

Chapter 9 & 10 Sustaining Terrestrial Biodiversity- Part 1

Forest Ecosystems

Old-growth or primary forest (36%)

- Uncut or regenerated forest that has not been seriously disturbed by human activity for several hundred years or more.
- They are biodiversity storehouses due to their varied habitat and niches for so many species.
- Five countries with largest area of old growth forests: Russia, Canada, Brazil, Indonesia, Papua New Guinea.

Second-growth forest (60%)

- Forest ecosystem resulting from secondary ecological succession
- Forests of the eastern United States decimated between 1620 and 1920;
- Grew back naturally through secondary ecological succession in the eastern states

Tree plantation, (tree farm, commercial forest) (4%)

In a commercial forest, the aim is to get the most possible timber, fuel, pulp-wood etc. Maintained by either through planting or natural reproduction or both.

- Often managed with multiple tracts with uniformly aged trees that are harvested in intervals and then replanted. (5%)
- Biologically simplified tree plantations reduce biodiversity and deplete nutrients from soil

Implications of Clearing Forests: Environmental Degradation

Any tree harvest technique has harmful environmental effects:

- Increased erosion results in sediment runoff into waterways
 - nutrient loss affecting biogeochemical cycles
 - Increases turbidity of water reduces photosynthesis (primary productivity)

Building roads into previously inaccessible forests results in:

- Habitat fragmentation & Loss of biodiversity

Plus, roads and disturbance facilitate invasion by: nonnative pests/invasive species & disease

Forestry: Logging & Tree Harvesting Practices

Major Tree Harvesting Methods

- Selective cutting
- Clear-cutting
- Strip cutting

Selective Cutting

- Intermediate-aged or mature trees are cut singly or in groups in uneven aged forest.
 - Reduces crowding, removes diseased trees, encourages new growth & provides trees of all ages for varied use
 - Soil retains water and nutrients
 - Habitat remains generally intact can recover reasonable quickly
 - Preserves biodiversity, to an extent; compared to clear-cutting

Clear Cutting

- All trees in an area are uniformly cut down.
- Foresters often prefer this method because it allows for regeneration and abundance of sun-loving trees in large in even-age stands; over long period of time (min. 50 years).

However, immediate environmental implications are catastrophic:

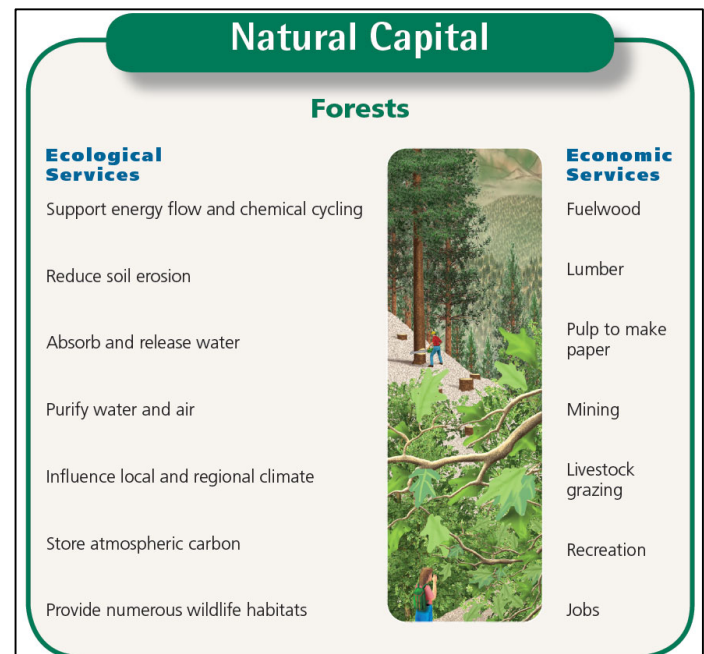
- Habitat fragmentation; destruction/loss of habitat; & reduction in biodiversity
- Erosion resulting in loss of topsoil and nutrients inhibiting regrowth of groundcover
- Resulting in large water loss and surface run-off, water pollution (nutrient loading & turbidity)
- Opens opportunity for establishment of non-native/pests grasses

