42. A Spectrum of Fires

Description: Teams of students create posters to illustrate the role of fire in different ecosystems.

Objective: Students will learn how fire in the bosque is different from fire in mountain forest or grassland areas.

Materials: Cards for each ecosystem, poster board or large paper, markers and/or crayons, books describing different ecosystems, pictures of different ecosystems or access to Internet to look up ecosystems and role of fire

Background: Although for many years Smokey Bear taught us that wildfires are bad for forests, we now understand that fire plays a natural role in many ecosystems. Some ecosystems are highly adapted to reoccurring fires, with plants and animals that not only survive this disturbance, but in many cases may require it in order to reproduce. The role that fire plays in an ecosystem, reflecting the frequency, predictability, intensity and seasonality of fire, is known as the *fire regime*. The fire regime describes the characteristics of fire in a given ecosystem over time. Fire regimes vary greatly across different ecosystems and can change when humans alter the way a system functions.

Prior to human intervention, fires were once a major form of ecosystem disturbance in tropical and temperate grasslands, temperate woodlands and shrublands, as well as in many types of forests. These are *fire-dependent ecosystems*—they are resilient to repeated fires and have plants and animals that may depend on fire to re-

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Grades: 6–12

Time: two class periods

Subjects: science, art, social studies

Terms: *cambium, crown fire, exotic species, fire adaptation, fire break, fire regime, fire-dependent ecosystem, fire-sensitive ecosystem, fire-independent ecosystem, fire suppression, fuel ladder, mosaic distribution, nutrient cycling, plant clone, succession*

produce. In the U.S., there are a number of vegetative communities adapted to fire. Examples of these include the tall-grass prairie of the Midwest, the chaparral (brushland) of California and the Southwest, ponderosa pine forest of the interior West, Douglas fir forest of the Pacific Northwest, boreal forest of Alaska, loblolly and shortleaf pine forest of the Southeast and jack pine forests of the Great Lakes states. Some examples from other regions of the world include the eucalyptus woodlands in Australia, the South African fynbos and the tropical savannahs of South America, Africa and Australia. In these ecosystems, fire determines which plant species can survive and sculpts the structure of the ecosystem itself. For example, in temperate grasslands like the Great Plains, fire favors the growth of grasses and forbs, while excluding woody vegetation. When fire is removed through human interference, woody plants invade and grasslands slowly give way to forest. Many prairie wildflowers have become endangered as a result of fire suppression.

Fire is a key ecological process in the Southwest. In New Mexico, fire plays an important role in desert grasslands, piñon-juniper woodlands, ponderosa pine forests and mixed-conifer forests (containing Douglas fir, white fir, blue spruce, Gambel oak and quaking aspen).

Plants in fire-dependent ecosystems have numerous adaptations to survive fires. A *fire adaptation* is a characteristic of an organism that enhances its ability to survive a fire. These include:

- Bark thickness: thick, tough bark acts as insulation to protect the tree against fire. Examples are ponderosa pine, Douglas fir, longleaf pine, slash pine, burr oak, giant sequoia.
- Underground roots and tubers: small woody plants and shrubs, as well as trees with thin bark, use the soil to protect their underground roots and tubers, from which they can produce shoots after a fire. Examples include aspen, willow, northern pin oak, fireweed, prairie grasses.
- Protected buds: some plants can re-sprout from buds that are protected within foliage (such as the buds of longleaf pine which are protected within thick clusters of needles) or within the main stem or branches.
- Fire-resistant seeds: these seeds are able to withstand the fire and fall into the nutrient-rich ash, from which they germinate when sufficient water is available.
- Serotinous cones: cones that will not open to release seeds until a fire occurs. Serotinous cones are held closed by a resin that only opens when a critical temperature is reached, requiring the high heat of a wildfire. An example of this is the jack pine. Some pine species, such as lodgepole pine,

have cones that can vary from serotinous to free-opening, depending on whether the tree is growing in an area with frequent fires. In areas where fires are infrequent, a lodgepole pinecone can open and release its seeds even without the fire.

Many animals can flee in the face of a fire, either by flying or running away. Large animals such as deer, bear, coyote, fox or kangaroo can typically run or jump out of harm's way. Smaller animals such as mice, shrews, lizards, snakes and tortoises burrow underground to escape. Adult birds can fly away, but their young usually cannot escape. Some predators take advantage of fires to hunt along the edges for other species fleeing the flames. The jewel beetle (genus *Melanophila*), also known as the black fire beetle, is actually attracted to fires, using infrared detectors to find its way to a source of heat. They can travel many kilometers to reach a forest fire, where they join a mating frenzy and lay their eggs on a charred stump or log. The young are able to eat the newly dead wood when they hatch out.

