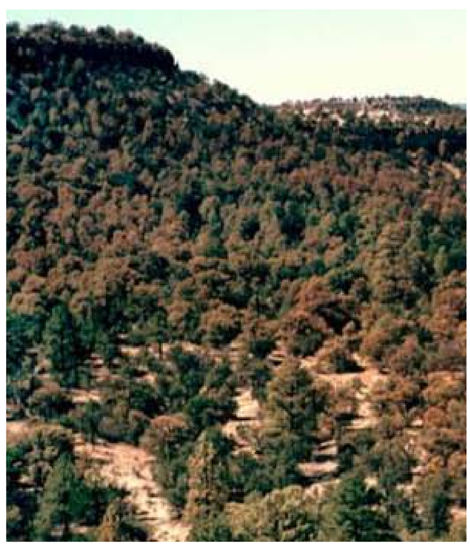
Managing Forests in the Face of Climate Change:

A Summary of the New Mexico Forestry and Climate Change Workshop

edited by Alexander Evans



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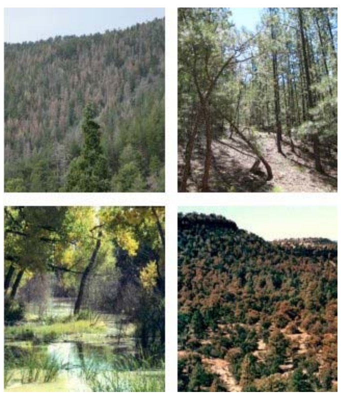

Cover photo credits: Bosque del Apache NWR archive photograph, piñon dieback in the Jemez Mountains from Craig Allen, reflected trees in upper right from Howard Gross, and mixed conifer and ponderosa pine from Zander Evans.

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The Forest Guild practices and promotes ecologically, economically, and socially responsible forestry—"excellent forestry"—as a means of sustaining the integrity of forest ecosystems and the human communities dependent upon them.

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Editors note: This paper represents a summary of material presented at the New Mexico Forestry and Climate Change workshop, held November 20, 2008 at the Albuquerque Grand Airport Hotel. In an effort to be brief, I have emphasized the main points of the speakers and working groups. For more details, see the individual workshop presentations available at www.forestguild.org/nmfccworkshop.html.

Introduction

New Mexico is likely to grow warmer by 2°F by 2030 and 6°F by 2080. Climate change will alter forest patterns and processes and although the specifics of these changes are uncertain foresters and other natural resource managers must include climate change in their plans. To begin to understand and plan for the impact of climate change on New Mexico's forests, the Forest Guild and the New Mexico Forest and Watershed Restoration Institute—along with other participants (see Acknowledgments at end of this document)—convened a workshop that brought together managers, scientists, landowners, students, and activists to discuss how forest management can respond to climate change.

In the six months before the workshop, four working groups met to pull together the best available research and field experience on each of four forest types: mixed conifer/aspen, ponderosa pine, piñon-juniper, and bosque. Each working group developed a forty-minute presentation about the projected impacts of climate change on a forest type, including practical on-the-ground knowledge and management considerations.

The working groups used the framework for managing in the face of climate change developed by Dr. Connie Millar and colleagues (Millar et al. 2007). This framework, presented by Dr. Millar at the opening of the workshop, separates adaptation strategies from those designed to mitigate climate change. While reduction of greenhouse gas emissions is crucial to ecosystem health, the workshop focused on the equally important adaptation to climate change. Adaptation strategies include:

- **Resistance options** – manage forests so that they are better able to resist the influence of climate change or to forestall undesired effects of change.
- **Resilience options** – resilient forests not only accommodate gradual changes but tend to return toward a prior condition after disturbance.
- **Response options** – enable or facilitate forest ecosystems to respond adaptively to, rather than resist, change.

Working groups also considered how current management objectives might be affected by climate change and what constraints managers face in adapting to climate change.

