Web of Life
Teaching Guide for *North American Biomes*

Eight 10-minute Programs
Grades 4 – 8

Written by Ida Phillips Lynch

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Contents

KEN: These sections could be noted in a contents sidebar like in the grasslands guide, and each subject heading could have a link to that section of the site.

The Biomes Project

North American Biomes is the latest title in the Biomes Project, a multi-year, curriculum-based initiative to help students, educators, and lifelong learners explore the earth's most ecologically significant biomes. (We use the term "biome" to specify an ecological region defined by its characteristic flora, fauna, climate, and geology.)

The Biomes Project evolved from our belief that understanding the earth's natural processes is essential to developing a conservation ethic. By developing an understanding of the inner workings of the earth's diverse habitats, both far-flung and local, people can strengthen their connection with nature and become better stewards of the planet. Concepts such as bioregionalism, "know your ecological address," and "think globally, act locally" are based on similar philosophies.

The Biomes Project began in 1991 with the production *of Oceans Alive!/Oceanos Vivos* and now includes programs like the award winning *Exploring the Diversity of Life; American Deserts; Shorelines;* and *American Grasslands*. To help educators broaden their teaching methods, we are expanding the project to include the latest CD-ROM and DVD technology. The Biomes Project is a collaboration of Environmental Media Corporation and Snyder Productions, Ltd.

Overview of North American Biomes series

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

Through the Biomes Project, we are creating an encyclopedic resource that provides students, educators, and adults with a comprehensive overview of the earth's major biomes. In his groundbreaking book, *The Diversity of Life*, naturalist E. O. Wilson defined a biome as "A major category of habitat in a particular region of the world, such as the tundra of northern Canada or the rain forest of the Amazon basin." You can also define a biome as an ecological region defined by its distinguishing characteristics, such as flora, fauna, climate, and topography.

Tips on Using *North American Biomes* and *Web of Life* teaching guide

Environmental Media produces environmental education programs that are designed to serve as portals to the natural world. Our programs are designed to help children and adults strengthen their connection to nature by exploring the earth's natural diversity and examining how people interact with the natural world. The last thing we want to encourage is passive TV watching, rather, we hope our programs inspire students, educators, and lifelong learners to explore the natural world with a new perspective.

In light of this philosophy, we developed the *Web of Life* guide with two overriding objectives:

1) Provide relevant background information for each program that will assist educators in developing classroom lessons and discussions centered on the *North American Biomes*.
2) Offer suggestions and resources for organizing relevant outdoor activities, such as field trips to natural areas.

The guide is divided into the following sections:

Curriculum Connections
Subjects**:**
Science
Biology
Biomes
Plants and Animals

Educator's background information – Provides helpful background for each of the eight programs in the series, including an overview of the habitats and natural processes featured in each program. Includes biome-specific web links at the end of each section.

1. **Forests**
2. **Grasslands**
3. **Deserts**
4. **Seashore**
5. **Rivers and Streams**
6. **Wetlands**
7. **Conserving North American Biomes**

Educator's Viewing Tips: Tips for formal and informal educators for making viewing *North American Biomes* a fun, informative experience.

Take it outside – Suggestions for organizing safe and memorable field trips to North America's biomes, whether in a park, preserve, or on your school grounds.

Hot links – Links to recommended biomes websites.

Further Reading - Suggests helpful books related to North America's biomes.

Curriculum Connections

Life Science Benchmarks (AAAS: Project 2061)

North American Biomes correlates to the Life Science Benchmarks from the American Association for the Advancement of Science's Project 2061. The programs are particularly useful for teaching concepts covered in the following subject areas as identified by Project 2061: (Benchmarks that are of particular significance within the series are described in full.) For more information about Project 2061, visit www.project2061.org.

The Nature of Science
- **Scientific Inquiry**
- **Scientific Enterprise**

Physical Setting
- **The Universe**
- **The Earth**

By the end of the 8th grade, students should know that:

The benefits of the earth's resources – such as fresh water, air, soil, and trees – can be reduced by using them wastefully or by deliberately or inadvertently destroying them. The atmosphere and the oceans have a limited capacity to absorb wastes and recycle materials naturally. Cleaning up polluted air, water, or soil or restoring depleted soil, forest, or fishing grounds can be very difficult and costly.

- Processes that Shape the Earth

By the end of the 5th grade, students should know that:

Waves, wind, water, and ice shape and reshape the earth's land surface by eroding rock and soil in some areas and depositing them in other areas, sometimes in seasonal layers.

By the end of the 8th grade, students should know that:

Human activities, such as reducing the amount of forest cover, increasing the amount and variety of chemicals released into the atmosphere, and intensive farming, have changed the earth's land, oceans, and atmosphere. Some of these changes have decreased the capacity of the environment to support some life forms.

- **The Structure of Matter**
- **Energy Transformations**

- **Motion**
- **Forces of Nature**

Living Environment

- **Diversity of Life**

By the end of the 5th grade, students should know that:

A great variety of kinds of living things can be sorted into groups in many ways using various features to decide which things belong to which group.

Features used for grouping depend on the purpose of the grouping.

By the end of the 8th grade, students should know that:

One of the most general distinctions among organisms is between plants, which use sunlight to make their own food, and animals, which consume energy-rich foods. Some kinds of organisms, many of them microscopic, cannot be neatly classified as either plants or animals.

All organisms, including the human species, are part of and depend on two main interconnected global food webs. One includes microscopic ocean plants, the animals that feed on them, and finally the animals that feed on those animals. The other web includes land plants, the animals that feed on them, and so forth. The cycles continue indefinitely because organisms decompose after death to return food material to the environment.

- **Heredity**
- **Cells**
- **Interdependence of Life**

By the end of the 5th grade, students should know that:

For any particular environment, some kinds of plants and animals survive well, some survive less well, and some cannot survive at all.

Insects and various other organisms depend on dead plant and animal material for food.

Organisms interact with one another in various ways besides providing food. Many plants depend on animals for carrying their pollen to other plants or for dispersing their seeds.

Changes in an organism's habitat are sometimes beneficial to it and sometimes harmful.

By the end of the 8th grade, students should know that

In all environments—freshwater, marine, forest, desert, grassland, mountain, and others—organisms with similar needs may compete with one another for resources, including food, space, water, air, and shelter. In any particular environment, the growth and survival of organisms depend on the physical conditions.

Two types of organisms may interact with one another in several ways: They may be in a producer/consumer, predator/prey, or parasite/host relationship. Or one organism may scavenge or decompose another. Relationships may be competitive or mutually beneficial. Some species have become so adapted to each other that neither could survive without the other.

- **Flow of Matter and Energy**
- **Evolution of Life**

Human Society

- **Cultural Effects on Behavior**
- **Social Change**
- **Global Interdependence**

The Designed World

- **Agriculture**
- **Energy Sources and Uses**
- **Communication**

Common Themes

- **Constancy and Change**
- **Scale**

National Science Education Standards (National Academy of Science)

North American Biomes also correlates to the National Science Education Standards from the National Academy of Science, particularly the content standards described below. To view complete information about the standards, visit: http://bob.nap.edu/html/nses/html/.

Life Science

As a result of activities in grades K-4, all students should develop understanding of

The characteristics of organisms
Life cycles of organisms
Organisms and environments

Science in Personal and Social Perspectives

As a result of activities in grades K-4, all students should develop understanding of

Personal health
Characteristics and changes in populations
Types of resources
Changes in environments
Science and technology in local challenges

GRADES 5-8

Life Science

As a result of their activities in grades 5-8, all students should develop understanding of

Structure and function in living systems
Reproduction and heredity
Regulation and behavior
Populations and ecosystems
Diversity and adaptations of organisms

Science in Personal and Social Perspectives

As a result of activities in grades 5-8, all students should develop understanding of

Personal health
Populations, resources, and environments
Natural hazards
Risks and benefits
Science and technology in society

Program Background: Introduction to North American Biomes

If a friend asked you, "Where do you live?" you would give them your street address. But what if someone asked you to describe the BIOME that you live in. What would you say? Do you know your ecological address?

Because the world is such an enormous place and is home to so many different habitats, biologists have divided the earth into different biomes. The word biome refers to a living community and its ecology. All of the different plants and animals in a biome interact and depend on each other for life . . . including us!" (From *Introduction to North American Biomes*)

This program opens with a compelling explanation of the term *biome* that helps students think about how to classify the world's diverse habitats. The program provides an overview of North America's major biomes, including forests, grasslands, deserts, seashores, rivers and streams, and wetlands. Each profile offers a colorful discussion of the salient features that distinguish one biome from another, including natural processes like fire and flooding, and also highlights the representative flora and fauna that inhabit different biomes. This introductory show helps students develop an understanding of what it means to know your ecological address.

Understanding the biome concept provides people with a framework to help them interpret complex and sometimes confusing landscapes. Many children consider their world to be composed of only manmade structures: houses, schools, and grocery stores. We hope that *North American Biomes* will open their eyes to a new way of thinking, so that they become more attuned to the natural world that supports every structure on earth, both artificial and natural.

Viewing *North American Biomes* will help students:

Understand the concept of an ecological address – such as the watershed or river basin in which they live

Understand connections between habitats. We all live downstream from each other. Activities in one biome can affect life in another biome. For example, when a riparian forest is clearcut and no trees are left next to the stream, the stream banks can erode and deposit sediment in the water. The sediment can block sunlight and harm the freshwater mussels that inhabit the stream.

Understand the diversity of life that inhabits particular biomes

Understand how different plant and animal species adapt to conditions in their particular biome

Understand that certain species can only live in one habitat and not in another

Understand what distinguishes one biome from another and study the habitat with a discerning eye. The students will begin to think about the distinguishing characteristics, such as:

- Dominant vegetation or soil type (i.e. grass, trees, cacti, or bare rock)
- Topography/terrain – physical features
- Climate
- Biodiversity

Forests: Program Background

Program Overview

Forests provides a snapshot of North America's most widespread forest types: coniferous forest, deciduous forest, and mixed forest. The program describes each forest type and its representative flora and fauna in detail and provides an overview of general forest ecology by describing the lively world found in each layer in a forest, from the ground to the canopy.

Key Concepts
Temperate forest
Coniferous forest
Deciduous forest
Mixed forest
Canopy
Understory
Litter layer

Most forests in North America are **temperate**, meaning that they are located in the temperate zone, which is distinguished by a moderate climate with warm summers and cool winters. (The major exceptions to temperate forest types in North America are boreal forests in Canada and tropical forests in Florida.) There are many sub-categories within temperate forests, including temperate rain forests in the Pacific Northwest, longleaf pine forests in the Southeast, and floodplain forests.

In general, you can categorize North America's forests into three major types:

Coniferous forests are dominated by evergreen trees such as pines and firs that bear cones and keep their needle-like leaves year-round.
Deciduous forests contain hardwood trees like oaks and sycamores that flower in the spring and drop their broad leaves in the autumn.
Mixed forests contain a mixture of conifers and deciduous trees.

Tree Identification
The best way to learn how to identify trees is to study them throughout the year. A true treehugger can identify trees in the middle of winter, when leaves are not available to provide clues. This takes a lot of practice but is well worth the effort! Time spent in a forest is never wasted. There are many books about tree identification available, and many field guides for North America's many forest types. There are two basic features to study when looking at a tree:

What do the leaves look like? North American trees either have
- needles (i.e. pines, spruce, fir, hemlock), or
- broad-leaves (oak, hickory)

Study the texture and color of the tree's bark. Is it smooth, peeling, ridged, or furrowed?

