Earth Gauge
A National Environmental Education Foundation Program

Ecosystems and Climate Change

Ecosystems are defined as all interacting living and non-living things in a given area. An ecosystem can be as large as the entire Earth, or as small as a puddle of water. While all ecosystems are subject to periodic disturbances such as fires, droughts, and wind storms, ecosystems move towards a state of equilibrium or stability between disturbances, where biodiversity and water and nutrient cycling are maximized. Except for gradual changes as species evolve or change their ranges, ecosystems remain in a state of equilibrium until there is another disturbance. Climate change that alters rainfall and temperature regimes in an ecosystem over a period of years or decades (as opposed to centuries or millennia) constitutes a disturbance to which life must adjust. Disturbances associated with climate change can cause changes in ecosystems including:

- changes in the **frequency and severity** of other **disturbances**, particularly fires and droughts;
- changes in the timing of seasonal life cycle events, or **phenology**;
- accelerated changes in **species composition**;
- complete **life zone shifts**, which usually result from a combination of the previous three factors.

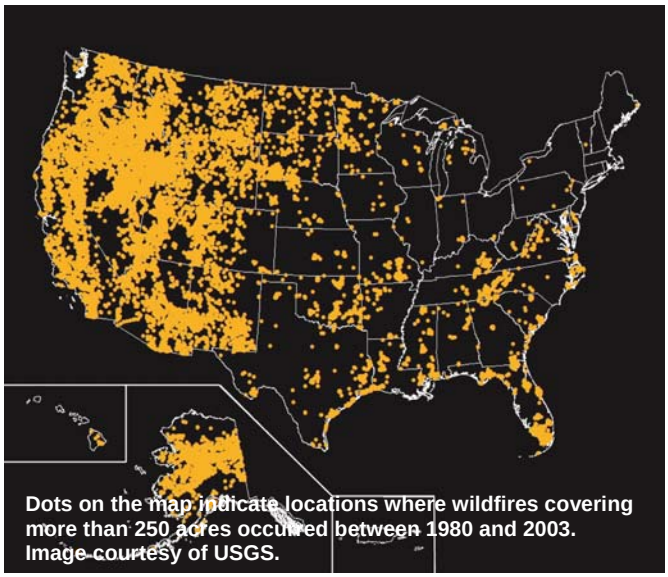
This fact sheet provides short case studies and examples of disturbances associated with climate change in terrestrial ecosystems of North America.

DISTURBANCE FREQUENCY AND SEVERITY

Case Study: Wildfires in the West

The ecosystems of the Western United States are adapted to fire at semi-regular intervals with varying degrees of frequency and intensity. Some areas, such as the coastal forests of the Pacific Northwest may go several thousand years without fire, while California's coastal chaparral can burn at high intensity as often as every few years. Some patterns in the relationship between climate and wildfire have been observed.

- The El Niño Southern Oscillation (ENSO) Cycle affects the severity of fire seasons. Specifically, El Niño phases correspond to above average precipitation in the Southwest and below average precipitation in the Northwest, with the opposite being true during La Niña phases. While drier years correspond to more fires, there is more plant growth (especially fuels such as grasses and shrubs) during wet years. If an especially wet year (when abundant fuel growth happens) is followed by an especially dry year, there will be lots of dry fuels on the ground and ideal conditions for wildfires will exist. Tree ring records show that in the Southwest, 1748 was record year for fires: from 1747 to 1748 there was an abrupt shift from wet to dry conditions.
- Teleconnections between the Pacific Ocean and warm phases of the Atlantic Multidecadal Oscillation (AMO) correspond to drier and warmer conditions in the Western U.S. For the past 500 years, the Western Region has consistently experienced more wildfires during warm phases of the AMO.



Dots on the map indicate locations where wildfires covering more than 250 acres occurred between 1980 and 2003. Image courtesy of USGS.

- Years when the West's mountain snowpack melts early in the season are almost always years with above average wildfire occurrence. The point in the year when rivers in the West experience their peak flow volume, which is a measure for when the snow that feeds the rivers melts, now arrives on average nine days earlier than it did in the 1950's.
- With rising temperatures and earlier snowmelt in the West, the average duration of the year when wildfires are burning has grown by about 78 days (a 64 percent increase) since the 1970's.