So that each of the four working groups would be starting from the same point, climatologist Dr. David Gutzler from the University of New Mexico generated climate change predictions for New Mexico. Dr. Gutlzer worked with Gregg Garfin and colleagues from the National Oceanic and Atmospheric Administration's Earth System Research Laboratory to create 100-year climate predictions based on the Intergovernmental Panel on Climate Change (IPCC) emissions scenario A1B. IPCC's A1B scenario was built on assumptions of rapid economic growth, declining population after about 2050, rapid implementation of new and efficient technologies, and a balance of fossil and alternative energy use (Intergovernmental Panel on Climate Change 2007). The scenarios used as the basis for the workshop included interannual variation during the next century, derived from the interannual variation observed during the last century. Dr. Gutzler provided annual precipitation, summer and winter precipitation, and temperature estimates for each of four climate divisions in New Mexico. All the scenarios are available at: http://www.forestguild.org/NMFCC_links.html.

In Julie Coonrod's presentation of the climate change scenarios, she showed that Dr. Gutzler's scenarios fall toward the dry end of a comparison of six climate change scenarios (Hurd and Coonrod 2007). At the state level, the expected summer increase by 2100 of 7.5°F is greater than the expected winter increase of 5.8°F. Estimated precipitation trends for the next century were dwarfed by the interannual variation. However, even without declines in precipitation, water stress will increase in the next century as rising temperatures increase evaporation and plant transpiration.

In his introductory talk, Dr. Craig Allen discussed changes in forest structure over the last century that compound the stress of climate change on ecosystems. Logging, grazing, and fire exclusion have created denser forests, which are outside the historical range of variation (HRV). In other words, though forests change over time, the forests of modern New Mexico are denser than at any previous time. Greater forest density means increased competition between trees and, as a result, greater stress on each tree. Stressed trees are more vulnerable to insect outbreaks, as highlighted by the drought and piñon bark beetle outbreak across the Southwest in 2003 (Breshears et al. 2005). Denser forests are also more prone to severe fires. While fire is a natural part of New Mexican forests, increases in the quantity and connectivity of fuels has made severe fires more common than in the past.

Climate can directly cause forest dieback through drought, high temperatures, and the synergy between moisture and temperature. The cumulative affect of continued stress on trees over a number of years is poor growth and low vigor. The physiological thresholds for most tree species are difficult to predict because they tend to be non-linear. These types of thresholds can cause abrupt ecosystem change even as climate is changing gradually (Allen 2007).

As Dr. Allen highlighted, changes in climate can augment the impacts of departure from historic forest conditions. Climate change can amplify other mortality agents, such as insect outbreaks. Insect outbreaks are changing because of warming temperatures and drought. Insect ranges are expanding northward and up elevation, becoming more extensive, and increasing in severity. Similarly, recent increases in the area and severity of wildfires in New Mexico are related to both drought and warmer temperatures. The number of large fires matches the pattern and trend of spring and summer temperature increases across the West.

Mixed Conifer Forests

Mixed conifer describes a forest type that covers a broad range of ecological settings and includes a wide variety of species, including ponderosa pine, Douglas-fir, white fir, blue spruce, corkbark fir, sub-alpine fir, Engelmann spruce, and lesser amounts of southwestern white pine or limber pine. Mixed conifer forests exist on a continuum of physiographic sites—between warmer and drier ponderosa forests in lower elevations and colder and wetter spruce-fir forests in higher elevations. Across this continuum is it useful to separate out to general types: dry and wet mixed conifer.

Dry mixed conifer forests within the HRV usually experienced frequent and low-to-moderate intensity fires. Ponderosa pine was a major component of these forests, which had an uneven-aged and patchy distribution of trees. In contrast, wet mixed conifer forests historically had a fire regime that consisted of a combination of frequencies and severities. These forests tended to form uneven-aged patches across the landscape. After stand replacement fires in mixed conifer forests, aspen often dominated early successional stages.

In the last century of fire exclusion, dry mixed conifer forests have shifted to closed canopies with shade tolerant species dominating the understory. Fuel loading has increased, making uncharacteristically severe fires more likely. In wet mixed conifer forests, fire exclusion has lead to late seral stages dominating the landscape. This increased homogeneity at the landscape scale permits severe fires to cover larger areas than was historically possible because of the mix of early, mid, and late seral stages across the landscape.

The impacts of climate change on the insects and diseases of mixed conifer are either uncertain or mixed with the notable exception of bark beetles. Bark beetles are likely to increase in activity because of warmer, drier weather. The impacts of insects or disease depend on condition of the host, so to the extent that climate change increases stress on the trees in mixed conifer forests, they will be more vulnerable to insects and diseases. A warming climate may increase both wildfire frequency and duration. Earlier springs, long fire seasons, and longer windy seasons all present fire management challenges in mixed conifer forests. All these threats will alter wildlife habitat―both for species with large home ranges such as Mexican spotted owl and those with small home ranges such as the Jemez Mountains salamander.