Stratification

Looking at the various layers in a forest is a helpful way to think about how a forest works.

The crowns of the tallest trees comprise the forest **canopy**, the uppermost layer of the forest. Because the canopy receives the most sunlight, this level of a forest produces the most energy in the form of flowers and fruit. Many bird and animal species inhabit the canopy to take advantage of the food source and seek protection from predators.

Forests often contain a middle layer comprised of smaller trees called an **understory**, such as dogwoods. In early spring, understory trees take advantage of available sunlight by blooming before the canopy leafs out.

The lowest level of the forest is called the **shrub and herb layer**, in recognition of the plants that grow on this level. Spring ephemeral wildflowers, such as mayapple and jack-in-the-pulpit, are the first bloomers in the forest, as they also seek out available light before it's blocked by the canopy. After the canopy leafs out, as little as 1% of light striking the canopy actually reaches the forest floor.

In the **litter layer** on the ground, microorganisms and insects feed on decaying leaves and other plant matter and help them decompose.

Forest Adaptations

Climate, soil, and topography play an important role in determining what type of forest develops in a certain area. Only certain trees can tolerate the saturated soil in swamps. Only certain tree species can grow on a rocky mountaintop. And only certain species of trees can grow in dry, sandy soil.

Different forest types evolve in response to ecological processes, such as fires, storms, and flooding. Longleaf pine forests evolved with frequent lightning-ignited fires, so longleaf pines are specially adapted to cope with fire. Water is scarce in western deserts, so forests can only grow near rivers, streams, and underground springs. Evergreens on high mountain peaks can survive brutal winters because their leaves are designed to withstand freezing temperatures.

Sample North American Forest Type

Note: There are numerous types of forest in North America. This guide focuses on one particularly threatened natural community, floodplain forests. Follow the web links at the end of this section to find more information about North America's many other forest types.

Floodplain Forests

A floodplain is the low-lying part of a river valley adjacent to the river channel. When rivers flood, they deposit **alluvium** (layers of silt) in the floodplain. The alluvium enriches the soil, so these areas support a diversity of natural communities, including floodplain forests, swamps, marshes, and bottomland hardwood forests. Rivers flood after a heavy rainfall or storm and when snow melts in the spring (in more northerly climates).

Because rivers are dynamic and change their course and flow rates over time, they shape the topography of the surrounding landscape, including the floodplain. Just look at the Grand Canyon as one example of the powerful forces of a river – the Colorado River carved this awe-inspiring gorge over time.

What are some of the common characteristics of North America's floodplain forests?

Rivers deposit much of their silt load along the banks, creating high ridges called **levees**.

Water marks on trees indicate the level of past floods.

The upland portions of a floodplain forest often explode with a colorful wildflower display in the spring.

The water level in a floodplain varies throughout the year. **Note**: Many rivers in North America have been dammed and the dams have altered the natural flooding patterns.

How do floodplain natural communities differ in various regions of North America?

Northern floodplain forests

- floodwaters peak in the spring and recede
- dominant hardwood trees include silver maple and cottonwood
- understory harbors ferns, wildflowers
- unique plants like jack-in-the-pulpit grow in litter layer

Southern floodplain forests

- range from Virginia to Texas
- dominant trees include water-tolerant species like bald cypress and water tupelo
- rich upland slopes support abundant wildflowers
- bottomland hardwood forests provide extensive wilderness corridors for wide-ranging mammals like black bear and bobcat

Western riparian forests

- Riparian forests develop along rivers and streams and provide shade and wildlife habitat and help prevent streamside erosion and siltation.
- Dominant trees include willows and cottonwoods, with stands of mesquite **(bosques)** farther away from river
- Western riparian areas provide habitat for more bird species than all other western habitats combined!

Northwest riparian forests

- Develop along swift-moving, cold rivers and streams
- Dominant trees include black cottonwood

Representative wildlife

Mammals: black bear, bobcat, deer, elk, coyote, raccoon
Birds: hawks, wading birds, woodpeckers, owls, neotropical migratory songbirds (These birds winter in Latin America and the Caribbean and return to North America in the spring and summer to breed. Floodplain habitats provide critical nesting areas for these long-distance travelers.)
Amphibians: frogs, salamanders
Reptiles: turtles, snakes
Insects

What ecological services do floodplain forests provide?

Wildlife habitat, nutrients from flooding, recreation/education, nurseries for fish, absorb floodwaters, filter pollutants, and hunting, fishing, farming areas

What are the main threats to floodplain communities?

Logging (Most southern bottomland forests have been converted to agricultural uses.)
Livestock grazing (Over 90% of the 900,000 acres of riparian areas owned by the Bureau of Land Management in the western United States are damaged because of livestock grazing.)
Pollution
Development
Dams – By altering natural flooding patterns, dams disturb habitats and wildlife in floodplains and can prevent anadromous fish like salmon from reaching their spawning grounds. Increased hard surfaces (i.e. pavement) results in increased runoff and flooding. As floodplain forests are converted to other uses, we lose their flood control services.

Web Links

Forest Conservation Portal – Wealth of links, information on all forest types, and conservation news
http://forests.org/

American Forests
http://www.americanforests.org/

WWF Forests for Life Programme
http://www.panda.org/about_wwf/what_we_do/forests/index.cfm

Trees of Eastern North American Forests
http://www.il-st-acad-sci.org/trees/tree.html

Ecotrust Website – Information about coastal temperate rain forests from Alaska to California
http://www.ecotrust.org/

Old-growth forests in the Pacific Northwest
http://www.wri.org/biodiv/b011-btl.html

Lots of old-growth forest links from the Eastern Old-Growth Clearinghouse
http://www.old-growth.org/links.html

Grasslands: Program Background

The North American prairie is a near mythical landscape. When early European settlers ventured west of the Mississippi River into the heart of North America, they were captivated by the sight of a seemingly endless sea of grass growing as high as a horse's back in places. Biologists estimate that in the mid-1800s, the numbers of individual mammals in the North American prairie, including buffalo, pronghorn, gray wolf, elk, and grizzly bear, rivaled that of the present-day Serengeti in east Africa. Frequent fire maintained the open grasslands and infused the soil with nutrients that provided fertile ground for abundant plant and animal life.

In just half a century, European settlers cultivated and converted most of the prairie to agricultural land, so that today, only fragments of this once-vibrant landscape remain. Conservation groups are working diligently to protect, maintain, and restore the prairie remnants.

Grasslands takes you on a virtual field trip to the major North American grasslands (tallgrass, mixed grass, and shortgrass) and showcases their great natural diversity. The program also discusses some of the ecological processes that maintain grasslands, including fire and grazing, and explains how grassland plants and animals have adapted to their unique environment.

KEY CONCEPTS
Grasslands
Natural disturbance
Herbivores
Adaptations
Succession
Edge effect

Grasslands Around the World

Grasslands cover ¼ of the earth's surface. All continents except Antarctica have some type of grassland. Around the world, grasslands go by many different names:

- Asia and Europe – *steppe*
- South America - *pampas*
- South Africa – *veld*
- East Africa - *savanna*
- North America – *prairie*

What is a grassland?

The grasslands biome is dominated by different species of grasses. Limited precipitation and seasonal droughts hinders tree growth. Unlike deserts, vegetation in grasslands forms a solid cover on the ground. And unlike forests, grasslands are open and offer expansive views.

Grazing animals (**herbivores** – animals that eat only plants) help maintain grasslands. For example, antelopes and zebras graze in African savannas, while deer, bison, and elk graze in North American grasslands.

Where are North America's grasslands?

The largest unbroken expanse of grasslands in North America is an enormous area covered by tall, mixed, and shortgrass prairie ranging from the Appalachian Mountains to the Rocky Mountains.

What do all grasslands have in common?

Different types of natural disturbance maintains grassland habitats:

- Grazing by native herbivores
- Fire (either ignited by lightning or humans) keeps the habitat open, removes dead plant matter, infuses the soil with nutrients, and prevents trees from invading.
- Drought

Grasslands are usually found on flat or rolling terrain with rich, fertile soil.

What is a grass?

A grass is an herbaceous plant (a nonwoody plant) that does not form woody tissue or increase in girth like trees. Grasses have hollow, round stems and small, nondescript flowers. They can be classified by their blooming periods. Cool-season grasses grow more during the spring and autumn, while warm-season grasses grow during the summer.

Tall grasses such as big bluestem, blue grama, and buffalo grass are warm season grasses. Cool season grasses include needlegrass and wheatgrass.

Grasses are primarily pollinated by wind, although insects pollinate some species.

Grasses are usually small, except for sugarcane and bamboo. Many of our most important crops are grasses: oats, wheat, rice, corn.

Perennials (plants with a life cycle lasting more than two years) are the dominant plants in natural grasslands.

What animals live in grasslands?

Large numbers of burrowing animals live in grasslands: prairie dogs, ground squirrels, and pocket gophers. Burrows provide a refuge from extreme temperatures, predators, and fire.

Throughout the world, the herbivores that live in grasslands are typically ungulates (hooved mammals) that share similarities: horns; broad, blunt teeth that are adapted for chewing; and complex stomachs that are designed to digest fibers.

Large grazing animals (pronghorn, bison) have various adaptations to life in the open prairie: they tend to be social and live in herds or colonies, they are fast runners, and rely on good vision for spotting enemies.

Smaller grazers (i.e. prairie dogs) sit upright so that they have a better field of vision. These animals are usually burrowers that live in large colonies.

There are abundant insects in grasslands, particularly grasshoppers.

The open spaces and abundance of small mammals make grasslands prime habitats for raptors (birds of prey such as hawks and eagles).

Yes, fire can be beneficial in grasslands!

Lightning often ignites fires in grasslands, usually during summer thunderstorms, so this biome evolved with frequent fires and plants are adapted to fire. Before European settlement, fires would spread uncheck until they ran into a creek or gully. Native Americans also started fires in order to drive game to hunters or to attract game by creating new growth. Today, fires are typically suppressed, unless land managers set a prescribed burn.

Fires unlock nutrients and kill trees and shrubs that would otherwise invade grasslands.

Unlike many tree species, grasses rebound quickly after a fire.

What are the different types of grasslands in North America?

Tallgrass Prairie
The so-called "true prairie," tallgrass prairie was once the most dramatic North American grassland, containing grasses that grew up to 12 feet in height (but averaged roughly 5 feet in height). According to The Nature Conservancy, tallgrass prairie originally spanned portions of 14 states and covered over 142 million acres. Early settlers described grass reaching high as a horse's back – often described as a sea or ocean of endless grass. Today this habitat may cover only 1% of its former range.

Mixed Prairie
On the western edge of its range, tallgrass prairie grades into mixed prairie, where medium-sized grasses average between two and four feet. Mixed prairie is considered a combination of short and tallgrass prairie and contains more plant species than any other prairie type.

Shortgrass Prairie
Short, warm season grasses, such as buffalo grass and blue grama grass, dominate shortgrass prairies. These grasses grow in poor soils, average less than 2' in height, and form sod. Grazing by large ungulates such as buffalo and pronghorn and small animals like prairie dogs historically maintained these grasslands. Shortgrass prairie is the largest remaining grassland biome in North America.

Remnant Grasslands
Although we often think of the "big three" grassland types (tallgrass, mixed grass, and shortgrass) when we think of North American prairies, there are actually other types of grasslands on the continent that are simply not as well-known. In fact, remnant grasslands can be found in eastern North America and in the Everglades in Florida.