In contrast to fire-dependent ecosystems, *fire-sensitive ecosystems* evolved without the influence of repeated fires, and plants and animals generally lack adaptations to come back after fires. Rainforests throughout the world are examples of this type of ecosystem. *Fire-independent ecosystems* tend not to have fires at all, either because there is no ignition source or due to a lack of vegetation. This type includes the Namib desert of southern Africa and tundra ecosystems of coastal Antarctica.

Unfortunately, humans have changed the role that fire plays in many ecosystems, either by suppressing fires where they naturally occur or by adding fires to systems that are not adapted to them. The U.S. Forest Service had a policy of fire suppression for 60 years, based on the mistaken belief that fires were harmful to the forests. In addition, the introduction of widespread grazing in the west, beginning in the late 1800s, decreased the cover of grasses that helped spread low-intensity ground fires. The result has been huge, catastrophic fires in forests that had tremendous fuel build-up in the absence of low-intensity ground fires. This has led to a shift in species composition of grasslands and forests. For example, stands of quaking aspen, which typically colonize burned sites in mixed-conifer forests, have declined in New Mexico due to fire suppression.

In the case of the bosque, changes in floodplain moisture, due to the suppression of periodic flooding, have resulted in a build-up of fuels, while increased human activity in and around the bosque have increased sources of ignition. The result has been catastrophic

fires in an ecosystem that was not adapted to large fires. We now understand the need to manage the bosque in a way that will decrease the impact of wildfires. Land managers are removing dead and downed wood and exotic species such as saltcedar and are trying to restore the mosaic of habitats that once provided natural fire breaks in the floodplain. It is hoped that these changes will decrease the effects of wildfires in the bosque.

Procedure:

1. Discuss the meaning of fire regime and differences among fire-dependent, fire-sensitive and fire-independent ecosystems worldwide. Show pictures, from a web search or from books, of the different types of ecosystems described above (Background).
2. Introduce students to the eight New Mexico ecosystems used in this activity (Rio Bravo, Rio Manso, Rio Nuevo, southwest grasslands, piñon–juniper, ponderosa pine, mixed conifer and subalpine conifer), using photos or pictures to illustrate differences. Note to teachers: to understand the differences between the bosque and upland systems, the non-bosque ecosystems are all presented as they existed without major fire suppression. Most of these systems today have been affected by long-term fire suppression (see #7).
3. Separate students into eight cooperative learning groups so there are two or three students per ecosystem. Hand out the descriptions of fire regimes. Each description includes the following and should be included on the student's poster:
   a. Environment: the general environment with a description of the ecosystem
   b. Ignition: typical sources of fires
   c. Fire frequency: how often fire will move through, may include the season
   d. Type: are fires typically ground or crown fires?
   e. Plant effects: fire's effect on the plants and/or plant adaptations to recover after fire
   f. Unique factors: interesting information about fire in that ecosystem
4. Each group reads how fire interacts with the ecosystem described on its card.
5. Give students poster board or large paper, markers and/or crayons. Instruct them to illustrate how fire changes their ecosystem. They can use words to describe or label any part of the drawing.
6. Have each group share their poster with the rest of the class.

7. Discuss as a class which ecosystems are dependent on fire or sensitive to fire. Discuss the effects of fire suppression in ecosystems adapted to low-intensity ground fires. The bosque has had the influence of major fires introduced into the ecosystem, while grassland and upland forests of New Mexico have been altered by the absence of fire.

Discussion Questions:

Which ecosystems are dependent on fire or are sensitive to fire?

What is the effect of fire suppression on each ecosystem?

What factors increase or decrease fire intensity in that ecosystem?

What is the effect of fire suppression on ecosystems adapted to low-intensity ground fires?

Is fire good or bad? Where/ under what conditions is it "good"? Under what conditions is it "bad"?

Extensions: Look up the definition of "ecological succession." Compare succession in the different ecosystems and the role that fire plays in succession for each. Some will work well to illustrate a cycle.