Mixed Conifer Management Responses

In dry mixed conifer, restoration of forests to conditions within HRV will improve resilience, even if future climate diverges from the past. Management should encourage fuel loading, stand structure, and species composition that are compatible with a frequent fire regime. This includes reducing tree density, promoting spatial heterogeneity, encouraging ponderosa pine, and reintroduction of surface fire.

In wet mixed conifer forests, restoration of a landscape mosaic of seral stages will improve resilience. This includes reducing the landscape continuity of homogeneous forest phases (especially climax phases), as well as increasing representation of stands at early- or mid-successional stages.

Response options for wet mixed conifer in a warmer, drier future can include the application of historical reference conditions from drier sites in wet sites that become drier with climate change. Resistance options may be focused around important wildlife habitat for threatened or endangered species. Both southwestern white pine and ponderosa pine on wet sites deserve species conservation attention.

Ponderosa Pine Forests

Ponderosa pine forests dominate areas that are drier and warmer than mixed conifer forests. Historically, fire and other disturbance agents regulated much of the structure and ecology of these forests, which typically had an open overstory canopy and an understory composed of grasses, forbs, shrubs and other plant forms. This open forest structure was maintained by comparatively frequent, cool surface fires. Management practices that focused on domestic livestock and timber production—including fire suppression—resulted in a denser, closed canopy forest structure. These management activities also resulted in a significant departure from the historic fire regime both, in frequency and type of fire. Ponderosa pine is not adapted to withstand or regenerate following landscape-scale crown fires. Oftentimes fuel loading following these unnatural fires is well outside of HRV, and the resulting inability to restore historic fire regimes limits the likelihood of returning the site to ponderosa pine forest.

Climate change in New Mexico is likely to increase the frequency of uncharacteristic, landscape-scale crown fires in ponderosa pine forests. These fires present a management challenge because ponderosa pine may be unable to reoccupy burned areas due, in part to a lack of seed source, competing vegetation and altered site (soil) conditions. Climate warming and drying is predicted to reduce the range of ponderosa pine in Arizona and New Mexico. The distribution and abundance of ponderosa pine on the Mogollon rim and Sacramento Mountains are likely to decline (Rehfeldt et al. 2006). As with mixed conifer forests, the impact of climate change on insects and diseases of ponderosa pine are uncertain or neutral, with the exception of an increase in bark beetle activity.

Ponderosa Pine Management Responses

Management options that promote resilience of forests to climate change include those that encourage structural and genetic diversity, improve tree vigor, and improve regeneration potential. An essential goal of management will be to restore functional processes that permit the forest to adapt to an altered climate (i.e. favor regeneration). Restoration of both structural conditions and disturbance patterns concomitantly should be emphasized. Thinning and prescribed fire can be used separately or preferably in combination to return ponderosa pine forests to HRV. Ideally, ponderosa pine stands with lower densities (15 to 30% of maximum stand density index), less than 10 tons per acre of surface fuels, a clumpy uneven-aged structure, and canopy gaps are more resilient to catastrophic, large scale crown fires, bark beetles, and hence the negative impacts of climate change.

Since some forests will inevitably burn in crown fires, managers must be prepared to respond to a variety of post-fire conditions. Management should focus on post-fire vegetation trajectories, and human intervention may be required to retain ponderosa pine on site. Where artificial regeneration is necessary, managers should consider future site suitability given a warming climate. If ponderosa pine is planted, genetic diversity will be important, and should include seed from both local and nearby seed zones when available. In response to the changing range of ponderosa pine, managers may need to consider how to facilitate migration of forest types. This may include assisted transition to another vegetation type or establishment of ponderosa pine in new locations.

Piñon-Juniper Woodlands

Piñon-juniper woodlands are more difficult to define than the other forest types discussed in the workshop. In fact no single, robust definition exists. Even the term “woodland” is an unofficial subdivision of forest and not included in all vegetation classification systems. One classification of piñon-juniper separates savannas, wooded shrublands, and persistent woodlands (Romme et al. 2008). A similar classification system identified by a working group that was convened by New Mexico State Forestry adds an open woodland category and provides a dichotomous key (Reid 2008). Another classification system is based on a combination of factors: which season the forest type receives the most precipitation (summer or winter) and the climate (warm or cool) (US Forest Service 1993). Regardless of how piñon-juniper is classified, it covers 46% more of New Mexico that all timberland types put together.