Chapter 9 & 10 Sustaining Terrestrial Biodiversity- Part 1**Strip Cutting**

- Usually done along contour of slope
- Reduces erosion, water loss, and nutrient loss.
- Fragments but does not destroy habitat.
- Secondary succession occurs naturally as reseeding is facilitated by seed dispersal from intact forest strips

Shelterwood Cutting

- Trees are removed gradually in two or more cuttings.
- Trees that are growing vigorously are retained to provide shelter, seed, and protection of site against deterioration.
- Facilitates establishment of a new generation of seedlings without planting
- Soil left intact *little danger of invasion of the area by weeds and grasses*

**Forest Ecosystems: Fire, Insects, & Climate Change****Surface fire**

- Burns understory and leaf litter; most mature trees and animals survive. Can have ecological benefits-reduce fuel, release nutrients, control pests, maintains habitat.

Crown fires

- Hot fires start on ground and eventually burn whole trees and leap from treetop to treetop. Much litter has accumulated (small trees & dead branches; fuel ladders), destroy most everything in path (including wildlife, insects and soil microorganisms) and increases erosion.

Suppression

- For most of the 20th century complete fire suppression was practice; putting out fires immediately and as quickly as possible.
- This led to an accumulation of large quantities of biomass on the forest floor which built up until large fires became inevitable.

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The Smokey Bear Educational Campaign

- Supported Total Suppression
- Turned out to facilitate fire prone conditions

Improve the Management of Forest Fires

- Allow fires on public lands to burn
- Protect structures in fire-prone areas
- Thin forests in fire-prone areas
- **Prescribed Burning**
 - A fire deliberately set under controlled conditions in order to reduce the accumulation of dead biomass on the forest floor.
 - Ecological benefits: liberates nutrients tied up in dead biomass; provides opening for early successional species + browsing and foraging vegetation for wildlife.

Healthy Forests Initiative

- **Healthy Forests Restoration Act of 2003 (P.L. 108-148),**

Goals of the law:

- Thin overstocked stands;
- Clear away vegetation and trees to create shaded fuel breaks;
- Provide funding and guidance to reduce or eliminate hazardous fuels in National Forests;
- Research new methods to halt destructive insects.

Controversy

- Opponents claimed it allowed loggers to unnecessarily cut medium to large diameter trees *under the false pretense of forest thinning*, while neglecting the greater issue of ladder fuels and possibly leaving debris that would add to extremely volatile ground fuels (such as brush and small trees; cut branches known as slash).
- Opponents claimed it used environmentally friendly terminology as "cover" for a give-away to business interests.

Introduction of Foreign Diseases and Insects Accidental & Deliberate

Pathogens and Insects cause ecological and economic damage

Integrated Pest Management: *Combined pesticide use* with other strategies such as:

- Ban wood transfer to control spread
- Prevention
- Remove infected trees
- Genetic engineering

Emerald Ash Borer

- Adults feed on ash foliage- little damage. Larvae feed on the inner bark disrupting the tree's ability to transport water and nutrients.
 - Probably arrived in the United States on solid wood packing material originating in its native Asia.
 - EAB is responsible for the death of tens of millions of ash trees in 30 states, and has become a concern for Colorado communities since its initial 2013 detection in Boulder, as 15 percent or more of all urban and community trees in the state are ash.

Gypsy Moth

- Defoliator primarily of hardwood trees, especially oak.
- Feeds on the foliage of numerous N. American plants and trees; most common hosts are oak and aspen; highest concentrations in the southern Appalachian Mountains, the Ozark Mountains, and in the northern lake states.

Chapter 9 & 10 Sustaining Terrestrial Biodiversity- Part 1**Mountain Pine Beetle**

- Hard winters with cold temperatures can kill beetle eggs and larvae wintering under a tree's outer bark.
- Related to general climate warming, average winter temperatures in the Rocky Mountains have been higher than normal over the past ten years.
- Trees have also been weakened by a prolonged period of low precipitation.
- The combination of milder temperatures and low precipitation has aided a vast outbreak of beetles.
- Bark beetles are native insects that have shaped the forests of North America for thousands of years.
- Several species of bark beetles are presently killing lodgepole pine, ponderosa pine, limber pine, Engelmann spruce, subalpine fir and Colorado blue spruce.
- Rocky Mountain National Park is just one relatively small area where trees are dying from the beetle epidemic.
- Because the task is enormous, the park's priorities for mitigation of the effects of beetles are focused on removing hazard trees and hazard fuels tied to the protection of life and property.
- Annual carbaryl spraying has been effective in protecting high value trees in the RMNP.