Desert Grasslands
A mixture of grassland and desert, desert grasslands are found in the southwestern United States, usually on slopes above desert habitats.
This habitat ranges through southeastern Arizona, southwestern New Mexico, and parts of Texas at elevations just above true desert, between 4,000-8,000'.
These are the most arid North American grasslands, receiving between 11-17 inches of rain annually, primarily during the winter and summer.

Intermountain Grasslands
Precipitation in this arid habitat averages 10-15" a year. This is similar to shortgrass prairie, but most of the precipitation occurs in the fall and winter. In summer, daytime temps can hit 100 F, so this climate is not very hospitable to plants.
AKA sagebrush grasslands, this habitat is actually dominated by sagebrush, not grasses. The dominant grass species here is bluebunch wheatgrass.
Desert grasslands are bounded by the Rockies to the east and the Sierra Nevadas and Cascade ranges to the west and are found in Utah, Nevada, and part of eastern California.

Eastern Grasslands or Successional Grasslands
This habitat is not completely "natural." Settlers in eastern North America cleared large areas of forest to create agricultural land. These areas are still maintained as

agricultural grasslands or are old fields that are slowly converting back to forest through **succession**. This is a process in which the dominant species in a habitat changes. During succession, trees gradually invade the grassland and slowly become the dominant species, making a forest.

The **edge effect** is important in eastern grasslands: the edge or ecotone is a meeting place between two habitats. The edge often contains more species than either of the individual habitats because it can support wildlife from both habitats. Common animals in eastern grasslands include gray squirrel, coyote, rabbit, gray fox, rats, and mice.

Birds include eastern meadowlark, bluebird, bobwhite, and goldfinch

Lots of insects – butterflies and grasshoppers

Coastal Grasslands

Everglades: The largest marsh system in North America, the Everglades is a vast low-lying plain fed by Lake Okeechobee in southern Florida. A diversity of habitats is found in this "river of grass", such as tropical hammocks, marshes with saw grass, sloughs, and gator holes. The United States government is funding a long-term project to restore the natural flow of water to the Everglades and rejuvenate this battered ecosystem.

Where have all the grasslands gone?

In half a century, European settlers completely altered the prairies by converting them to agricultural land and killing off many of the native animals, particularly bison, prairie dogs, and predators such as wolves. Now only remnants of grasslands remain.

Grassroots – A Sampling of Grassland Web Links

World Resources Institute grasslands information
www.wri.org/wri/wr2000/grasslands_page.html

World Wildlife Fund ecoregion information
www.wwfus.org/ecoregions/ecoregions_map.htm

Grasslands information from National Wildlife Federation
http://nationalwildlife.org/grasslands/americas_grasslands.html

Grasslands description from eNature.com
www.enature.com/outdoors/outdoors_home.asp

Greatplains.org
www.greatplains.org/

Status and Trends of the Nation's Biological Resources
www.npwrc.usgs.gov/resource/2000/grlands/grlands.htm

Yahooligans grasslands links:
www.yahooligans.com/Science_and_Nature/The_Earth/Ecology/Prairies_and_Grasslands/

Library of Congress Prairie Settlement photos and writings

http://memory.loc.gov/ammem/award98/nbhihtml/pshome.html

Deserts: Program Background

Refuting the myth that deserts are hostile places that only a vulture or a snake could love, this program highlights the beauty and mystery of North America's four major deserts: the Great Basin, Chihuahuan, Mojave, and Sonoran. The program discusses traits common to deserts all over the world, describes the important differences between each of the deserts, and showcases representative plants and animals in each desert.

Key concepts
Desert
Ephemeral plants
Endemic species
Keystone species
Ice age

What is a desert?

The *Dictionary of Physical Geography* defines a desert as "an arid region characterized by little or no rainfall in which vegetation is scanty or absent, unless specially adapted or where groundwater conditions are favorable."

North American deserts are more than just dry places – these areas are characterized by a combination of climatic conditions.

North American deserts usually receive less than 10 inches of rain annually and evaporation often exceeds that amount. The evaporation is caused by high radiation (sunlight).

There is a wide range between the daytime high temperatures and nighttime low temperatures in the desert because the earth loses heat quickly after the sun sets.

Where are deserts located?

Deserts cover approximately one-fifth of the total land area on earth. The Sahara Desert covers one-third of Africa and is the largest desert in the world.

Where are North American's deserts located?

North American deserts are sandwiched between two major mountain ranges: the Rocky Mountains on the east and the Sierra Nevada Mountains on the west. In North America, deserts cover more than 500,000 square miles. Note: Biologists and geologists have differing opinions about the exact boundaries and sizes of the North American deserts, so the area figures discussed in this guide are approximations.

Much of the desert landscape in North America has a **basin and range** topography, characterized by mountain ranges interspersed with flat, valley-like basins.

What are the different types of deserts in North America?

In a **cold desert** (like the Great Basin) more than half of the yearly precipitation falls as snow. The desert's northern location results in low average annual temperatures. Conversely, a **hot desert** (like the Mojave) receives either winter or summer precipitation (or both) mainly as rainfall.

Overview of North American Deserts

Chihuahuan Desert

Hot Facts

Most of the Chihuahuan Desert is located in Mexico, but about 10% of this desert creeps into southern New Mexico, western Texas, and southeastern Arizona. North America's largest desert covers approximately 200,000 square miles.

The Chihuahuan Desert receives less than 10 inches of rain between mid-June and mid-September, while October to June are typically dry months.

This high desert ranges from elevations of about 1,000 feet at the Rio Grande River to mountains over 6,000 feet. Because of the wide range in elevations, the desert can have freezing temperatures during the winter, while the summer can be extremely hot.

Plant Life

Low shrubs, such as **creosote** and **mesquite**, dominate this desert. Most of the **ephemeral plants** (annual plants that have a brief growth cycle) bloom in the summer. Although this desert contains more species of cacti than the Mojave or Great Basin Deserts, cacti are not as dominant as they are in the Sonoran Desert.

Agave lecheguilla symbolizes the Chihuahuan Desert and stands beacon-like on the mesas and hillsides. Archaeologists have unearthed ancient sites containing evidence that people were using agave fibers 9,000 years ago to make baskets, ropes, and mats.

Several species of **yucca** are also a significant part of the Chihuahuan Desert landscape.

Representative animals

The **javelina** or **collared peccary** is a member of the Old World swine family. This social animal forages in herds of 6 to 30 animals.

The **black-tailed jackrabbit** is actually a hare. Hares are typically larger than rabbits and are easily identified by their long ears and strong hindlegs.

Other representative animal species include: **coyote**, **mule deer**, **kit fox**, **bobcat**, and **mountain lion**.

Protected Areas

Llinks to many of the significant publicly-owned parks in the Chihuahuan Desert
http://www.nature.nps.gov/im/units/nw24/index.htm
(Amistad National Recreation Area, Big Bend NP, Fort Davis National Historical Site, Guadalupe Mountains NP, and White Sands National Monument)

Nature Conservancy, Texas Chapter preserves
http://nature.org/wherewework/northamerica/states/texas/preserves/

Hot links: Websites

Centennial Museum's excellent site offers comprehensive information on this desert, species lists, photos of representative species, links, and a bibliography.
http://nasa.utep.edu/chih/chihdes.htm

Chihuahuan Desert Research Institute
http://www.cdri.org/

Chihuahuan Desert Biosphere Reserve
http://www.nps.gov/bibe/mab.htm

Digital Desert library page about Chihuahuan Desert
http://horizon.nmsu.edu/ddl3/chihuahua.html

Description of Chihuahuan Desert ecoregion
http://www.neartica.com/ecology/ecoreg/321.htm

Sonoran Desert

Hot facts

The Sonoran Desert comprises approximately 100,000 square miles in the United States and Mexico, wrapping around the Gulf of California and reaching into southeastern California and southern Arizona and extending into Sonora and Baja California in Mexico.

This subtropical "hot" desert receives rainfall in both the summer and winter, contributing to its great natural diversity.

The Sonoran contains more plant and animal species than any other North American desert.

This young desert is probably no more than 10,000 years old.

The Sonoran Desert ranges from 235 feet below sea level to 3,450 feet above sea level. Snow usually falls in part of the mountainous portions of the desert, while lower reaches of the desert never receive frost and can have up to 90 consecutive days with temperatures over 100 degrees Fahrenheit during the summer months.

Plant Life

The Sonoran Desert has the classic desert look, with many species of cactus dominating the landscape, including **saguaro**, **cholla**, and **prickly pear**.

The saguaro cactus (*Cereus giganteus*) symbolizes the Sonoran Desert to many people. The largest cactus in the United States, the statuesque saguaro can live up to 200 years and may grow over 40 feet tall. When the plant reaches between 15 and 25 feet, it sprouts branches or arms, which give it an almost human-like appearance. You can determine a saguaro's age by its size; a saguaro that is 25 feet or taller is probably more than 85 years old.

The saguaro and other cactus species have been such hot items for landscaping in the western United States that their numbers are declining. Many cactus species are now protected by law in Arizona.

The Sonoran Desert also contains tall shrubs such as **ocotillo** and **palo verde** that are called subtrees.

Animal Life

The Sonoran Desert is home to many species of reptiles, including the federally listed endangered **desert tortoise**, which spends the hottest part of the day languishing in a shallow burrow.

The ominously named **Gila monster** is a venomous lizard that overpowers predators and prey with its bite.
The **chuckwalla** is a vegetarian lizard that dines exclusively on leaves, flowers, fruit, and buds.
The Sonoran Desert is home to abundant birdlife, including **roadrunner**, **curve-billed thrasher**, and **cactus wren**. The state bird of Arizona, the aptly named cactus wren nests in cactus, darting in and out of a prickly entrance that deters most predators.
Many woodpecker species nest in saguaro, including the **Gila** and **ladderback woodpeckers** and the **northern flicker**. The **elf owl**, the smallest owl in the world, roosts in nest holes that woodpeckers drill in the saguaro.
Sonoran Desert mammals tend to be nocturnal to avoid the oppressive daytime temperatures. Representative mammals include **bighorn sheep, coyote, ground squirrel, white-nosed coatimundi** or **coati, badger**, and various species of mice.
A member of the raccoon family, the coati is an agile climber that sleeps in trees at night and descends during the day to forage for food, including its favorite delicacy, fruit.
Contrary to popular myth, the bite of a **desert tarantula** is not lethal to a healthy person and is usually equivalent to a wasp or bee sting. The largest spider species in the North American desert, tarantulas can have a leg span of six to seven inches.

Protected Areas

Organ Pipe Cactus National Monument
http://www.nps.gov/orpi/

Saguaro National Park
http://www.nps.gov/sagu/

Sonoran Desert National Monument (and 4 other national monuments in AZ)
http://azwww.az.blm.gov/sonoran/sondes_main.htm

The Nature Conservancy Arizona Chapter
www.tnc.org/arizona

Arizona-Sonora Desert Museum
http://desertmuseum.org/

Hot links

"Sonoran Desert: 5000 Square Miles of Silence" - A beautiful visual and literary virtual journey through the Sonoran Desert
http://www.oneworldjourneys.com/sonoran/eco_gallery.html

Pre-eminent desert natural history museum - Arizona-Sonora Desert Museum
http://desertmuseum.org/sonora.html

Desert Watch – A nonprofit coalition working on critical environmental issues in the Sonoran Desert
http://www.desertwatch.org/index.html

Proposed Sonoran Desert National Park
http://www.sonorandesertnp.org/

Mojave Desert

Hot Facts

A transition area between the Great Basin and Chihuahuan deserts, the Mojave contains plant life representative of both deserts.

