Forestry, Ecosystems and Wildlife

THE DIFFERENCES ARE IN THE DETAILS

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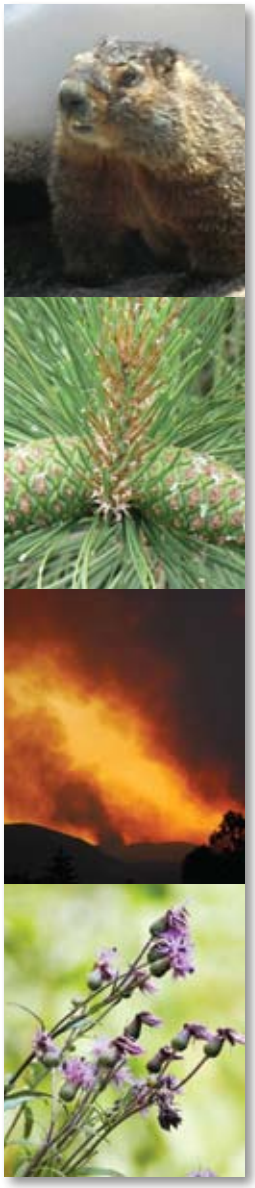

Phenology—*the recurrence of annual events that correlate with climate.*
Ecosystem—*a community of plants, animals and microorganisms that constantly interact.*

Climate affects all terrestrial and aquatic ecosystems in Colorado, and over the long term, plants and animals adapt. In the short term, fires, increased attacks by insects and invasive plant species, and higher temperatures are changing familiar landscapes.

Annual and seasonal changes in climate will alter the mountain snowpack, plant flowering, animal breeding, seasonal migrations, plant and animal species' ranges, and ecosystem productivity and processes. Further, the changes in the atmospheric chemistry, such as the increases in carbon dioxide concentrations, also influence plant growth and plant species composition.

Recently observed changes in plants and animals are apparent in the timing of plant phenology; animal breeding, nesting behaviors and hibernation; as well as geographic distribution. Whether these changes are successful adaptations to climate change depends on many connections within plants, animals and ecosystems, the human influences on the landscapes, and the rate at which climate changes.

The changes in climate and the ecological effects will probably be gradual and abrupt. Gradual changes in temperature will likely influence annual events, such as when flowers bloom. Birds may begin to nest earlier. Abrupt changes could include the coincidence of drought, water stress on trees and insect outbreaks. For instance, in northern New Mexico over a recent two-year period, large areas of mixed conifers died.

Ecosystems

The state's ecosystems vary from the grasslands on the eastern plains to the forests and alpine tundra that cover the Rocky Mountains in central Colorado to shrublands, woodlands and forests that cover the western landscapes. In the mountains, vegetation gradually changes in species from the montane forests, to the subalpine forests, and finally to tundra as elevation rises.

Grassland ecosystems are dry. Precipitation comes mainly in the months of March through May and June. The grasslands will see increased temperatures throughout the year. The growing season will lengthen, with severe frosts occurring earlier in the fall and later in the spring.

Precipitation projections are uncertain. With temperature increases, there is likely to be more stress on the plants even if precipitation remains at historical levels. Colorado grasslands adapt for drought, shifting species composition to plants better suited to warmer temperatures and less precipitation. For example, under drought, the vegetation adapts by shifting to the shortgrasses of blue grama and buffalo grass. But precipitation pattern changes may influence species composition in new ways.

Ongoing experiments in grassland ecosystems explore the impact of nearly double the atmospheric concentration of carbon dioxide on the grassland. After four years, the plant response is evident and varies greatly by species. Woody shrubs, such as fringed sage, appear to increase in productivity more than the native grasses. The native grasses appear to decline in palatability and digestibility, suggesting a decline in the future quality of forage for wild and domestic grazers, such as pronghorn and cattle.

Montane and subalpine forest ecosystems cover the lower to higher slopes of the Rocky Mountains. Ponderosa pine is predominant in the montane forest. Subalpine forests can include lodgepole pine, subalpine fir, Engelmann spruce and limber pine. Climate change is likely to result in warmer and earlier springtimes, and warmer autumns and later frost. Most of the precipitation comes in the form of snow; but under a changing climate, some of this precipitation will come as rain in the fall and spring.