Fundamentals of Environmental Science**Systems Have Inputs, Flows, and Outputs**

System: Set of components that interact in a regular way

→ **Inputs:** from the environment

→ **Flows, throughputs** of matter and energy

→ **Outputs** to the environment

Systems Respond to Change through Feedback Loops

- **Feedback Loop:** results of a process feed back into the system to change the rate of that process.
- **Negative Feedback Loop:** a system responds to a change by returning to its original state or decreasing the rate at which change is occurring; resists change
- **Positive Feedback Loop:** Causes the system to change further in same direction; amplifies a change

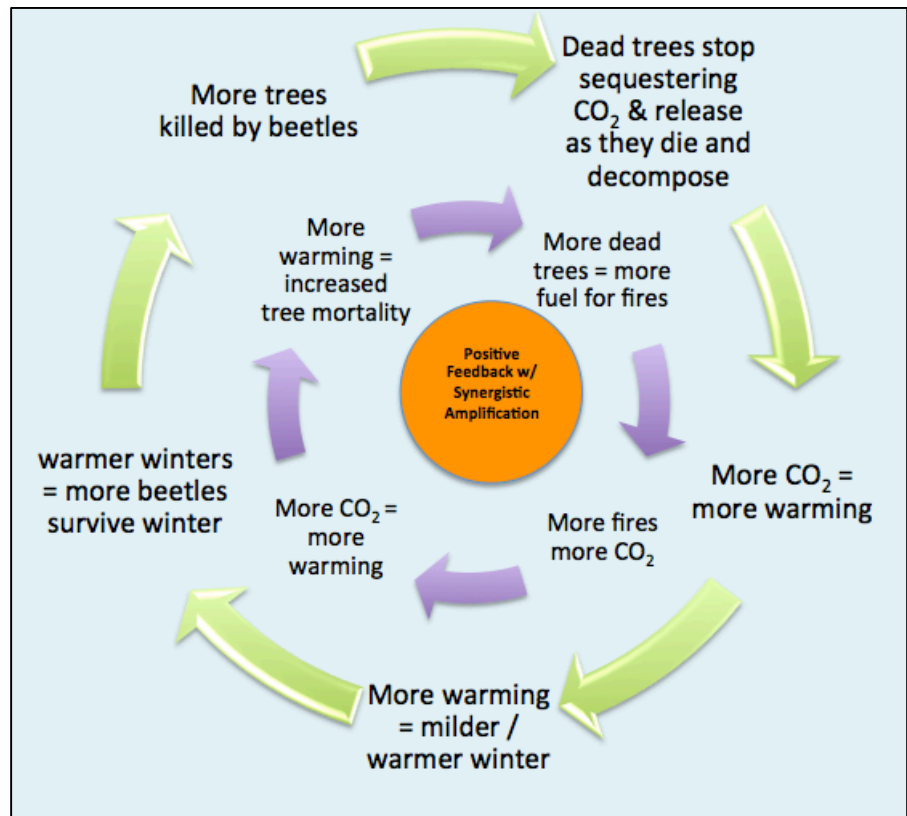
Global Warming

- Rising temperatures
- Trees more susceptible to diseases and pests
- Drier forests: more fires
- More greenhouse gases

Positive Feedback Loop

-Synergy

-Amplification



Chapter 9 & 10 Sustaining Terrestrial Biodiversity- Part 1**Deforestation**

We have cut down almost half of the world's forests.

- Tropical forests
 - Especially in Latin America, Indonesia, and Africa
- Boreal forests
 - Especially in Alaska, Canada, Scandinavia, and Russia

Tropical Forests are Disappearing Rapidly

- Majority of loss since 1950
- Africa, Southeast Asia, South America
- Role of deforestation in species extinction

Causes of Tropical Deforestation are Varied and Complex

- Population growth
- Poverty of subsistence farmers
- Ranching (cattle – beef)
- Agriculture (cash crops)
 - *Plantation farms: palm oil, sugar cane, soy beans (cattle feed)*
- Lumber (wood)
- Begins with building of roads
- Many forests burned
- Large dam construction
- Fuel wood

→ Can tilt tropical forest to tropical savanna

Deforestation: Beef Cattle and Soy Beans**Beef cattle**

- Of the major deforestation drivers, beef has by far the largest impact.
- Converting forest to pasture for beef cattle, largely in Latin America, is responsible for destroying 2.71 million hectares of tropical forest each year—an area about the size of the state of Massachusetts.