In general, piñon-juniper woodlands are made up of piñon pine, single seed, Rocky Mountain, or alligator juniper. As climate has changed since the last ice age, the species mix and even the geographic and elevational distribution of piñon-juniper has changed significantly. However, historically the extent of piñon-juniper woodlands was smaller and stands were less dense. Land use change has allowed grasslands to become piñon-juniper savannas, and savannas to increase in number of trees and resemble woodlands (Gori and Bate 2007).

In addition to climate, fire and piñon bark beetle have determined the historic range and structure of piñon-juniper woodlands. Fire regimes in piñon-juniper were variable, with savanna types burning frequently at low severity and persistent woodlands burning infrequently at high severity. More research is needed to completely categorize fire regimes across piñon-juniper types.

Warming and drying due to climate change is likely to exacerbate natural disturbances in piñon-juniper woodlands. As mentioned above, a climate change-type drought and bark beetle outbreak have caused mass mortality in piñon-juniper woodlands (Breshears et al. 2005). However, the bark beetle outbreak was spatially heterogeneous and did not kill all the piñon. While fires in piñon-juniper may not be as uncharacteristic as in other forest types, the addition of non-native invasive species such as cheatgrass has altered post-fire outcomes. Before invasive exotics entered the system, piñon-juniper woodlands were able to re-establish after stand-replacing fires. Now exotics can prevent re-establishment of woodlands and create uncharacteristically frequent fire regimes (Floyd et al. 2006).

Piñon-Juniper Management Responses

Managing for climate impacts begins with the maintenance of healthy and diverse piñon-juniper woodlands. Another key element is an accurate characterization of site potential and existing ecosystem components. This is particularly important in piñon-juniper woodlands where ecosystem processes such as fire different greatly across types. Similarly, the presence of exotic species may require significant management attention before further restoration can take place. Any efforts to promote transition between types of piñon-juniper woodland should be consistent with site potential. Managers should use existing species and encourage a natural ecosystem response to change.

Bosque Forests

The bosques that line many of the rivers in New Mexico are, by definition, depositional low elevation floodplain forests along waterways. In the past, bosques were made up of cottonwood stands, patches of dense young willow and native olive, and wetlands with rushes and cattails. River flooding and ground water recharge were the ecological processes that maintained this mosaic of vegetation. These key ecological processes have been altered by human use of the river and floodplain. Dams have changed the timing, duration, and extent of high river flows. Levies reduce the extent of the active floodplain while drains, agriculture, and development have extended and altered the more xeric sections of the bosque. Exotic species such as tamarisk and Russian olive have invaded bosques, reduced diversity, and increased fire threat.

Like other forest types bosques will be affected by climate warming, drying, and increased frequencies of fire. However, bosques will bear the brunt of altered precipitation regimes. Increased flood frequency, intensity, and flashiness will increase channel cutting and filling. Earlier snow melt and peak flows will result in a disconnect between peak flows and seed dispersal of native plants. Warming and drying may favor invasive species over cottonwoods and willows, which may be ill-suited to new, more xeric conditions.

Bosque Management Responses

Current bosque management tends to focus on particular elements of the system, such as cottonwood trees or sensitive wildlife species. Fire protection has focused on removing invasive species, particularly in wildland urban interface (WUI) areas. Bosque management in the face of climate change must take a holistic approach that includes macroinvertebrates, fungal decomposers, mychorrhizal associations, insects, and herbaceous plants—in addition to the more common focus on woody plants, birds, mammals, reptiles. This type of management will be particularly important for those plant and animal species that exhibit significant downward trends in population numbers or habitat degradation. Other species sensitive to a warming climate include amphibians in environments where water temperature and quality has been impaired, migratory birds whose habitat quality and extent has been impacted, and plants that have had their seed dispersal or growth processes interrupted.

Management should focus on restoring river processes, such as timing of river flows to facilitate regeneration of native plants and fish spawning. Activities that improve diversity of native plants and restore the mosaic of vegetation types across the bosque will also increase resilience. This may require creation of backwaters, increase in connectivity, exotic plant control, and planting of trees, shrubs and grasses. Bosque restoration requires evaluation of site suitability as well as identification of seed sources and appropriate nursery stock.