The smallest North American desert, most of the roughly 54,000-acre Mojave Desert is located in California, but the desert extends into southern Nevada and a small portion of Arizona.

The desert is characterized by a basin and range topography, with elevations ranging from 2,000 to 4,000 feet.

The Mojave receives very little rainfall – much of the desert receives less than six inches a year. Rain falls in the Mojave primarily in the winter, and spring ephemeral wildflowers bloom from March through May.

The all-time maximum high temperature in the United States, 134 degrees F, was recorded at Death Valley National Monument in California. This is also the world's second highest recorded temperature. At 282 feet below sea level, Death Valley is the lowest point in the United States.

The ground surface in the Mojave can reach 190 degrees F in the summer.

Plant Life

Because of the lack of rainfall, the Mojave is characterized by low, widely spaced shrubs. Found in all the North American hot deserts, **creosote bush** is the dominant ground cover in the Mojave Desert.

Of the 250 species of ephemeral plants in the Mojave, 80% of these plants are **endemic species** (found only in the Mojave region).

The **Joshua tree** symbolizes the Mojave. The largest yucca, the Joshua tree has a short stout trunk and spiny pointed leaves. Like the saguaro in the Sonoran desert, the Joshua tree is a **keystone species** (a **keystone** or **indicator species** dominates an ecosystem because of its great importance to other species). Other plants like creosote and sagebrush grow in the Joshua tree "forest" and at least 25 bird species nest in Joshua trees, including **Scott's oriole**.

The Mojave also harbors a few cactus species, mainly **prickly pear** and **cholla**.

Animal Life

Bighorn sheep are about the size of a small deer. The mature males are characterized by their huge, spiraling horns. This sheep drinks water about every 3 to 5 days in hot weather and every 10 to 14 days in cold weather.

Other representative animals include **desert tortoise**, **whiptail lizard**, several species of **ground squirrel**, **coyote**, **bobcat**, and four species of **bats**, including the **western pipistrelle**, the smallest bat in the United States.

Protected Areas

Mojave National Preserve (Includes ecological information and photos)
http://www.nps.gov/moja/home.htm

Death Valley National Park
http://www.nps.gov/deva/Expanded.htm

Joshua Tree National Park
http://www.nps.gov/jotr/desert/desert.html

Mojave Desert State Parks
http://www.calparksmojave.com/

Hot Links

Geology of Mojave National Preserve
http://www2.nature.nps.gov/grd/usgsnps/mojave/mojave1.html

Mojave Desert digital cartographic database
http://www.gis.uiuc.edu/mojave/mojave_baa/mojave.html

On-line photos of Mojave Desert
http://wrgis.wr.usgs.gov/MojaveEco/photos.html

General Mojave Desert information
http://mojavedesert.net/

Great Basin Desert

Hot Facts

The Great Basin comprises approximately 200,000 square miles in eastern Washington, central and southeastern Oregon, southern Idaho, a small portion of Colorado, and much of Nevada and Utah.
Elevations range from 5,000 to 13,000 feet.
The Great Basin receives 4 to 11 inches of rain annually, with about 60% of the precipitation falling in the colder months in the form of snow.
The desert has a classic basin and range topography; mountain ranges are visible throughout the desert.
During the last **ice age** (any period in history when the Earth's surface temperatures were lowered and ice sheets expanded), glaciers migrated southward and the melting ice and wetter climate covered the basin in lakes. When the glaciers retreated, the lakes dried out. Today the Great Basin contains remnants of these ancient lakes, including Great Salt Lake.

Plant Life

The Great Basin landscape is dominated by low shrubs, particularly **sagebrush**, which provides food for many animals and firewood for people. Trees are uncommon in this desert, except for **cottonwoods** and **willows** that grow along some streambeds and **pinons** and **junipers** that are found on the edge of the desert. This desert contains few cactus species.

Animal Life

Many Great Basin animals, such as the **sage grouse**, **sage sparrow**, **sage thrasher**, and **sagebrush lizard**, are closely linked to sagebrush. The sage thrasher and sage sparrow breed in sagebrush habitat, building their nests in the shrub and using the bark for nesting material.

The male sage grouse does a lot of primping and preening in order to attract a female. In the early spring, the male goes through an elaborate courtship display in which he displays his plumage, fans his tail, puffs out a ruff on his neck and makes a loud popping noise by releasing air from sacs on his breast. The **pronghorn** is sometimes inaccurately called an antelope. This species was almost eliminated by hunting, but protection laws helped bolster its numbers, although the overall population is still small. People hunt these grazing and browsing animals. When alarmed, pronghorns can run up to 50 miles an hour.

Protected areas

Great Basin National Park
http://www.nps.gov/grba/home.htm

Hot Links

Sierra Club information about Great Basin desert
http://www.sierraclub.org/ecoregions/greatbasin.asp

Great Basin - Mojave Desert region information
http://biology.usgs.gov/s+t/SNT/noframe/gb150.htm

General Hot Links – North American desert websites

Great general resource with fact sheets, photos, links and updates.
http://www.desertusa.com/

Digital desert library
http://horizon.nmsu.edu/ddl/

Yahooligans desert links
http://www.yahooligans.com/Science_and_Nature/The_Earth/Ecology/Deserts/

Bureau of Land Management environmental education website features activities related to Sonoran and Great Basin deserts.
http://www.blm.gov/education/

General information on deserts and geology.
http://pubs.usgs.gov/gip/deserts/

Good general information on deserts from the Evergreen Project.
http://mbgnet.mobot.org/sets/desert/index.htm

Links to websites discussing deserts, arid lands and desertification throughout the world.
http://geography.about.com/education/geography/msub99.htm

Seashore: Program Background

Other than beet-red sunbathers and waterlogged surfers, what other lifeforms inhabit North American seashores? This program unearths the mysteries of the coast by describing the characteristics of habitats found along the Atlantic, Gulf, and Pacific coastlines. Unique maritime habitats, such as sandy barrier islands and rocky shorelines, are compared and contrasted.

Key Concepts:
Plankton
Wrack zone
Pioneer plants
Estuaries
Succession

Hit the Beach!

North America's dynamic shorelines are areas of constant change. The distinctive maritime habitats are affected in varying degrees by powerful forces such as salt spray, wind shear, intense sunlight, and storms. Wind, water, and tides constantly reshape the open beach habitat, while maritime forests are more stable habitats that are typically protected from the roiling ocean. In general, North America's beaches range from rocky coastlines found on the New England and West coasts, to the sandy beaches and barrier islands found along the Southern Atlantic and Gulf Coasts.

Rocky shorelines are exposed edges of rock that have been weathered by the ocean. Tide pools on rocky coastlines provide a fascinating "aquarium" for nature study – you can lose yourself for hours gazing at tidepool life, such as vibrant starfish and prickly sea urchins. Coral shores are found near offshore reefs and are made of tiny pieces of dead coral. In contrast, sandy beaches are created over millions of years when rivers dump sand into the ocean and the ocean spits the sand back onto the shore.

Beach Beauties

Sandy beaches are often found on barrier island that parallel the mainland. Storms and hurricanes are part of life on these dynamic systems.

The **strand** is the part of the beach that is completely unprotected from waves, salt spray, and sunlight. Microscopic plants and animals thrive in the water between sand grains, while larger organisms inhabit two worlds, both above and beneath the sand. When waves break on the beach and recede, mole crabs and tiny colorful coquina clams tunnel into the wet sand to escape the sun and predators. Burrowing in the sand is an essential survival skill for many coastal species.

Crabs and clams feed on **plankton**; these tiny plants and animals wash up with the waves and form the bottom layer of the marine food web. In turn, sandpipers, plovers, and other shorebirds feast on the crabs and clams. Shorebirds have specialized bills for probing in the sand or prying open mollusks.

The **wrack zone** of the beach lies above the high tide line. This area is often littered with shells and seaweed and is a treasure trove for beachcombers. The ghost crab is a common resident of the wrack zone. This pale predator is a master digger that excavates deep tunnels in the sand. Particular plant species, called **pioneer plants**,

gain their first toehold on the beach in the wrack zone. Many of these plants, like sea elder, have thick leaves that contain water and can withstand salt spray and wind.

No shoes, ouch! – Dune Field

Sea oats and American beachgrass trap sand that then forms sandy clumps and gradually develops into dunes. Over time, the wind blows the dunes towards the mainland and rows of dunes become established behind the older dunes as they migrate to the back side of the island.

The dune field habitat is subject to searing temperatures in the summer, but it also hosts a variety of life. Morning glory, prickly pear cactus, yucca, and sandspurs are some of the plants typically found in dune fields. Small mammals like rabbits, reptiles, and songbirds and harriers also live here.

Ancient Woodlands: Maritime Forests

Vegetation can develop on the sound side of stable barrier islands that contain an extensive dune system. Over time, this vegetation can develop into thickets dominated by evergreens like juniper and large shrubs such as wax myrtle. Eventually, the thicket can develop into a rare maritime forest. This developmental process is called succession.

Maritime forests are globally rare habitats found on the highest parts of islands on ancient stabilized dunes that shelter trees from most storms. These forests often have a distinctive rounded canopy that has been pruned and molded by countless storms and hurricanes. This protective canopy serves many important functions: it shades the forest and blocks salt spray, but allows rainwater to penetrate to the ground. The dunes absorb rainwater and slowly release it into the ground, forming a dome or lens of fresh water over the salty groundwater. This fresh water is essential to the diversity of life found in maritime forests.

A great variety of plants and animals inhabit maritime forests. Freshwater ponds can develop in low-lying swales, providing habitat for reptiles and amphibians. Gray fox, white-tailed deer, and raccoons forage in the woods. The forests are important resting and nesting places for neotropical migratory birds, as well as resident ducks and other aquatic birds.

Threats

Everyone loves a day at the beach, so around the world, coastal communities and natural areas are besieged by exploding development. Development, road building, constructing jetties and sea walls to battle beach erosion, and growing numbers of beachgoers can have devastating effects on coastal habitats.

Estuaries – Life in Flux

An **estuary** is a body of water where fresh water from inland rivers and streams mixes with seawater flowing in from the ocean. Estuaries are created when the ocean floods old river valleys and are usually located at the mouths of rivers and streams. There are many types of estuaries, including inlets, sounds and bays.

The word “estuary” is derived from the Latin word “aestus”, which means “boiling” or “heaving of the sea.” As rivers flow from the mainland towards the ocean, they carry

fresh water into the sea. At high tide, salt water flows into inshore places like bays, where it meets the river water that is heading for the ocean. Because fresh water is lighter than salt water, the fresh water usually flows over the salty water. Sometimes, they mix together to create brackish water. Because most aquatic organisms can only live in fresh or salt water, but not in both, estuarine organisms have adapted to their constantly changing environment, where powerful currents swish them around in a watery world that is very salty in some places and not so salty in others. It's almost like living in a washing machine!

Estuaries are tidally influenced. A low tide exposes all the creeks, marshes, and mud flats found on the edge of estuaries. High tide submerges these habitats.

Did you know?

Biologists consider estuaries one of the richest ecosystems in the world because they provide food and shelter for countless plants and animals. A healthy estuary provides up to ten times the weight of organic matter produced by a cornfield of the same size.

The rivers that flow into estuaries and bays are full of silt, tiny particles of soil containing nutrients like phosphorus and nitrogen that are essential to all living organisms. When the tide goes out, another nutrient-rich current flows into the estuary: a rich soup of decomposed plants created in salt marshes. All these nutrients help feed the plants that grow in estuaries and bays. Many of these plants, like eelgrass, grow underwater and have adapted to the salty conditions in an estuary. These plants are a vital part of a complex food web and provide food and shelter for fish that hide in the underwater stalks and snails that cling to the plants above water. These smaller organisms provide food for larger marine fish, waterfowl, and mammals.