Soybeans

- Growing global demand for meat and dairy products has contributed to the doubling of soybean production in the last 20 years.
- Soy is primarily used to feed pork, poultry, and dairy cows, though significant amounts are also used to produce vegetable oil and biodiesel.
- Large soybean fields in the tropics, particularly in Latin America, are often planted on newly deforested land—or they may expand onto former pastureland, pushing cattle to the forest frontier. Every year around 480,000 hectares is deforested for soy in major soy-producing tropical countries.

Deforestation: Palm Oil Production**Effects of Producing Palm Oil**

- 90% of Sumatra's orangutan population has disappeared since 1900.
- Sumatra's orangutans now face extinction.

How To Spot Palm Oil in Products

- Palm oil is found in everything from food and household products, food and cosmetics. It is also being used as a biofuel.
- It is thought that one in ten products found on our supermarket shelves today contain palm oil.

These products list palm oil under a variety of different names including:

Vegetable oil, Sodium Lauryl Sulphates, Sodium Dodecyl Sulphate, Palmate, Palm Oil Kernal, Palmitate, Stearic Acid, Glyceryl Stearate, Elaeis Guineensis, Steareth-2, Steareth-20, Hydrated palm glycerides, Cety palmitate & ocyl palmitate (anything ending with palmitate)

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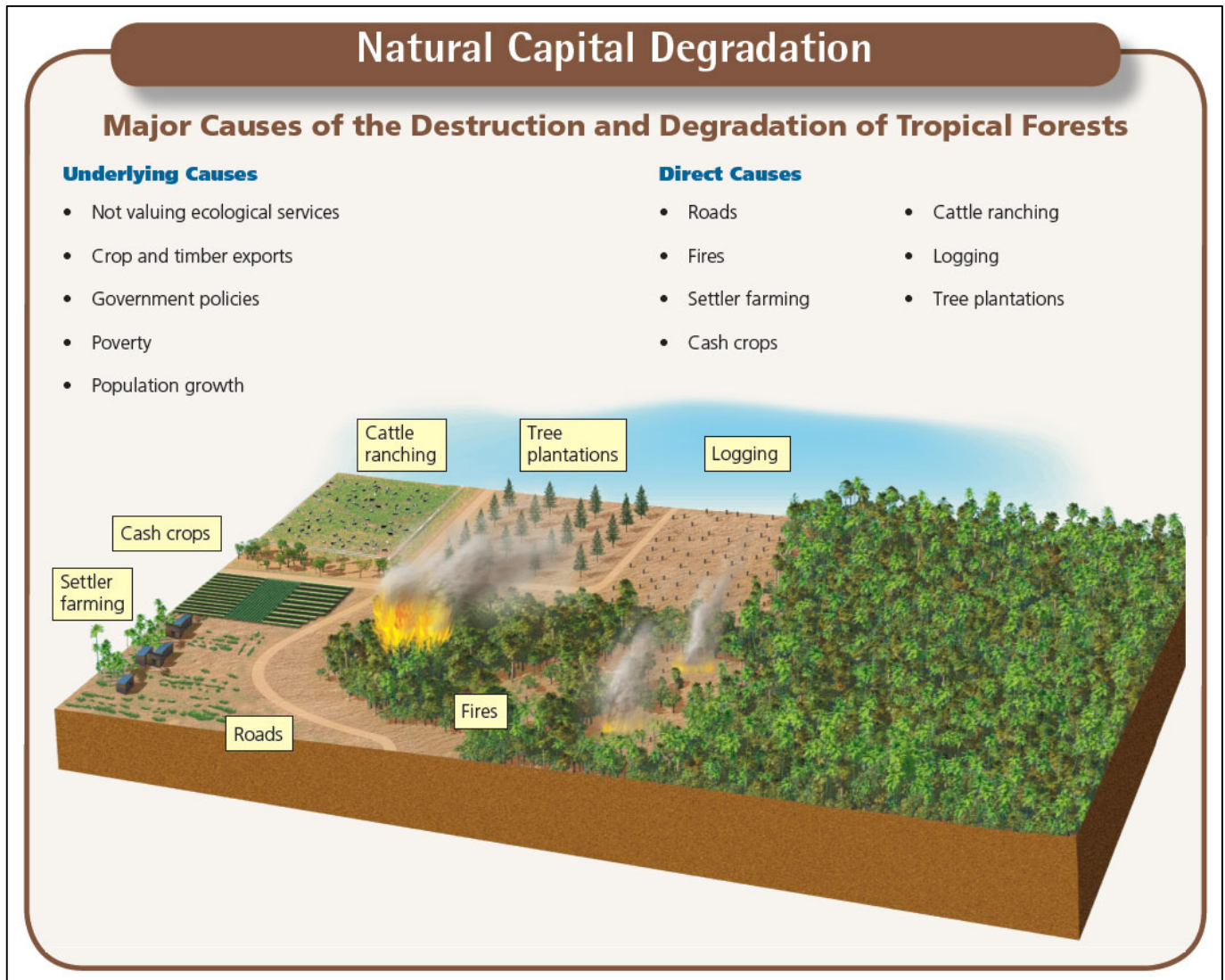
Deforestation: The Global Fuelwood Crisis