Colorado and its ecosystems depend on the snowpack to store water and gradually release moisture throughout the spring. Earlier melts and runoffs may mean a longer growing season with less moisture and greater moisture stress in summer and fall. Stress in trees opens the possibility for greater impacts from insects and disease. If the climate is drier, then the possibility exists for grassland and shrubland ecosystems to move into the montane forest and for the montane species to move into the elevation previously occupied by the subalpine forests.

Alpine tundra, the Rocky Mountains' highest ecosystem, is covered by snow for long periods of time; but snow distribution is highly influenced by topography and wind. Warming temperatures and changes in the snow to rain occurrence will likely alter this distribution of snow on the landscape. Experiments manipulating the snow distribution show that plant species composition is very sensitive to snow distribution changes.

Under a changing climate, snowmelt would occur earlier, exposing the vegetation to sunlight and warming temperatures, which also portend the possibility of trees moving into the alpine. Such projections for the areas around Aspen suggest that the ski season will start later and end earlier, the possible need for increased snow-making and potential conflicts with agriculture for water.

Disturbances

Many of Colorado's ecosystems are sensitive to climate. Warm and dry conditions mean more fires. An analysis of the recent precipitation and temperature records in western United States suggests warmer, drier conditions have already resulted in longer fire seasons and fire at higher elevations, in the subalpine forests.

Similarly, studies on bark beetles, such as the mountain pine beetle, show the beetles' population increases with warmer temperatures. The extreme winter cold that kills bark beetles hasn't happened. Instead, beetles have thrived, suggesting that under a warming climate, bark beetles and greater epidemic attacks will increase.

Weather and climate strongly influence insects and fire, but so does human activity. The current bark beetle epidemic in Colorado is in large areas of trees of similar age; and the legacy of fire suppression in the western United States left landscapes with dense stands. Future climate change impacts will interact with the human effects on the landscape.

Invasive Species

A species is considered invasive if it is non-native to the ecosystem under consideration; and if its introduction causes, or is likely to cause, economic or environmental damage, or to harm human health.

Colorado has identified a number of noxious plant species. The Colorado Commissioner of Agriculture—in consultation with the state noxious weed advisory committee, local governments, and other interested parties—develops and implements state noxious weed management plans designed to stop the spread of invaders, such as the yellow starthistle (centaurea solstitialis) Canada thistle (cirsium arvense), leafy spurge (euphorbia esula), and spotted knapweed (centaurea maculosa). These species could benefit from climate change.

Researchers explored the response of six invasive weeds—Canada thistle, yellow starthistle, leafy spurge, spotted knapweed, field bindweed, and perennial sowthistle—to concentrations of carbon dioxide from the beginning of the 20th century to the end of the 21st century. Increases in atmospheric carbon dioxide from the early 20th century to the present stimulated invasive plant biomass by an average of 110 percent, raising the possibility that more atmospheric carbon might be partly responsible for the spread of invasive weeds during the 20th century.

The trend is expected to continue: Likely future concentrations of carbon dioxide in the atmosphere will stimulate invasive plant biomass in the six species studied by Ziska (2003) by an average of 46 percent, with the largest response for Canada thistle. While studies like this one are important to increase our understanding of invasive plants' response to increased carbon dioxide concentration, little is known about many invasive species' life history, growth or response to climate change.

Wildlife

Colorado wildlife includes many species of birds, mammals, reptiles and amphibians. The State Wildlife Action Plan includes 205 Species of Greatest Conservation Need. The gravest threats to Colorado wildlife include habitat conversion; infrastructure and other resource demands from a growing Colorado population; recreation; invasive and/or exotic species; and coordination, funding and information gaps.

Climate change is likely to affect wildlife, too, through habitat changes, such as interaction with invasive species and changes in the availability of cover and protection from temperature extremes. Already, the yellow-bellied marmot comes out of hibernation nearly three weeks early, a response to the warmer air temperatures.

Climate change could alter the habitat for Colorado's cool- and cold-water fish, including the endangered greenback cutthroat trout. Competition with non-native fish species already reduced their territory.

Future vegetation pattern changes will fragment habitat and open the possibility of novel combinations of plant species co-existing. Such landscape changes will affect the wildlife habitat suitability as well as the potential to migrate across a different landscape to seek habitat.

Snow Dependent Species

Asynchrony is defined as the relation that exists when things occur at unrelated times. Plants, animals and ecosys-

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tems have evolved over time to have dependent relationships, such as the birth of young to coincide with the availability of food. Climate change could unravel these close relationships.