Different organisms have adapted to estuaries in different ways. When water conditions are unfavorable for a mollusk like an oyster, it simply closes its shell and waits for things to improve. Animals that can swim, like crabs, move throughout an estuary until they find a suitable spot. Blue crabs have adapted so well to estuarine life that they can live in both the open ocean and in estuarine rivers where there is very little salt water.

Although estuaries do not have as many different kinds of species as you find in the ocean or some freshwater habitats, species that inhabit estuaries usually have large populations. Because all the changing conditions make life in an estuary risky, animals like blue crabs and oysters produce tons of offspring to ensure the survival of the species.

Many marine fish spawn, or lay their eggs, in the sheltered waters of estuaries and bays. Their young hatch and grow in the relative safety of the estuary and then swim out to sea to live until they return to the estuary to spawn. It is estimated that 90% of all the commercially collected saltwater fish and shellfish have spent part of their lives in an estuary.

Bays are great places to birdwatch because many bird species, particularly waterfowl, frequent these areas where they have productive feeding grounds and

sheltered places to nest. In the winter, huge, noisy flocks of migratory waterfowl, birds that breed in the north in the spring and summer and fly south in the winter, congregate in the warmer temperatures of southeastern bays.

Threats

Unfortunately, people have disrupted the delicate balance of life in bays and estuaries by dredging the wetlands, filling them in, and building houses and developments on their banks. Pollution and sediment can have a devastating effect on the ecology of a bay or estuary. When fertilizer from agricultural fields runs off into rivers and flows into estuaries and bays, it transports high concentrations of nitrogen and phosphorus that cause too much algae to grow in the habitat. The algae consumes all the oxygen and cuts off sunlight to the underwater vegetation, causing the submerged grasses to die. Because these grasses feed and shelter estuarine organisms, their destruction harms all life in the estuary.

There are many reasons why we should work to protect these irreplaceable habitats that provide food and shelter for an abundance of wildlife. Bays and estuaries provide ecological services to humans that we could never duplicate ourselves. They serve as nurseries for most of the fish and shellfish that we harvest and eat. Estuaries also buffer the mainland from storms, protecting mainland habitats and sheltering human developments.

For centuries, people have reaped the fruitful harvest provided by bays, as evidenced by the discovery of middens, or mounds of shells, left by Native Americans. Since Colonial times, estuaries and bays have provided critical channels to the sea and mainland rivers for ships transporting goods. Many lives, both human and wild, rely on healthy, unpolluted estuaries and bays.

Go with the flow: Coastal (Saltwater and Brackish) Marshes

Marshes develop in shallow, calm water when rivers and oceans deposit layers of sediment, or organic matter, on flat, sheltered shores. Marshes are usually found on the border of estuaries and between offshore islands and the mainland.

Few species of plants can tolerate salt water every day, but plants like **cordgrass** have adapted to daily doses of salt water. Over time, these plants gain a toehold in the sediment and spread, creating the marsh ecosystem. This grass dominates many salt marshes.

Depending on their location and whether they are flooded by ocean tides or fresh water from rivers, marshes are classified as freshwater, saltwater, or brackish, meaning slightly salty water. Most of the coastal marshes in the United States are salt water because they tend to be located near the ocean and are flooded with sea water twice a day.

In a salt marsh, life goes with the flow -- the rise and fall of tides. At high tide, creeks flood the marsh with seawater from the ocean and brackish water from estuaries. Wading birds, ospreys, and harriers fly around the marsh at high tide.

At low tide, the salt water drains out of the marsh and flows down tidal creeks into the estuary, exposing mud flats, oyster reefs, and creek channels. Great armies of fiddler crabs scurry about feeding on small life they find by probing the marsh mud. Their eyes are perched on tops of stalks, improving their vision on land, and in the water.

All life in the marsh depends on cordgrass either directly or indirectly. When cordgrass dies, microscopic bacteria attaches to it and causes the grass to decompose into small particles called **detritus**. Consumers in the marsh, like snails and fiddler crabs, eat the bacteria and detritus. In turn, predators, like larger fish and birds, dine on the consumers.

Tidal creeks also spread the wealth of food energy stored in the detritus. At low tide, the creeks drain the marsh and transport most of this power food into the estuaries and oceans where it is eaten by other organisms like shrimp and fish.

A few mammals, like raccoons, feed on the crustaceans and fish in marshes, but for the most part, salt marshes are home to many aquatic and bird species and few mammals. Marshes are important nurseries for many species of marine fish and crustaceans. After these organisms hatch, they swim up tidal creeks and into ponds in marshes, where they can feed and grow and be relatively safe from predators.

Every winter, large flocks of waterfowl migrate from the north to the south to spend these harsh months in a place where they can find enough food to survive.

Threats

In spite of their great value, people have mistreated marshes, spraying them with pesticides, dumping garbage in marshes, and draining and filling them in for developments. Before the Civil War, settlers converted many marshes into rice plantations.

Yet, without the abundant food provided by these habitats, many of the fish and shellfish that we eat would die. Marshes buffer the mainland from storms. Marsh grass filters pollutants out of the water. Wetland laws provide some protection for North America's wetlands like marshes, but these fragile habitats continue to be damaged.

Websites

SeaWeb – clearinghouse for a wealth of coastal and marine information and organizations
www.seaweb.org

The Ocean Conservancy – A nonprofit conservation group (formerly Center for Marine Conservation)
www.oceanconservancy.org

Woods Hole Oceanographic Institution – World's largest independent oceanographic institution
www.whoi.edu

Surfrider Organization – Grassroots nonprofit working to protect oceans and beaches in North America
www.surfrider.org

NOAA – A plethora of marine and coastal information
www.noaa.gov

National Estuarine Research Reserve System
www.ocrm.nos.noaa.gov/nerr/

Clearinghouse of estuary information
http://www.estuaries.org/

Rivers and Streams: Program Background

Did you know that North America's rivers and streams are home to the world's richest populations of freshwater fish, mammals, mussels, crayfish, snails, and aquatic insects? *Rivers and Streams* follows a river as it journeys from its headwaters to the sea, describing the natural processes and riverine plants and animals you encounter along the way. The program introduces important concepts such as the role of riparian areas and why river and stream conservation is linked to our quality of life.

Key Concepts:
Groundwater
Watershed
Riparian
Benthic
Anadromous fish

How do rivers and streams form?
Streams originate from precipitation and springs and seeps, where cool, clear water flows out of the earth from **groundwater** (the water reservoir beneath the surface). The water flows downhill, forming rivulets that develop into streams. Eventually, streams braid together to form rivers, which drain into the ocean. The United States contains 3.5 million miles of rivers. Rivers are most common in areas that receive a lot of rainfall. Arid regions in the western United States contain **temporary streams** or **arroyos** that only fill with water after a heavy rain.

What is a watershed?
A watershed is a distinct geographic region named for the body of water into which all the area's rivers and streams drain. Watersheds contain both water (aquatic) and land (terrestrial) habitats. Hills and mountains form watershed boundaries.

What are the different types of rivers?
The surrounding landscape and topography influence both the health and individual features of rivers. Fast-flowing rivers and streams are usually found in hilly or mountainous areas and contain abundant oxygen. Slow-moving rivers are usually found in areas with a slight gradient, like the Coastal Plain.

Rivers can by classified by the appearance and clarity of the water:
Brownwater or **whitewater** rivers carry a lot of sediment and can look muddy.
Blackwater rivers are tea-colored, as they contain decaying dissolved plant matter that produces **tannic acid**.
Clearwater rivers are usually fed by springs and carry little sediment.

What is a riparian area?
A riparian area is a vegetated or forested buffer along a river or stream that provides shade and wildlife habitat and helps prevent streamside erosion and siltation.

What are some of the unique forms of aquatic life in rivers and streams?
Some insects, like dragonflies and mayflies, lay their eggs in water and their larvae (called **nymphs**) develop underwater.
Benthic or bottom-dwelling invertebrates are the most abundant life forms in some streams (i.e. **mollusks** and insect larvae).

Bivalves (clams and mussels) help maintain a healthy aquatic environment - these filter feeders eat plankton and filter pollutants and nutrients from the water.
Anadromous fish (i.e. salmon and shad) spend most of their lives in the sea but return to their river or stream birthplace to spawn.
Other riverine inhabitants include mammals such as river otter, mink, muskrat, and raccoon, wading birds like herons and egrets, migratory songbirds, and reptiles and amphibians.

What are the different components of a riverine food web?

Drift consists of the algae, bacteria, and detritus that flow through the water.
Grazers like snails eat algae, moss, and bacteria.
Decomposers like bacteria break down plant remains.
Shredders like mayfly nymphs eat bigger plant remains.

How do the upstream and downstream segments of a river differ?

Upstream segments of a river may be cool, fast-flowing and rocky, but as a larger river flows downstream, it slows and spreads out throughout its floodplain. Marsh-like habitats can develop along the riverbanks. Trees cannot shade the entire river so the water temperature rises.

What do rivers and streams provide?

Transportation, food, drinking water, and recreation

What are the major threats to rivers and streams?

Pollution, dams (alter natural flooding patterns), sedimentation, and non-native species

Web Links

American Rivers – Leading river conservation organization
http://www.americanrivers.org/

National Park Service website with many links to river-related organizations
www.nps.gov/rivers/information.html

An incredibly detailed website about microscopy and microorganisms: go to the Pond and Stream life section on this page
www.microscopy-uk.org.uk/dww/index.html

National Wild and Scenic Rivers
http://www.nps.gov/rivers/

Rivers of Life – Educational resources
http://cgee.hamline.edu/rivers/

Wetlands: Program Background

The confusing thing about wetlands is that sometimes they are wet, and sometimes they are bone dry. *Wetlands* will help students understand the many different types of wetlands in North America, ranging from permanent lakes to floodplains that have a fluctuating water level.

Key Concepts:
Hydrophyte
Oligotrophic
Mesotrophic
Eutrophic
Littoral zone
Vernal pools

What is a freshwater wetland?

The definition of a wetland is often a point of debate, because the water levels in wetlands varies greatly – some of these habitats are permanently flooded (like marshes), while others only flood at certain times of the year (like bottomland hardwood forests).

The federal Clean Water Act defines wetlands as: "areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation (**hydrophytes**) typically adapted for life in saturated soil conditions (**hydric soils**). Wetlands generally include swamps, marshes, bogs, and similar areas."

Wetlands are often found in places where groundwater comes to the surface or where surface water collects.

Different types of wetlands share similar hydrology, soil, and vegetation patterns.

Wetland plants (**hydrophytes**) are adapted to living in places with varying water levels. The soil in wetlands is often saturated or waterlogged and can have a characteristic "marshy" smell.

Wetlands are one of the earth's most productive habitats because they capture a lot of the sun's energy and recycle it back through the system, providing an abundance of plant matter for wildlife.

Lakes, Ponds, and Pools

Lakes and ponds are inland bodies of water that were formed by different natural forces such as glaciers (after the end of the last ice age, 10,000-12,000 years ago), fires, beavers. Many of North America's ponds and lakes are artificial reservoirs– people built them to provide electricity, drinking water, and recreation.

What is the difference between a lake and a pond?

Lakes are usually deep, large bodies of water. The water temperature in a lake changes with the depth.