One half of world wood harvest is for fuel for cooking and heating

- **Haiti**: ecological disaster
- Deforestation in **Tanzania** threatens the future of forests
- Average citizens of the **Democratic Republic of the Congo (DRC)** are reliant on fuelwood as are many citizens across Africa.

Possible solutions

- Establish small plantations of fast-growing fuelwood trees and shrubs
- Burn wood more efficiently
- Solar or wind-generated electricity
- Burn garden waste



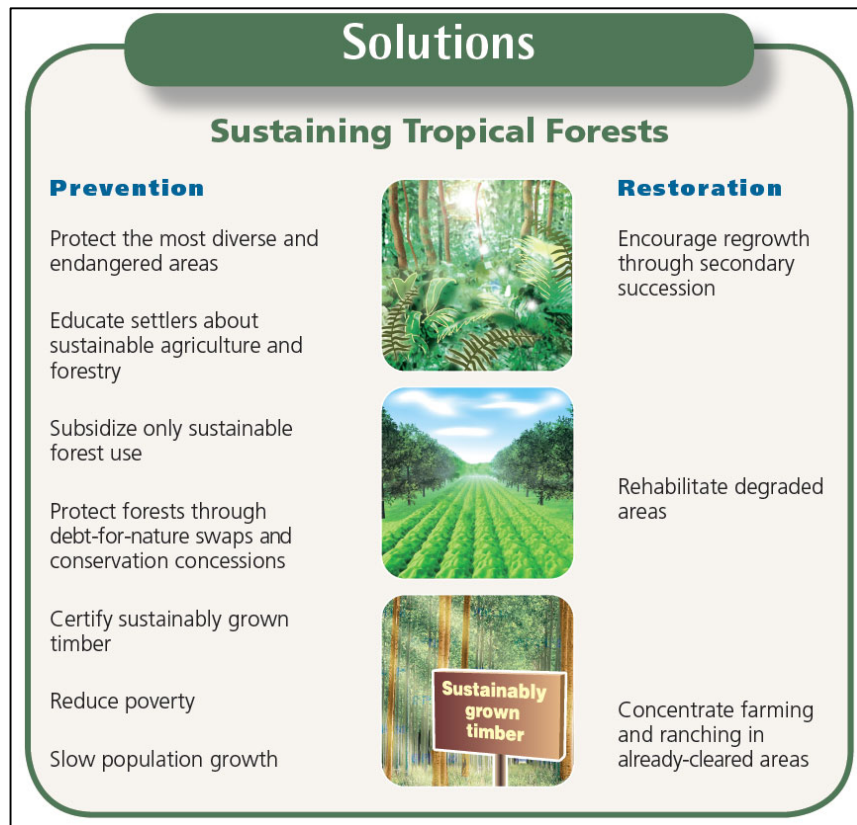
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Certifying Sustainably Grown Timber

- Collins Pine
 - Owns and manages protective timberland
- Forest Stewardship Council
 - Nonprofit
 - Developed list of environmentally sound practices
 - Certifies timber and products
 - 2009: 5% of world's forest have certified to FSC standards
 - Also certifies manufacturers of wood products