Constraints

Each of the working groups identified constraints, but most of these constraints cut across forest types. Challenges to managing forests in the face of climate change include landscape segmented by ownerships, limited management resources, larger political and social dynamics, and uncertainty. The division of natural landscapes into parcels with different objectives makes management to re-establish ecological processes more difficult. Natural environmental processes seldom respect human boundaries. Multi-jurisdictional planning is difficult because it adds more rules, bureaucracies, objectives, and opinions to the decision making process. The existence of many small parcels, especially in the WUI, makes prescribed fire or wildland fire use very difficult. A related issue—particularly important for piñon-juniper—is the large number of archaeological sites that require protection.

Resource limitations plague managers of New Mexico's forests. The financial resources available are dwarfed by the enormity of the management challenge posed by climate change. Organizations have limited capacities to implement treatments and their capacities may decline as more baby boomers retire, taking valuable experience with them. By the same token, New Mexico has few skilled thinning and logging crews to apply prescriptions. Lack of markets for small trees removed in restoration treatments adds to the financial limitations. However, sales of woody material from forests can help offset the cost of restoration where markets exist.

Forest management does not occur in a vacuum, and is constrained by the larger political and social environment. For example, the social acceptability of prescribed fire changes after large wildfires. Prescribed fire also requires the general public to acquiesce to smoke in the air and some level of fire risk (even if wildfire threat is higher). While a consensus has grown regarding restoration in ponderosa pine forests (as demonstrated by the New Mexico forest restoration principles, www.fs.fed.us/r3/spf/nm-restor-principles-122006.pdf), agreement about treatments in piñon-juniper or mixed conifer is much more tenuous. The high degree of variability in processes in piñon-juniper and bosque ecosystems means prescriptions are more complicated and consensus less certain.

One of the central challenges to developing a strong consensus on management in the face of climate change is uncertainty. Though the climate is clearly warming, there remains uncertainty about the details of New Mexico's future climate. Most notably, future precipitation patterns are very difficult to predict because of large interannual variability. The lack of certainty makes it more difficult to define an optimal management strategy and build consensus around that strategy.

Conclusion

Although climate change will alter New Mexican forests and even cause extirpation or extinctions, all is not lost. Many of the management recommendations from the working groups emphasized accepted restoration strategies. In other words, "most of what needs to be done soon is what we've known we need to do for a long time" (Brown 2008). There are concrete treatments managers can implement to increase the resilience of New Mexico's forests to climate change.

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Mixed Conifer
Ken Smith (leader), Debra Allen-Reid, Carol Bada, Bryan Bird, Anne Bradley, Zander Evans, Peter Fulé, Marlin Johnson, and Jim Youtz.

Ponderosa Pine
John Harrington (leader), Debra Allen-Reid, Karen Bagne, Randy Balice, Don Falk, Darin Law, Melissa Savage, Mary Stuever, and Jim Youtz.

Piñon-Juniper Woodland
Dave Borland (co-leader), Kent Reid (co-leader), Debra Allen-Reid, Lisa Floyd-Hanna, Hollis Fuchs, Dave Gori, Gerald J. Gottfried, Brian Jacobs, Jeff Morton, Wayne Robbie, Bill Romme, and Wayne Waquiu.

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Steering Committee Members (in addition to working group leaders)
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For More Information

For more information on climate change please see:

- http://www.fs.fed.us/ccrc/
- http://www.forestguild.org/carbon-climate-change.html

General management resources:

- http://www.nmfwri.org/for-land-managers

Mixed conifer forests:

- http://www.forestguild.org/rg_sw_mixed_conifer.html
- http://www.forestguild.org/rg_sw_aspen.html

Ponderosa pine forests:

- http://www.eri.nau.edu/joomla/content/category/5/32/134/
- http://www.forestguild.org/rg_sw_ponderosa.html

Piñon-juniper woodlands:

- http://www.forestguild.org/rg_sw_pinon_juniper.html
- http://www.cfri.colostate.edu/docs/P-J_disturbance_regimes_short%20synthesis_5-07.pdf

Bosque:

- http://www.forestguild.org/rg_sw_bosque.html
- http://www.fws.gov/southwest/mrgbi/index.html

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