Ponds are usually smaller and shallower than lakes.

Since sunlight can reach the bottom of a pond, the water temperature in a pond is usually more uniform than that of a lake.

Lakes and ponds can be fed by groundwater, runoff, streams, or rivers.

What are the different types of lakes?

The United States contains approximately 100,000 lakes.

The different types of lakes are:

- **oligotrophic** (low in nutrients, like lakes in northern climates that are cold and deep)
- **mesotrophic** (somewhat enriched)
- **eutrophic** (very enriched)

North America's uncommon lake types include:

- **Playa lakes** – Found in the arid Southwest and Great Plains, playa lakes are often dry, but after a heavy rain, they fill with water and provide important resting areas for migratory birds.
- **Carolina bays** – These elliptical wetland depressions are found in the eastern United States and provide habitats for amphibians, birds, and large mammals.

What are the major characteristics of lakes?

Shallower, warmer lakes are more hospitable to plants. The shallow water on the edge of a pond or lake is called the **littoral zone**. Marshes often develop on the edge of lakes, so plants in the littoral zone are similar to those found in true marshes. **Emergent plants** like bulrush and cattails grow here and attract waterfowl. These plants can survive in flooded soils, but not for an extended length of time.

Lakes and ponds may fill in and succeed into other wetlands.

Lakes and ponds often support floating plants (like water lilies) and submerged plants (like bladderwort).

What kind of wildlife inhabits ponds and lakes?

Ponds and lakes support a wide variety of plant and animal life, including microscopic life:

- **Phytoplankton** are tiny plants such as algae that are a basic part of the lake and pond food web.
- **Zooplankton** are minute animals that swim in the water and feed on algae. Common zooplankton includes **daphnia** and **rotifer.**

What are the different types of pools?

Vernal pools are temporary wetlands that contain water for just a few months in the spring and early summer. Because fish cannot survive in temporary wetlands, these pools offer an important predator-free breeding habitat for amphibians like frogs and salamanders.

Some spring-fed pools in the southwestern United States are desert oases that house fish found nowhere else on earth.

Representative wildlife:

Mammals: moose, muskrat, beaver, raccoon
Birds: great blue heron, ducks, osprey, tundra swan, snow goose, common loon, cormorant
Plants: cattails, water lilies, duckweed, bladderwort, reeds
Reptiles and amphibians: snakes, frogs, turtles, salamanders
Insects: Dragonflies, water striders
Fish

What are the major benefits of lakes, ponds, and pools?
Drinking water, irrigation, wildlife habitat, and recreation.

What are the greatest threats to lakes, ponds, and pools?
Pollution; non-native plants, fish, and mussels

Freshwater Marshes

General description: Marshes are **emergent** wetlands dominated by soft-stemmed herbaceous plants, particularly grasses, reeds, and sedges (i.e. cattails and pickerelweed). Marshes develop in potholes, basins, sinks, and edges of lakes, ponds, and rivers, and have varying water levels throughout the year.

The U.S. contains about 15% of the world's freshwater marshes. In general marshes have greatest natural diversity of any wetland type.

What are the different types of freshwater marshes?

Shallow marshes contain up to 6" – 12" of water when flooded.

Deep marshes are permanently flooded and contain up to 2 - 3' of water and support floating and submerged aquatic plants (water lilies, pond weeds, carnivorous bladderworts).

Wet meadows or **wet prairies** are poorly-drained, precipitation-fed wetlands that support moisture-tolerant grasses, sedges, and broadleaved plants. Resembling grasslands, these habitats are seasonally flooded or may remain wet throughout the year.

Alkaline or saline marshes are primarily found in western North America and have high concentrations of dissolved salts.

Tidal freshwater marshes are found upstream of estuaries and provide critical nurseries for fish and shellfish and support large bird populations.

What kinds of plants grow in marshes?

- **Emergents** (stems partly in and out of water) – cattails, pickerelweed, wild rice, saw grass, *carex* (genus of sedge)
- **Submergents** (underwater) – bladderwort, pondweed
- **Floaters** (floating plants) – float on surface, like water lilies or duckweed

Why are freshwater marshes so productive?

Because marshes lack trees, a lot of sunlight enters these habitats and photosynthesis occurs without interference.

Lots of moisture and nutrients cycle throughout the system.

Examples of significant marsh habitats in North America:

Prairie potholes – About 300,000 square miles of prairie potholes are found in parts of Iowa, the Dakotas, Montana, and Minnesota. Melting glaciers created these wetland depressions after the end of the last ice age. Some potholes dry out for part of the year, but in the spring, the potholes fill with melting snow and rainwater. More than 50% of North American waterfowl depend on prairie potholes at some part of the year.

Everglades: The largest marsh system in North America, the Everglades is a vast low-lying plain fed by Lake Okeechobee in southern Florida. A diversity of habitats in this "river of grass" (tropical hammocks, marsh with saw grass, sloughs, gator holes) support an abundance of wildlife.

Representative wildlife:
Mammals**:** Muskrat, mink, voles, mice
Birds: Marshes harbor abundant birdlife, including waterfowl, wading birds, perching birds
Reptiles: Alligators, turtles

What ecological services do marshes provide?
filter pollutants and protect drinking water

What are the greatest threats to marshes?
draining, ditching, canals (for flood control and agriculture), and invasive non-native species like Australian pine and purple loosestrife

Forested Wetlands

What is a forested wetland?
Forested and shrub-dominated seasonal wetlands are found in low areas that drain very slowly, if at all. Water levels in these wetlands vary; they can be full of water or bone dry.

What are the different types of forested wetlands in North America?
Bog - Bogs are mainly found in northern areas that were once covered in glaciers, primarily in Canada, Alaska, and the northern United States. Northern or boreal bogs formed after the last ice age. Bogs contain a sub-surface layer of peat, or partially decayed plant material, that soaks up rainwater and slowly releases it into the surrounding landscape**. Representative species**: black spruce, tamarack, peat moss, carnivorous plants (sundew, pitcher plants), bog turtle, moose, and porcupine.

Pocosin - Native Americans called evergreen shrub bogs found in the Southeast "pocosins", which means "swamp-on-a-hill." Like bogs, pocosins occur on flat, poorly drained ground above layers of organic peat up to 20 feet deep. **Representative species**: black bear, red wolf, bobcat, white-tailed deer, and neotropical migratory songbirds.

Longleaf pine savanna – One of the country's rarest habitat types, the longleaf pine community was once a dominant part of the landscape of southeastern North America. Longleaf pine savannas have been called North America's tropical rainforests in terms of their great natural diversity: more than 50 species of plants have been documented in one square meter of a longleaf pine savanna. Lightning strikes are common in the Southeast so plants in both pocosin and longleaf habitats evolved with frequent fire. **Representative species**: Longleaf pine, wiregrass, Venus flytrap, pitcher plant species, and red-cockaded woodpecker.

Swamp - In addition to swamps found in river floodplains, many swamps occur near lakes, ponds, and low-lying areas. Northern swamps are dominated by red maple,

willows, and Atlantic white cedar, while bald cypress dominates these wetlands in the southeastern United States. **Representative species**: Wading birds, migratory songbirds, American alligator, and numerous reptile and amphibian species.

Carolina bay - One of the most unusual forested wetland habitats in North America, Carolina bays are egg-shaped depressions that dot the Coastal Plain from New Jersey to Georgia, ranging in size from a fraction of an acre to over 5,000 acres.

Representative species: Numerous reptiles and amphibians (spotted salamander, spring peeper, and gopher frog), wading birds (egrets and great blue heron).

What services do forested wetlands provide?
Wildlife habitat, absorbing flood waters, filtering pollutants, and recharging groundwater

What are the greatest threats to forested wetlands?
Draining, logging, and conversion to agriculture or silviculture

Wetland Web Links

Learn about your watershed with EPA's Surf your Watershed program
www.epa.gov/surf

National Geographic's website offers extensive educational resources
www.nationalgeographic.com/education

Excellent resources from the National Biological Information Infrastructure
www.nbii.gov/education

Frogwatch U.S.A. – A volunteer amphibian monitoring project
www.mp2-pwrc.usgs.gov/frogwatch

Microbe zoo (Digital Learning Center for Microbial Ecology) – Water World section includes information and photos of microscopic life in wetlands
http://commtechlab.msu.edu/sites/dlc-me/zoo

Wetland-related educational resources from the Society of Wetland Scientists
www.sws.org/education

Canada's aquatic environments
www.aquatic.uoguelph.ca

River of Words – Connecting children to their environment through art
http://www.riverofwords.org/

Conserving American Biomes: Program Background

Understanding your ecological address is an important step in developing a conservation ethic. This concluding program helps students understand why every North American biome is important to our quality of life, as they provide us with ecological services, drinking water, food, and recreation. The program examines how various biomes have been treated and mistreated and suggests how everyone can get involved in protecting and restoring these irreplaceable wild lands.

Background Information for Classroom Discussion

Whether you live in a city, or in the country, we all live in a biome. What does the word biome really mean? A biome is a geographic region where the climate and natural processes determine what kinds of plants and animals can live there. All the species in a biome, including people, interact with each other, and depend on each other to survive. In North America, you might live in a desert, a grassland, in a watershed, on a lakeshore, the seashore, or in a forest.

Ecological Services

Biomes are an essential part of our lives. They provide us with many ecological services:

They offer habitats for plants and animals. Estuaries are nurseries for fish and shellfish – without estuaries, we would not have seafood!
All biomes provide us with food of some sort.
They supply fresh drinking water and protect underground water supplies.
They offer building materials and medicines.
Wetlands help filter pollutants and absorb rising floodwaters.
Forests help regulate the climate and produce oxygen.
Rivers provide us with transportation.
And biomes are irreplaceable outdoor wonders where we can walk, watch wildlife, and just get away from it all.

European settlement in North America: A very brief history!

Just as all the organisms in a biome are connected and depend on each other for food and shelter, all biomes are connected. Changes in one biome can affect another habitat. If you cut down a forest, silt can run into a nearby river and upset its natural balance. All of our actions have consequences.

When European settlers arrived in North America, they were captivated by the New World's beauty and bounty of life. As they explored the pristine wilderness, they found ancient forests with colossal trees, pristine rivers full of fish and animals, herds of bison and elk ranging over open grasslands, and enormous flocks of passenger pigeons that blocked out the sun. North America seemed a land of infinite possibilities.

To build a home for themselves and their families, these hardy settlers began to tame the wilderness, harnessing its resources, and unfortunately, destroying many things that seemed to threaten them or their progress.

From the first settlements on the East Coast, the settlers pushed into the heart of the continent, building roads and establishing towns. They logged many forests, used the trees for building materials, and converted the land to agricultural uses.

They plowed the prairies and introduced cattle to the grasslands. All over North America, people killed predators such as wolves, and western settlers also killed bison and prairie dogs to prevent them from competing with cattle.

Thinking that wetlands were just mosquito-infested, worthless swamps, they drained them and converted them into agricultural land. To control floods and generate power, the settlers dammed rivers. They also imported exotic plants and animals that competed with native species for space and resources.

Trains and other machines accelerated the rate of development and the entire continent began to change.

Habitat Destruction

Habitat destruction is the greatest threat to North America's biomes. Even building a road near a natural area can harm it, as it isolates the area and makes it dangerous for animals to travel in search of food and shelter.

Converting natural areas to other uses pushes animals and plants out of their habitats. Many animals and plants in North America are threatened or endangered, including migratory birds, grassland birds, large mammals like wolves and bears, reptiles and amphibians, and rare plants that grow in fragile habitats like bogs and grasslands.