Governments and Individuals Can Act to Reduce Tropical Deforestation

- Reduce fuelwood demand
- Practice small-scale sustainable agriculture and forestry in tropical forest
- Government protection
- Debt-for-nature swaps/conservation concessions
- Plant trees
- Buy certified lumber and wood products



Chapter 9 & 10 Sustaining Terrestrial Biodiversity- Part 1Managing and Sustaining Grasslands and Rangelands

Rangelands: Unfenced grassland in temperate and tropical climates where livestock graze; e.g. cattle, sheep, & goats

- Many ecosystem services: soil formation, erosion control, nutrient cycling, food, carbon dioxide sequestration in biomass, habitat, and biodiversity.

Overgrazing of Rangelands

- Grass grows from the tip not from the base. Grass will grow back if not overgrazed (i.e. eaten down to the roots).
- Thus, overgrazing reduces grass cover and leads to erosion of soil by water and wind.
- Overgrazing from too many animals for too long a period of time causes desertification (grassland → desert).
- Soil becomes compacted by trampling from grazing ungulates (i.e. hooved animals; cows) → *Result: difficult for plants to establish; soil can't hold water.*
- Enhances/facilitates invasion of plant species that cattle won't eat
- Overgrazing causes plant root die-back, which reduces moisture holding capacity of the soil, in-turn reducing organic matter and soil fertility.
- As desirable native plants become stressed, weedier (invasive) species thrive in harsh conditions & may take over.
- Native vegetation decreases causing reduced biodiversity.
- Soil is compacted and becomes more susceptible to erosion.
- Riparian zones are damaged by livestock; streambeds experience silting and water becomes cloudy (turbid), thus decreasing aquatic productivity.
- **Desertification:** Overgrazing → diminished plant life → rain washes away soil (erosion) since there are no plants to hold water → weeds take over → wind and dry heat blow away topsoil

Managing Rangelands

- Control number of animals allowed to graze
- Implement **Rotational grazing**
- Protect Riparian Buffer Zones: thin strip of lush vegetation along river and stream banks (fencing).

Restoration: To restore to its former condition or natural state; facilitate the recovery or re-establishment of native ecosystems. (a.k.a. Ecological restoration)

Managing Rangelands

- Suppress growth of invasive species
- Herbicides
- Mechanical removal
- Controlled burning
- Controlled short-term trampling
- Restoration: Replant barren areas with native grass seed
- Apply fertilizer
- Reduce soil erosion

Examples:

Removal of Scotch Broom from Point Reyes National Seashore” This invasive plant has been in the park for over 35 years and threatens native habitats, including several rare plants and threatened and endangered wildlife. The species also changes soil chemistry, which alters plants that can grow nearby. By removing this plant, we open up room for native species to repopulate.

Maasai community on Kuku Group Ranch, decided to develop and implement an integrated grazing and rangeland restoration management plan.

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Restoration of Malpai Borderlands & Restoration of San Pedro River in Arizona

- Arizona-New Mexico border
- Overgrazing and fire suppression allowed trees and shrubs to replace grasses, the soil was badly eroded, and area lost value for grazing.
- Management success story: controlled burns, native grass restoration, and limiting livestock access to riparian zones allowed native plant regeneration within ten years.

Overexploiting Shared Renewable Resources: Tragedy of the Commons

- **Private property:** individuals or companies own rights to land, minerals or other resources
- **Common property:** rights to certain resources are held by large groups or individuals
- **Open-access renewable resources:** owned by no one and available for use by anyone at little or no charge.

Tragedy of the commons

- Common property and open-access renewable resources degraded from overuse
- Ecologist Garrett Hardin 1968 outlined the misuse of open-access resources
- **Solutions:** 1) use resource at a rate well below sustainable yield or 2) convert to private ownership

Economics and Sustainability

Externality: A side effect or consequence of an industrial, agricultural, or commercial activity that affects other parties without this being reflected in the cost of the goods or services involved.

Maximum sustainable yield (MSY):

The maximum amount of a renewable resource that can be harvested without compromising the future availability of that resource. **MSY** keeps the resource population at about one-half the carrying capacity.