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An example: At the Rocky Mountain Biological Laboratory near Crested Butte, the timing of snowmelt has not changed in the two decades it's been studied. Vegetative growth does not occur until the snow has melted, so the resulting appearance of green vegetative material has not changed much.

Temperatures have risen over the last several decades. Consequently, hibernating animals, such as marmots, come out earlier, when there is still snow. Vegetation is sparse and little food is available. This type of asynchrony could increase stress on marmots. Other types of asynchrony include migrants arriving earlier and their food source, insects, having already hatched and flown. Asynchrony is likely to cause surprises.

Adaptation Options

Plants and animals will seek to adapt to climate changes as they have in the past. The challenge may be the speed of climate change and the rate plants and animals can adjust. Human activity confounds landscape features and that may affect plants and animals' ability to migrate to new habitat. Minimizing the stress may improve ecosystem health and resilience in the face of a changing climate.

Colorado landscapes are subjected to a variety of current stressors, such as air and water pollution, habitat fragmentation and invasive species, as well as the legacy of past land management. A focus on minimizing stresses may improve the ecosystem's resilience and improve its health. ❑

Asynchrony—*a lack of synchronism or coincidence; the relation that exists when things occur at unrelated times*

Additional Reading

Aspen Global Change Institute. 2006. "Climate Change and Aspen: an assessment of impacts and potential responses." Aspen Global Change Institute, Aspen, CO.

Baron, Jill S. 2002. "Rocky Mountain futures: an ecological perspective." Washington, D.C.: Island Press

Bentz, Barbara. (in press). "Bark Beetle Outbreaks in Western North America, Causes and Consequences." Utah State University, Utah.

Bosworth, D., Birdsey, R., Joyce, L., Millar, C. In press. "Climate change and the nation's forests: Challenges and opportunities." Journal of Forestry.

Colorado Division of Wildlife. 2006. "Colorado's Comprehensive Wildlife Conservation Strategy." Colorado Division of Wildlife.

EPA. 5/21/2007. "Climate Change and Colorado." EPA. http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BPPNK/$File/co_impct.pdf

Inouye, D.W., Barr, B., Armitage, K.B., Inouye, B.D. 2007. "Climate change is affecting altitudinal migrants and hibernating species." PNAS 97:1630-1633

Joyce, L.A, Blate, G., Littell, J., McNulty S., Millar, C., Moser S., Neilson R., O'Halloran, K., Peterson D.L. In press. "Adaptation options for climate-sensitive ecosystems and resources: National Forests." Synthesis and Assessment Product 4.4, U.S. Climate Change Science Program. 151 pgs.

Joyce, L.A, Blate, G., Littell, J., McNulty S., Millar, C., Moser S., Neilson R., O'Halloran, K., Peterson D.L. 2008. National Forests. IN: Julius, S.H., J.M. West, J.S. Baron, B Griffith, L.A. Joyce, P. Kareiva, B,D. Keller, M.A. Palmer, C.H. Peterson, and J.M. Scott. Preliminary review of adaptation options for climate-sensitive ecosystems and resources. A report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. U.S. Environmental Protection Agency, Washington, D.C.

Kruger, F.A., Fielder, J., Meaney, C.A. 1995. "Explore Colorado: A naturalist's Notebook, Denver Museum of Natural History." Westcliffe Publishers

Logan, J., Powell, J. 2001. "Ghost forests, global warming, and the mountain pine beetle." American Entomologist 47: 161-172

Morgan, J.A., Derner, J.D., Milchunas, D., Pendall, E. 2008. Management implications of global change for Great Plains rangelands. Rangelands 30(3):18-22.

National Assessment Synthesis Team. 2000. "Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change." Overview. Report for the U.S. Global Change Research Program. Cambridge University Press, Cambridge UK. 154 p.

National Assessment Synthesis Team. 2001. "Climate Change Impacts on the United States: The Potential Consequences of Climate Variability and Change." Foundation Report. Report for the U.S. Global Change Research Program. Cambridge University Press, Cambridge UK

Ojima, D. S., J. M. Lackett, and the Central Great Plains Steering Committee and Assessment Team. 2002. "Preparing for a Changing Climate: The Potential Consequences of Climate Variability and Change—Central Great Plains." Report for the U.S. Global Change Research Program. Colorado State University. 103 pp.

Increased carbon dioxide levels affect native range plants (background), including blue gramma (above), and encourage the spread of noxious weeds.