy: a formalized plan that addresses a desired outcome or goal
  - policies need to be flexible, adapt to new findings, address the environmental problem, fit social need and be economically viable in order to work effectively.

20.3 Summary

- Scientific knowledge, through reliable and durable, is never absolute pr certain
- This knowledge, including facts, theories, and laws, is subject to change
- Physical evidence, systematically collected and logically analyzed, helps scientists understand environmental issues and guide policy decisions

21 08.25.20

21.1 Applied v Empirical Science

- Applied Science = research whose findings are used to solve practical problems
- Empirical science: A scientific approach that investigates the natural world through case studies

21.2 Social Traps

- Occurs when a large amount of people are using a shared resource
- Seem good in the short term but are actually bad in the long term
- 3 Types:
  - Tragedy of the Commons: When resources are shared, individuals try to maximize personal benefit which hurts the resource itself
  - Time delay: Collective decisions that are good today but gone tomorrow
  - Sliding reinforcer: related to the evolution of natural organisms and GMOs

21.3 Beginning with Data Interpretation

- Variables represent factors that can be manipulated, controlled, or merely measured for research
- Variation = how much a variable changes
- Independent var is controlled to see effects in the Dependent var
- Graphs explore relationships with data and report this data

21.4 Observational v Experimental Studies

- Observational studies can observe a correlation but are unable to derive a causational reln.
- Experimental studies have a control var (required) and are able to derive causactional rlns.

22 08.24.20

22.1 Definitions

- Ecology: the branch of science dealing with the relationships of living things to one another & the environment
- Environmental Science: The study of all aspects of the environment, including physical, chemical, and biological factos, particularly with respect to how these aspects affect humans, and vice versa
- Environmental Ethics: Personal philosophy that influences how a person interacts with their natural environment and thus influences how one responds to environmental problems

22.2 Ecology != Environmentalism

- Distinguish between envrironmentalism & ecology

Environmentalism	Ecology
Activism to protect the environment	Scientific study of living and non-living things