PHENOLOGY

Phenology is the study of recurring natural phenomenon, such as the first budbursts, beginning of animal migrations, emergence from hibernation, etc. In recent decades, springtime events have been occurring earlier and earlier in the calendar year, a trend which has been linked to less severe winter weather. Over the second half of the 20th Century in the U.S., the growing season, or the period between the last frost in spring and the first frost in fall or winter, grew by ten days. Winter temperatures in general rose during this period as well, especially in the West where there was a 1.5 degree Fahrenheit increase. Warmer temperatures stimulate plant blooms, and these recent warming trends have corresponded to plants blooming earlier in the year. In the Eastern U.S., for example, lilacs bloom an average of 4.2 days earlier than they did in the 1950's. In the West, they bloom an average of 7.5 days earlier.

The earlier onset of warmer temperatures and plant blooms has been matched by birds advancing the average dates of their migration and breeding activities. Examples of this trend include:

- Mexican Jays in southern Arizona are laying eggs ten days earlier than they did in the 1970's.
- Tree Swallows throughout North America are laying eggs nine days earlier than they did in the 1970's.
- In parts of the Southeast, the colorful wood duck is breeding a full month earlier than it did in the 1970's.
- In southwestern Wisconsin, when compared to the 1930's, Cowbirds, House Wrens, Eastern Phoebes and Great Blue Herons are all returning from their wintering grounds significantly earlier in the year.

ACCELERATED CHANGES IN SPECIES COMPOSITION

Every plant and animal has a specific range of climate conditions within which it can survive. Even small changes in climate can have appreciable effects on an area's species composition.

- In the Short-grass Prairie region of the Great Plains, a rise in average daily minimum temperature over the past four decades has corresponded to the replacement of Buffalo Grass by less nutritious forb species.
- Since 1976, winters in the American Southwest have become wetter as summers have become drier. In the Chihuahuan Desert, this change has favored shrubs over grasses, which has made conditions unsuitable for former residents like the Burrowing Owl, Mojave Rattlesnake, and Horned Lizard.

Red Brome is replacing other plants that provide food and shelter for the Desert Tortoise. Photo by Jeff Servoss, USFWS

- The change in the Southwest's seasonal rainfall distribution has also allowed the invasive Red Brome grass to establish itself in places like the Mojave Desert. Because this grass is highly flammable, its increased presence in the Mojave (which occurred between 1980 and 2004), has been linked to increased fire frequency.

COMPLETE LIFE ZONE SHIFTS

If the change in species composition is of sufficient magnitude, a certain area may be said to have experienced a complete shift in life zone, which is an area with similar plant and animal communities. The Great Basin, or the flat, low-lying (relative to the mountains surrounding it) area that covers Nevada and parts of Utah, Oregon, and California, experienced a climate induced life zone transition about 12,000 years ago. During the last Ice Age, the region was cooler and wetter than it is today, allowing forests to cover much of the Basin. As the climate warmed, pine, spruce, and juniper trees could no longer tolerate the Basin's temperature and lack of rainfall and retreated to higher elevations. Plants like sagebrush and shadescale moved in, creating the desert vegetation community common in the Basin today. While this transition involved a dramatic climate shift, more subtle climate changes can have significant effects in sensitive ecosystems, like alpine zones.

Case Study: Alpine Zones

Alpine zones, areas in tropical and temperate mountain ranges that occur above the tree line and below the snow line, are especially vulnerable to complete life zone shifts, as rises in temperature allow trees to survive in high elevation zones that were previously dominated by grasses and shrubs.

- Western North America warmed by between two and three degrees Fahrenheit over the last century, with most of this warming occurring in the last 30 years. This trend has corresponded to high-elevation forests expanding into areas that were formerly treeless alpine zones. In Alberta's Banff National Park, Engelmann Spruce zones have moved about 150 feet uphill since 1990.
- The sub-alpine zones of the Cascade Mountains in Oregon are a transition zone between forests and alpine zones. On north-facing slopes, the factor that limits tree growth is the duration of seasonal snow cover. Warmer temperatures and shorter duration of snow cover since the 1970's have corresponded to increased tree growth on the colder north-facing slopes.
- In the Green Mountains of Vermont, warmer temperatures over the last 40 years have allowed hardwood species, such as oaks and maples, to thrive in areas where only conifers could before. The area of these mountains that are dominated by hardwoods as opposed to conifers grew by 19 percent during this period.

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