Resources: New Mexico Department of Game and Fish "Life Zones of New Mexico" coloring book has information and line drawings. Available on line at www.wildlife.state.nm.us/education/index.htm

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Rio Bravo Bosque

Fire Regimes

1. Environment: Before river regulation (upstream dams) and changes to the floodplain, the mature bosque probably existed in patches, called a “mosaic distribution.” Groups of large cottonwoods alternated with younger stands of trees and shrubs, open meadows, and wetlands. Mature forests probably had patchy understory due to regular flooding.
2. Ignition: Prehistoric fires were generally started by lightning strikes in adjacent grasslands, with wind often sending fire into the bosque.
3. Fire frequency: Fires in the prehistoric bosque were probably infrequent, occurring during the dry late spring to early summer (April through June), particularly in dry years.
4. Type: Fires were generally cool, ground fires that crept around the forest floor, sparing many cottonwood trees.
5. Plant effects: Cottonwoods and many native shrubs can re-sprout after light fires. The thick bark of cottonwoods protects them from debris during floods. Trees are damaged by even low heat from fires.
6. Unique factors: The mosaic of meadows, marshes and forests would have provided natural firebreaks that stopped the spread of wildfires. Regular overbank flooding would have aided decomposition of fuels and helped to clear out underbrush, reducing the fuel load. Flooding also would have kept fuels moist in the early summer. Altogether, there were fewer fires, and fires did not spread as much in past river environments.

1

Rio Manso Bosque

Fire Regimes

1. Environment: The changed bosque is a continuous forest of mature or dying cottonwoods, with dead wood and leaves on the ground and a brushy understory including exotic shrubs such as saltcedar and Russian olives.
2. Ignition: In addition to lightning, careless human activity provides many ignition sources.
3. Fire frequency: Fires in the changed bosque typically occur each year. Fires can occur in any month, but most occur in the late winter to early summer (February through June).
4. Type: Large amounts of dry fuel on the forest floor, along with exotic shrubs, cause very hot fires. Shrubs and fallen trees create vertical fuel ladders that carry flames up into the cottonwood canopy.
5. Plant effects: Cottonwoods can sprout after some fires. Exotic saltcedars are highly flammable due to the amount of leaf litter and dead woody material within the plants. They sprout easily after fires and can often produce seeds in the year following a fire, spreading into areas where cottonwoods have been killed.
6. Unique factors: Regulation (controlling the flow with dams) of the river and changes to the floodplain resulted in decrease or elimination of flooding. Without it, leaf litter and wood accumulate in the forest, providing more fuel for fires. Shrubby undergrowth also contributes to fire.

2

Rio Nuevo Bosque

Fire Regimes

1. Environment: The new bosque mimics the prehistoric bosque, but is restricted to the area within the levees. It includes stands of mature cottonwoods, with open, park-like understories. These alternate with stands of younger cottonwoods of varying ages, grassy meadows and wetlands, forming a “mosaic”: a patchwork of different vegetation.
2. Ignition: In addition to lightning, careless human activity causes ignition.
3. Fire frequency: Management to reduce standing fuels and remove exotics, along with public education, have decreased the frequency of fires. Fires can still occur annually and throughout the year due to human activity.
4. Type: Fires burning in “treated” stands (see #6) generally stay on the ground rather than moving into the tree tops. These fires move rapidly but generate less heat than crown fires. Untreated areas may still burn very hot and do considerable damage.
5. Plant effects: In light fires, few cottonwoods as fire creeps along the forest floor. Some of those killed above ground produce root sprouts.
6. Unique factors: Many places have been “treated”: the fuels in the new bosque have been removed or decreased to reduce damage should a fire start. The majority of the exotic understory (such as saltcedar or Russian olive) has been removed and native plants now form the understory. Managers allow overbank flooding in wet years; this reduces fire danger by increasing decomposition and moisture.

3

Southwestern Grasslands

Fire Regimes

1. Environment: Grasslands are extensive flat stretches of grass and other small plants.
2. Ignition: Lightning was a traditional source of fire; today, careless human activity provides additional ignition sources.
3. Fire frequency: Historically, grasslands probably burned every couple of years, typically in late winter through early summer, when dry dead grasses from the previous growing season were abundant.
4. Type: Fires move quickly across large areas, fueled by the dead grasses and gentle slopes typical of grasslands.
5. Plant effects: Grasses are able to regenerate after fires because their growing tissue is underground, at the base of the plant. Many grassland plants (such as wildflowers) also benefit from fires, sprouting from seeds that are able to withstand the burn.
6. Unique factors: Fire helps to maintain the grasslands by reducing the establishment of trees and shrubs. Fires release nutrients from litter (dead plant material) and accelerate the rate of decomposition in the soil, making important nutrients available for new growth. When fires are suppressed, shrubs and trees replace grasses.