Federal Rangeland Management

To avoid a tragedy of the commons situation the federal government uses a permit-based grazing system. Jurisdiction of public grazing rangelands is coordinated through the U.S. Forest service and the Bureau of Land Management (BLM). Federal Grazing permits average about 5 cents per day per animal through federal subsidies.

In 2009 the federal government spent seven times more money managing its rangelands than it received in permit fees. Thus, in effect, grazing is being subsidized with federal funds.

The true cost of doing business would make this fee closer to \$10 to \$20 per animal per day.

Environmental economists believe that a true fair market price (value) includes the costs of negative externalities. This is often referred to as full-cost pricing.

The Sagebrush Rebellion

A movement during the 1970s and 1980s that sought major changes to federal land control in the American West. Much of the land in question is sagebrush steppe, supporters adopted the name "Sagebrush Rebellion". Sagebrush Rebels wanted the federal government to give more control of federally owned Western lands to state and local authorities.

The term "Sagebrush Rebellion" was coined during fights over designation of National Wilderness lands, especially in Western states, and especially after the U.S. Forest Service (USFS) and Bureau of Land Management (BLM) identifying areas for potential designation as part of the National Wilderness Preservation System. This particularly stirred conflict with traditional public lands users' groups such as ranchers, miners, off-road vehicle enthusiasts.

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Public Land Management in the United States**Conservation vs. Preservation**

- Conservation is the sustainable use and management of natural resources including wildlife, water, air, and earth deposits.
- Preservation, in contrast to conservation, attempts to maintain in their present condition areas of the Earth that are so far untouched by humans.

Resource conservation ethic: The belief that people should maximize the use of resources, based on the greatest good for everyone.

Multiple-use lands: A classification used to designate lands that may be used for recreation, grazing, timber harvesting, and mineral extraction.

Management of public lands in the U.S. is administered by the four main land agencies. They are managed for many purposes, primarily related to preservation, conservation, recreation, and development of natural resources.

The greatest good for the greatest number of people.

- **National Park Service (NPS)**
- **Forest Service (FS)**
- **Bureau of Land Management (BLM)**
- **Fish and Wildlife Service (FWS)**

42% of land in U.S. is publicly held; includes rangelands, national forests, national parks, national wildlife refuges and wilderness areas.

National Park Service

- 58 Major national parks in the U.S.
- Conserve lands and resources and make them available for public use. Activities that harvest or remove resources generally are prohibited.

Stresses on National Parks

Biggest problem may be popularity:” *Are we loving our national parks to death?*”

- Noise
- Congestion
- Pollution
- Damage or destruction to vegetation and wildlife

Threats to National Parks

- Congestion (overcrowding)
- Eroded trails
- Noise that disrupts wildlife
- Pollution from autos and visitors
- Off road vehicles (in some parks)
- Introduction of non-native species that impact biodiversity by outcompeting native species and altering ecosystem function; i.e. damaging ecosystems

A few solutions...

- Set quotas on attendance through advanced reservations
- Adopting a fee system that covers external costs
- Banning autos (private passenger vehicles) and instead provide shuttle busses to control traffic
- Conducting periodic wildlife and plant inventories!

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Forest Service

- 155 national forests containing 188 million acres, and 20 national grasslands containing 4 million acres.
- *Typically try to balance conservation and use.*
- Manages for multiple uses and sustained yields of various products and services, including:
 - timber harvesting
 - recreation
 - livestock grazing
 - watershed protection
 - preservation of fish and wildlife habitats

Major issue affecting National Forests: the appropriate level of timber harvesting for economic & fire safety purposes.

Bureau of Land Management

- Mostly in the western United States; extensively grasslands, shrubland, and desert; but also forests, high mountain and arctic tundra.
- BLM manages public land and administers multiple-use, sustained-yield mandate that supports a variety of uses and programs:
 - mineral extraction (mining)
 - energy development (oil & gas)
 - recreation
 - rangelands: livestock grazing, wild horses, burros etc.
 - conservation
 - wildlife management and preservation

Wildlife Refuges

- 1903 President Theodore Roosevelt established the first U.S. Federal wildlife refuge at Pelican Island, Florida to help protect birds like the brown pelican.
- **Mission:** *to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the U.S.*
- **Wildlife refuges**
- Birding, hunting, fishing, hiking, and photography