Conservation Efforts in North America

The settlers who brought these changes to North America did not realize the extent to which they would alter the landscape. In fact, they were simply trying to survive and mistakenly thought that our natural resources were endless. When people began to realize the great pressure they were placing on the natural world, they initiated conservation efforts. Catastrophic events like the near-extinction of the buffalo and the Great Dust Bowl galvanized early conservationists to saving North America's wild lands.

Countless Individuals, landowners, and private and public conservation agencies are working together to save our irreplaceable biomes by setting aside wild lands for parks and preserves. (Many of these conservation groups are listed in the websites at the end of the guide.) They are also restoring the ecological processes that sustain biomes, such as fires that keep pine forests open and floods that bring life to river floodplains.

Biologists are working to reintroduce rare plants and animals to their native habitats. Bison herds now range over the prairies, wolves howl from woodlands, and prairie chickens boom in the springtime. Although conservation can be an uphill battle, we still have time and hope.

Biomes Conservation

What you can do

There are many ways that individuals can help save North America's biomes. Just a few examples include:

Create a natural habitat in your backyard by planting native plants and providing food and water for birds and animals.
Conserve water at home, at school, and in the office. (see Water: A User's Guide below).
Grow a vegetable garden – it will help you understand where your food comes from.
Support conservation groups.
Reduce your ecological footprint: recycle, carpool, ride a bike, be thrifty!
Spend time outdoors. Take a hike or a paddle. Take some photos, or just watch the birds and butterflies.

There are many special places in the world. Get to know the one right in your backyard.

A Few Case Studies in Conservation Issues
Note: The following case studies describe some of the conservation issues surrounding some of North America's biomes: wetlands, grasslands, and deserts.

Water: A User's Guide

What is the water cycle?
When sunlight heats the water in lakes, rivers, and oceans, the water evaporates and rises into the atmosphere. Clouds collect the moisture and transport it to different places. When the moisture cools, it falls to the earth as precipitation, such as rain, snow, or ice. Some of this water seeps into the **groundwater**. Plants and animals absorb some of the water and some of it runs into lakes and streams, where the never-ending cycle starts anew.

Does North America contain a significant portion of the world's freshwater wetlands?
North America contains 10% of the world's freshwater wetlands and its aquatic diversity is globally significant. The United States harbors the world's greatest diversity of freshwater mussel, crayfish, and aquatic insect species.

How do freshwater wetlands benefit wildlife?
An amazing diversity of flora and fauna inhabits North America's freshwater wetlands, including fish, waterfowl, wading birds, and aquatic mammals like river otters and beavers. Up to half of all the bird species in the continent depend upon wetland habitats. 45% of all the United States' federally listed threatened and endangered species live in freshwater habitats.
Wetlands produce organic matter that provides a foundation for the food webs of many aquatic plants and animals.
Many species of fresh and saltwater fish and amphibians develop, breed, and spawn in freshwater wetlands.

Up to one-half of North America's bird species depend on wetlands during some part of their life cycle.

How do freshwater wetlands benefit people?

Freshwater wetlands, like rivers, lakes, and groundwater, provide North America's drinking water.

Rivers are important transportation routes.

Wetlands, like floodplain forests, help prevent catastrophic flooding by absorbing and slowly releasing rising floodwaters.

Wetlands are critical to the wellbeing of the fish and shellfish we eat.

Wetlands and certain aquatic animals, like freshwater mussels, filter pollutants from drinking water.

Wetlands are outdoor classrooms where we can learn about nature, enjoy incredible scenery, and get away from it all.

How have people historically treated North America's freshwater wetlands?

Badly. When European settlers arrived in North America, they dismissed wetlands as buggy, worthless, and dangerous places. Because they could not build in the wetlands, they began draining, logging, and filling in wetlands, to convert them to "good use." The United States once harbored 215 million acres of wetlands – today only 100 million acres remain. Until the 1970s, the United States government funded these conversion efforts.

In addition, North Americans have dammed most of the continent's rivers in order to create drinking water reservoirs, control flooding, and produce electricity. Only two percent of the United States' rivers are free flowing and not constrained by dams. The United States is the second-most dammed country in the world, with some 5,500 large dams. China has 19,000 dams. (The Nature Conservancy, Freshwater Initiative)

What are the greatest threats to freshwater wetlands?

Habitat destruction through development, logging, industry, and roadbuilding is the greatest threat to the continent's natural areas, including wetlands.

According to The Nature Conservancy's Freshwater Initiative: "The three leading threats to aquatic animals are: alterations in natural river flow patterns due to dams, diversions, and ground water pumping; polluted runoff from farms and urbanizing areas; and the introduction of non-native species that compete with natives."

Exotic or nonnative species are plants and animals that were brought to North America from other countries either accidentally or intentionally. In the absence of their natural predators, these plants and animals can outcompete native flora and fauna for resources. Consider the purple loosestrife: This plant may look sweet and innocent, but beware! It's a killer that is taking over North America's freshwater marshes.

The world's growing population is depleting our fresh water. The United States consumes water twice as fast as other developed countries. 80% of this water is used for irrigating crops and producing thermoelectric power.

Did you know?

- **Point source pollution** goes directly into a water supply, such as a factory that dumps sludge directly into a river.

- **Nonpoint source pollution** enters the water supply indirectly, such as fertilizer that runs off a lawn after a rain and eventually flows into a river. Nonpoint source pollution is much more difficult to monitor and control.
Pollution depletes oxygen in wetlands, so that only animals like the tubifex worm can survive in polluted waters.

Worldwide, four out of every 10 people live in water basins where water is becoming scarce.

1.2 billion people worldwide do not have access to clean water

Most people in the world must walk three hours or more to obtain water.

(Much of this information is from The Nature Conservancy's Freshwater Initiative)

Wetland Resources on the Web

Ramsar Convention – Wetlands of International Importance
www.ramsar.org

World Resources Institute: People and Ecosystems – Freshwater
www.wri.org/wri/wr2000/freshwater.html

U.S. Fish and Wildlife Service National Wetlands Inventory
www.nwi.fws.gov

EPA Office of Wetlands, Oceans, and Watersheds
www.epa.gov/owow

Grasslands Conservation

Grasslands provide vital ecological services, such as soaking up carbon (a greenhouse gas) from the atmosphere and pumping into the soil, thereby helping build fertile soils and combat global climate change. Some of the world's most important grain crops, such as wheat, corn, oats, and rice, are grass species. Yet grasslands are one of North America's rarest and most beleaguered biomes, as they have been destroyed or altered from several hundred years of conversion to agricultural land, fire suppression, and animal control. The different grassland habitats cover only a fraction of their former range. Public and private environmental groups are working together to save North America's relict grasslands and restore them to their original condition through prescribed burning and the reintroduction of native species.

What are the primary causes of the destruction of grasslands?
1) conversion to agricultural land (rangeland and cropland)
2) animal control – Historically, people hunted predators such as wolves and coyotes, and exterminated grazing animals such as bison and prairie dog almost to extinction.
3) fire suppression

According to David Wilcove, (*Condor's Shadow*, see "Further Reading) "By 1883, bison had been all but erased from N. America, with only a few small, scattered

herds in Alberta, Yellowstone, and Colorado left." The Colorado herd was eventually wiped out, but the other 2 herds were protected and formed the "nucleus" (along with captive-bred animals) for restoration efforts.

During the cattle boom in the last quarter of the 19th century, the government subsidized cattle ranching. This eventually led to cattle overgrazing the land and damaging grasslands habitats.

Bison and cattle have different grazing habitats that affect the land in different ways:

1) Bison migrate, so they give land time to recover. But cattle are not nomadic and they will stay in one place, constantly grazing, until an area becomes arid.
2) Cattle congregate around water and damage riparian habitats.
3) Unlike cattle, bison paw at the dirt and wallow in it, helping create microhabitats.

People historically eliminated carnivores (i.e. wolves and grizzly bears) that preyed on herds of bison, pronghorn, and other grazing animals.

Settlers also killed off prairie dogs because they were seen as "competitors for forage" (Wilcove). Millions of these animals were shot and poisoned.

The decline of prairie dogs negatively affected other animals, such as the black-footed ferret. This species subsists almost entirely on prairie dogs and it almost became extinct. In 1985, biologists put 18 ferrets in a captive-breeding program.

"Sodbusters" followed the cattlemen. They worked to cultivate the land when the US government encouraged the settlement of the West. From 1900-1930, much of the Plains were converted to wheat fields. A drought began in 1931 and lasted the entire decade, creating a Dust Bowl in the southern Plains. Crops died, the soil hardened, and topsoil blew away. Enormous dust storms were spawned. Farmers were encouraged to introduce conservation measures, such as planting trees.

How are people restoring grasslands?

Public and private conservation groups are working to protect the remaining grassland habitats by acquiring land for nature preserves or working with landowners to ensure their protection.

Conservation groups are also managing the remaining grasslands with a variety of management techniques that mimic natural processes, including:

- prescribed burning
- moving cattle around as they graze
- planting native prairie grasses and wildflowers
- reintroducing native species such as bison and black-footed ferret

Did you know?

Grassland birds are declining more than any other group of birds in North America, primarily due to habitat loss. These birds like a wide range of grass heights and densities. The Nature Conservancy has launched the Prairie Wings program, "a multi-million dollar program to protect the imperiled grassland birds of the central US, south-central Canada and north-central Mexico," according to the organization. "This is first program that will work to identify, protect, manage and restore prairie bird habitat across their entire range." The organization identified 13 species (the "Unlucky 13") as targets for this conservation program: greater prairie chicken, lesser prairie chicken, long-billed curlew, ferruginous hawk, lark bunting, chestnut-collared longspur, McCown's longspur,

burrowing owl, Sprague's pipit, mountain plover, Baird's sparrow, Cassin's sparrow and, scaled quail. For more information, see:
http://nature.org/initiatives/programs/birds/explore/

Desert Conservation Issues

Symbiotic Relationships

Desert plants and animals are linked in **symbiotic** relationships, in which the lives of utterly different organisms are completely intertwined. These relationships can benefit all the species involved, or they can benefit some species and harm others. In a beneficial relationship, insects, bats and hummingbirds pollinate most desert plants, including wildflowers and cactus. Nectar-feeding creatures are attracted to the plants' fragrant, showy blossoms. The pollinators feed on the plants, obtaining sugars and amino acids for energy, while simultaneously spreading pollen between the plants.

Did you know?

Biologists are concerned about the declining populations of migratory pollinators like bats, butterflies and birds that migrate between Mexico and the southwestern United States and pollinate many native plants and agricultural crops. The populations of many of these species are declining, probably due to the loss of their roosting habitats and the lethal effects of herbicides and insecticides. This pattern is not only harmful to wild plants and animals, but also to agriculture and consequently, humans.

There are about 2,000 vertebrate species and countless invertebrate species that pollinate wild native plants and agricultural crops. Loss of pollinators could mean the loss of crops and native plants. Conservationists are working together to study migratory pollinators in order to save these animals and their habitats. They are focusing on the "nectar corridors," the favored migration routes that are characterized by a great abundance of plant life.

The Arizona-Sonora Desert Museum and other partner groups and individuals have organized the Migratory Pollinator Program to monitor four migratory pollinator species – white-winged dove, lesser long-nosed bat, rufous hummingbird, and monarch butterfly.

To get involved in this important effort, visit the Arizona-Sonora Desert Museum website at: http://desertmuseum.org/mp/.