4

Piñon-juniper Woodland

Fire Regimes

1. Environment: Woodlands, characterized by widely spaced small trees, occur below the forest and above the grassland or chaparral shrub zones. In the Southwest, the main trees are piñon pine and juniper. Where piñons dominate at higher elevations, native shrubs such as oaks also occur.
2. Ignition: Lightning was a traditional source of fire; today, careless human activity may provide additional ignition sources.
3. Fire frequency: Historically, low-intensity fires probably occurred every 10 to 30 years. Most fires occurred during late winter through the early-summer dry season. Today human activity means fires can occur during any month. Fire suppression in this habitat has been common, so in most areas there has not been a fire in decades.
4. Type: Surface fires burn quickly through the open, grassy spaces between piñons and junipers.
5. Plant effects: Ground fires burn dried grasses and other small plants and help to clear out smaller shrubby species. Piñons and junipers can withstand light fires.
6. Unique factors: These trees are drought tolerant, but water limitations, as well as fire, keep them well spaced. Relatively frequent, low-intensity ground fires help to maintain the piñon-juniper woodlands. Fires also help to cycle nutrients back into the soil, a particularly important function in such a dry ecosystem.

5

Ponderosa Pine Forests

Fire Regimes

1. Environment: Ponderosa pine forests historically contained large, widely spaced ponderosas, with grassy understory.
2. Ignition: Lightning was a traditional source of fire; today, careless human activity provides additional ignition sources.
3. Fire frequency: Prior to fire suppression, ground fires burned ponderosa pine forests every two to 12 years, particularly in the dry spring-to-early summer period.
4. Type: When fires burn regularly, they remain low-intensity ground fires. Since fire suppression, fires that do occur become hot crown fires that kill mature trees. Many areas have not burned in decades.
5. Plant effects: Ponderosa pine has thick bark, deep roots and no low branches. These factors increase its ability to withstand ground fires and decrease the possibility of a fire climbing to the crown; crown fires can kill ponderosa pines.
6. Unique factors: Frequent low-intensity fires historically did not reach into the canopy, but rather quickly burned the grasses, fallen wood and accumulations of pine needles on the ground. Such fires release nutrients into the soil and provide a good seedbed for ponderosa pine seeds. Seedlings are shade intolerant, doing well in sites that have been cleared by burning. The seedlings are vulnerable to fire, but at about five or six years of age, the tree begins to develop thick bark and deep roots that make them resistant to fires.

6

Mixed-conifer Forest

1. Environment: The composition of trees in mixed-conifer forests varies with elevation and location, but includes Douglas fir, white fir, blue spruce, Gambel oak, and quaking aspen. Understory plants include grasses, small plants (such as wildflowers) and shrubs.
2. Ignition: Lightning was a traditional source of fire; today, careless human activity provides additional ignition sources.
3. Fire frequency: Historically, fires occurred every five to 25 years. Since fire suppression, many areas have not burned in decades.
4. Type: Under natural conditions, fire in these forests varied from frequent ground fires to infrequent, patchy crown fires.
5. Plant effects: Most of these trees can withstand low-intensity ground fires. The less frequent crown fires would have killed the trees, leaving cleared areas. This allowed aspens to establish. Aspens spread through cloning: after a fire they can sprout from underground roots.
6. Unique factors: Low-intensity, quickly burning ground fires would have cleared out the understory and returned nutrients to the soil. Aspen groves within mixed-conifer forests tend to be short-lived; through the process of succession, conifers become reestablished within 10 years.

Fire Regimes

7

Subalpine Conifer Forests

1. Environment: These forests are dominated by Englemann spruce and subalpine fir, and in New Mexico occur on small, isolated mountaintops where snow covers the ground much of the year and the ground is usually damp through the short growing season. Stands of aspen also occur, particularly after fires.
2. Ignition: Fires are started by lightning, by fire moving up from lower elevations during dry years or by human activity.
3. Fire frequency: In some areas, historic fire intervals are 150 years or more. Some spruce-fir forests experience low-intensity ground fires every five to 30 years, depending on surrounding ecosystems.
4. Type: Fires tend to be intense crown fires that kill mature trees.
5. Plant effects: Spruce and fir trees have thin bark which offers little protection for the cambium (growing part of the tree), and the shallow roots are susceptible to soil heating. Seeds are usually killed by fire on the ground. Aspen are clones, with all the trees in one stand joined by underground roots; these roots can re-sprout quickly after a fire.
6. Unique factors: Ground fires will burn low-growing branches and rise up the tree to produce crown fires, which can kill a whole stand of trees. After a crown fire, aspen will quickly grow to dominate the area. Spruce seeds, carried by wind, become established under these aspen; spruce grow slowly but eventually will replace the aspen.

Fire Regimes

8