Fish and Wildlife Service

- The FWS manages public land primarily to conserve and protect animals and plants.
- **National Wildlife Refuge System**
- **FWS** manages National Wildlife Refuge System; network of lands and waters that are managed for **conservation** and often **restoration** of the fish, wildlife, and plant resources and their habitats.
- **Endangered Species Act (ESA; 1973)**
 - **FWS** is responsible for administering the Endangered Species Act (ESA; 1973). The goal of the Endangered Species Act is the recovery of listed species to levels where protection under the Act is no longer necessary.
 - listing endangered and threatened species
 - listing critical habitat
 - Developing and administering habitat conservation plans

FWS- National Wildlife Refuge System

Rocky Mountain Arsenal National Wildlife Refuge

EPA Superfund Program: ROCKY MOUNTAIN ARSENAL (USARMY), ADAMS COUNTY, CO

1942-1992 Weapons manufactured at RMA included both conventional and chemical munitions, including white phosphorus (M34 grenade), napalm, mustard gas, lewisite, and chlorine gas. RMA is also one of the few sites that had a stockpile of Sarin gas (aka nerve agent GB), an organophosphorus compound.

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Managing Ecosystems & Repairing Damaged Ecosystems

- **Conservation:** Controlled Use", "Scientific Management" of natural resources. "Greatest good for the greatest number of people."
- **Preservation:** Remaining wilderness areas on public lands should be left untouched
- **Restoration:** Repair of areas damaged by humans; returning degraded habitat or ecosystem to a condition as similar as possible to its natural state. Replant forest or grassland, restore wetland, stream-bank improvement.
- **Remediation:** Most often used with cleanup of chemical contaminants in a polluted area.
- **Rehabilitation:** Turning a degraded ecosystem into a functional or useful ecosystem without trying to restore it to its original condition; e.g. Removing pollutants and replanting to reduce soil erosion in abandoned mining sites, landfills, and clear-cut forests
- **Mitigation:** Repairing/Rehabilitating a damaged ecosystem or compensation for damage, Most often by providing a substitute or replacement area; frequently involves wetland ecosystems.
- **Reclamation:** Typically used to describe chemical or physical manipulations carried out in severely degraded sites, such as open-pit mines or large-scale construction
- **Replacement:** Replacing a degraded ecosystem with another type of ecosystem; e.g. A degraded forest could be replaced by a productive pasture or tree plantation
- **Artificial Ecosystems:** e.g. Creating artificial wetlands to reduce flooding or treat sewage
- **Reconciliation Ecology:** is the science of inventing, establishing and maintaining new habitats to conserve species diversity in places where people live, work or play; e.g. *community based conservation*.

Protecting Wilderness to Preserve Biodiversity

Wilderness Act (1964): Created the National Wilderness Preservation System; Wilderness are wild or primitive portions of national forests, national parks, wildlife refuges where timbering, most commercial activity, motor vehicles, and human made structures are prohibited.

Encompasses variety of ecosystems: swamps Southeast U.S., tundra in Alaska, snowcapped peaks in Rocky Mountains, hardwood forests in Northeast U.S., and deserts in Southwest U.S.

Managed by NPS, FWS, BLM, and Forest Service

Wild and Scenic Rivers Act (1968): Established a system of areas distinct from traditional park concept to ensure protection of river environments; maintains free-flowing condition. Preserves rivers with distinct scenic, recreational, geologic, cultural or historic values.

Wilderness Areas

- **Collegiate Peaks Wilderness San Isabel National Forest;** South of Buena Vista, CO
- **The Brainard Lake Recreation Area** is set in a glacially-carved valley and the high peaks of the Indian Peaks Wilderness Area (Within Arapaho & Roosevelt National Forests); North of Boulder, CO

Land Trust Groups

Private, nonprofit organizations that actively work to conserve land by undertaking or assisting in stewardship of the land, purchasing the land, or assisting in the acquisition of conservation easements.

Conservation Easements

- Conservation easements protect land for future generations.
- A conservation easement is a restriction placed on a piece of property to protect its associated resources.
- Prevents future development of the land
- e.g. logging, ranching, mining etc.
- A conservation easement is legally binding, whether the property is sold or passed on to heirs (permanently written into the deed).
- Economic benefit: landowners are eligible for tax breaks.

High Creek Fen Preserve, Fairplay, CO- The Nature Conservancy
Yampa River Preserve, Steamboat Springs, CO- The Nature Conservancy