The Hunt for Water in the Desert

Find the watering hole

The desert provides some clues that you can use to help you find water:

Trees like cottonwoods require water close to their roots. Look for water-loving trees like cottonwood, mesquite, sycamore and willow. These trees often grow in **arroyos**, or dry streambeds, where they can seek out groundwater with their roots. Mesquites indicate a deep water supply, as the plant's taproots can reach up to 30 feet below the ground to seek out groundwater.

Animals like **javelina** and **desert bighorn** depend on these perennial water sources and often congregate in these shady areas.

Desert wetlands

There are a few extremely rare wetland systems in the North American deserts:

Desert riparian areas - One of the rarest habitats in the American Southwest, a desert riparian area is a plant and animal community that develops along waterways, such as streambeds that run out of canyons, and contain water part of the year. Permanent rivers like the Colorado may support heavy plant growth with cottonwoods and sycamores, but this green belt only extends for a short distance from the river.

Playa – These temporary lakes are more often dry than wet. These level areas in the center of basins periodically fill with water, attracting migratory waterfowl like snow geese.

Oasis – One of the most unique wetland habitats in the desert, an oasis is any area in the desert that contains enough water to support plants. The Mojave Desert contains a few oases, where rainwater soaks into the earth, collects in underground springs, lakes and rivers and eventually seeps back to the surface through cracks in the earth.

Strange but true

One of the most ecologically significant oases in all the North American deserts is an area called Ash Meadows in the Mojave Desert. According to Precious Heritage (see bibliography), "Ash Meadows, a group of more than 30 springs and seeps located about 40 miles east of Death Valley and 90 miles northwest of Las Vegas, has the highest local endemism of any area in the continental United States, including 10 or more mollusks, 8 plants, 5 fishes, 2 insects, and 1 mammal. (Endemic species are unique to an area.) These pools are remnants from the Pleistocene when torrential rains created a system of lakes and rivers in the area, including a huge lake called Lake Ash Meadows. The lake dried, leaving behind these springs that continue to be fed by groundwater today."'

One of the most unique endemic species at Ash Meadows is the Devils Hole pupfish, a tiny fish which has the smallest range of any vertebrate species; the entire population of no more than 1,000 individuals inhabits a 70-by-10-foot pool called Devils Hole.

The Ash Meadows springs became threatened when nearby landowners began pumping groundwater from the **aquifer** (underground water source). The springs are now protected in a national wildlife refuge.

Ash Meadows National Wildlife Refuge

http://desertcomplex.fws.gov/ashmeadows/

When the well runs dry

Since desert wetlands are increasingly rare and water is a scarce commodity in the desert, plants and animals have adapted various ways of coping with little moisture.

Escaping seasonal dry spells

Annual or ephemeral plants remain in seed form for much of their existence. After a rain, the plants go through a rapid growing season, sprouting, blooming and producing seeds in the course of a few weeks or months.

Migratory waterfowl only inhabit the desert in the winter, when playas fill with water and provide a suitable feeding and resting area.

Avoiding seasonal dry spells

Like northern deciduous trees in the water, perennial plants are dormant during dry periods and only grow leaves after rainfall.

Some animals like the ground squirrel slow down or go into a torpor state during hot, dry periods or when there is a food shortage as a means of conserving energy and water.

During the hottest summer months, some ground squirrels go into a deep sleep called **estivation**, which is similar to hibernation, in which the squirrel slows its breathing and metabolism.

Coping without much water

Succulent plants like cactus have shallow roots that capture rainwater, which the plant stores in its roots, leaves and stems.

Rodents like the kangaroo rat can survive without drinking water; instead, the animal derives water from eating seeds, which can be composed of up to 20% water. As the rat converts the seeds into energy, its body produces water. Larger mammals like coyotes and mountain lions obtain much of their water from their prey.

The human factor

Humans have borrowed some strategies from nature to cope with the lack of water in the desert. Native Americans and early pioneers who settled in the desert depended upon an available water supply so many early settlements were established near springs and rivers. Some Native Americans constructed irrigation channels to water their crops -- the canal system in modern-day Phoenix is almost identical to a system planned by Native Americans. These early inhabitants also built wells, digging much deeper than the long-rooted mesquite, and constructed dams to store water.

Today, as more people move to the desert, they are dramatically changing the landscape in a feverish quest to find and save water. Technology enables people to settle in places that were historically uninhabitable because of the extreme heat and aridity. People have built dams on many western rivers in a bid to provide water for drinking, agriculture, electricity, and recreation. Cities like Las Vegas and Los Angeles have mushroomed in the middle of the desert. People have built channels to divert water from rivers like the Colorado to cities like Las Vegas.

Solutions

Like many environmental problems, the disruption of the desert environment is a complicated issue, with many complex questions and answers. There are some ways that we can help restore the natural balance in the desert, by protecting desert habitats, gardening with native vegetation, educating people about the desert biome, and conserving water.

Educator's Viewing Tips

Learning Objectives

After viewing programs in *North American Biomes*, most students will be able to:

1. Explain the term biome and hypothesize about the biome in which they live.
2. Discuss some of North America's major biomes and describe their distinguishing features.
3. Discuss how every animal and plant is adapted to live in a particular biome but may not be able to survive in another biome.
4. Describe some of the benefits that biomes provide people.
5. Discuss how people interact with biomes, both positively and negatively.

Pre-Viewing Activities

Before viewing the *North American Biomes* series, divide your students into groups and assign a biome from the series to each group. Ask the groups to brainstorm and write a description of what they would see and hear if they went on a field trip to that biome. After viewing the program, ask the groups to write another description of the same imaginary field trip, but add information that they learned from the program. Each group can then discuss how the program changed their perceptions of that habitat.

Viewing Activities

While showing the program, pause on an individual image and suggest an appropriate discussion question or make a writing or art assignment based on the image.

Post-Viewing Activities

After viewing the program, ask each student to write a definition of an ecological address. Then lead a discussion about what the term means to different people. Ask the students to write a description or draw a picture of the biome that they inhabit. Have each student share his or her creations with the class.

Take it Outside

We hope that after viewing the *North American Biomes* series you and your students will want to learn more about natural diversity by going on a field trip. Any habitat will do -- take your class to a nearby pond, creek, forest, nature preserve, park, or even the schoolyard. Just get your students outside! The *Where to Go* section below lists Web sites with information about some of the premier wild places in the United States and Canada. Contact your state and county natural resource agencies to find out more about educational opportunities at public natural areas. Below are some suggestions for organizing a field trip that will help your students become lifelong nature enthusiasts.

Any teacher can lead a field trip, even if they do not have a science background. Enthusiasm and interest can be contagious.

Do your homework. Have your students research the natural area you are going to visit. If you are going to a park or nature center, request a tour guide and written materials if available.

Lead students in a pre-field trip discussion and provide information about the natural area and what they can expect to see. Show them photos or maps of the site, and photos or drawings of some of the plants and animals they might see.

Talk to the class about "etiquette" in the wild. "Leave no trace" is a good mantra – remind students to treat all wild creatures and plants with respect. Some students may have very limited experience outdoors and may have misconceptions or fears that you should discuss. Reassure students that most wild creatures (i.e. snakes and spiders) are wary of humans. However, poking your finger in a hole in the mud is asking for trouble!

Lead the students in a pre-field trip discussion in which you provide information about the area you are visiting and what they can expect to see. If you have photos or maps of the site you are going to visit, show them to the students beforehand, as well as photos of some of the plants and animals they might see.

Send a note home to parents to ensure that students wear proper attire for an outdoor adventure, including:

- long pants
- shoes that can get muddy
- raingear
- hat
- sunscreen
- insect repellent

Find out if any of your students are allergic to insect stings and carry the proper medicine in your first aid kit. You have a first aid kit, right?

Recruit some parents to act as chaperones.

List of things to bring:

- first aid kit
- water/drinks
- maps!
- field guides
- binoculars
- camera

Field Trip Activities

In addition to interpreting the habitat, flora, and fauna for your students, there are an endless number of activities that you can organize during your day in the field. Here are just a few ideas:

Provide journals or notebooks so that the students can record their observations during the trip. (Field Notes weatherproof mini-notebooks are a wonderful tool for documenting notes in all kinds of conditions – available from Environmental Media: 800-368-3382 or www.envmedia.com).

Some of the key observations your students can record include:

- Basics: Date, time, location
- Weather: Conditions, temperature, wind speed, precipitation
- Habitat specifics: Type of habitat
- Flora and fauna: List animals and plants seen, tracks noticed, sounds, smells, scat (an all-time favorite for most students!)

Divide the students into small groups. Assign each group to a different section of the natural area. Ask the group to record all of their observations. When the students return to school, ask each group to collaborate on an artistic rendition of their day in the wild, i.e. a song, written report, or drawing/painting. The groups can present their project to the class. Then lead a discussion on the differences/similarities between the various parts of the habitat.

If possible, take the class to the natural area at two different times of the year, so that they can see how the habitat varies from season to season.

Where to Go

Note: Given the difficulty of producing a "best-of" list of publicly-accessible biomes in all of North America, we offer a list of websites that provide general information for publicly and privately owned nature reserves throughout the continent.

Web sites for national parks with educational resources.
www.nps.gov/interp/pksmart.htm

National Wildlife Refuge System (U.S. Fish and Wildlife Service).
http://refuges.fws.gov/

U.S. National Park Locator
http://usparks.about.com/travel/usparks/msubfindpark.htm

Web site addresses for all state parks in the United States.
http://usparks.about.com/travel/usparks/blstparklistings.htm

The Nature Conservancy owns one of the world's largest systems of nature preserves.
www.nature.org

Audubon Society nature centers and parks.
www.audubon.org

Canada National Parks System.
http://parkscanada.pch.gc.ca/parks/main_e.htm

National and provincial parks in Canada.
http://canadaonline.about.com/aboutcanada/canadaonline/msub95.htm

Hot Links

Numerous Web sites are devoted to global and North American biomes.

An innovative site from World Wildlife Fund that maps and describes the world's ecoregions.
www.wwfus.org/ecoregions

Neartica – A wide variety of links and information about the natural world in North America, including a comprehensive search engine.
www.neartica.com

A great website with a searchable database of selections from *Audubon Field Guides*, including photographs.
www.enature.com

Descriptions of the world's major biomes and many links.
www.worldbiomes.com/default.htm

A wonderful site about North America's biomes created with student involvement.
www.blueplanetbiomes.org/

Biomes of the World
http://mbgnet.mobot.org/fresh/

World's Biomes page
http://www.ucmp.berkeley.edu/glossary/gloss5/biome/index.html

Animal Omnibus – A website from the Birmingham zoo with lists of web sources indexed by the name of the animal. An enormous collection of links.
http://www.birminghamzoo.com/ao/

EELink – Link to environmental education resources on the Internet
http://eelink.net/

National Geographic's website offers extensive educational resources
www.nationalgeographic.com/education

Excellent resources from the National Biological Information Infrastructure
www.nbii.gov/education

Many links to animal behavior websites
http://users.erols.com/mandtj/behavior/behavior.html#EDU

U.S. Fish and Wildlife Service website with detailed information about wildlife refuges, programs and endangered species throughout the country.
http://www.fws.gov/

Searchable database of USFWS endangered species in the Southwest.
http://ifw2es.fws.gov/endangeredspecies/lists/

International and National Conservation Organizations

Center for Marine Conservation
http://www.cmc-ocean.org/index.php3

Cornell Lab of Ornithology
http://birds.cornell.edu/

Environmental Defense
http://www.edf.org

Conservation International
http://www.conservation.org/

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