Institute for Natural Resources White Paper

Managing for climate change in an ecosystem dynamics framework
Recommendations from April 16, 2009 seminar

Executive summary

- The effects of climate change will be highly variable in Oregon. Some of the changes that occur will be the product of abrupt disturbance events, not gradual or linear changes.
- Ecosystem resilience may be disrupted by climate driven changes in species behavior, such as changes in the population, behavior and distribution of birds and insects, which exert a strong control on forest composition and productivity.
- Forestland managers need to revisit reforestation strategies in anticipation of contemporary forests and forest seed sources being maladapted to future site conditions. Plans for assisted migration of species should be developed.
- Oregon forests have significant potential to offset national carbon emissions by storing carbon. The most effective way of storing carbon is afforestration and longer timber harvest rotations. Credible accounting and monitoring methods need to be developed.
- Creating and maintaining diverse forests with heterogeneous forest structure, composition and function is the most important silvicultural adaptation to climate change.
- The effects of climate change on water delivery in Oregon will be mixed. Oregon's "warm" snowpacks will most likely be among the first casualties of regional warming. Some areas of the state that have low summer stream flows are likely to see those flows occurring earlier in the year. Rivers sourced by spring flow from large volcanic aquifers will continue to have relatively high summer base flows. In general, the influence of the Pacific Ocean, the mid-latitude position of our state, and mountainous geography will probably result in less severe impacts from climate change relative to many other parts of the nation. This raises the possibility of significant environmental impacts from the indirect effect of climate-driven in-migration of people.
- In-migration of large numbers of people will require a focus and emphasis on long-term land use planning. Managing people will be a critical part of managing climate change.
- INR's work on the Dynamic Ecosystems Project has emphasized the perpertuation over time of desired ecological processes, which involves maintenance of key components of these processes, such as fire adapted forest structures, large wood for streams, etc. New regulation is one way to maintain these components over time, but we recommend instead that ecosystem services markets be developed to incentivize landowner action.
- The expected indirect effects of climate change are a reason to prefer non-regulatory strategies to manage change. Increased regulation of the forest products industry will likely reduce the competitiveness of Oregon's forest products industry, leading to greater pressure to convert forests to urban and rural residential uses. This pressure

will be exacerbated by the increased population pressure we expect from climate change. To maintain the forest products sector's competitiveness while achieving ecological objectives, payments to landowners for ecosystem services from a trust funded by proceeds from charges on fossil fuel emissions and water consumption is recommended. This does not mean that regulation is innapropriate, only that non-regulatory strategies have significant undeveloped potential.

Introduction

This paper synthesizes information from an April 16, 2009 seminar convened by the Institute for Natural Resources (INR) to discuss climate change management and adaptation in an ecosystem dynamics framework, as well as other research conducted by INR's team of Oregon University System (OUS) and US Forest Service (USFS) principal investigators.[1] The seminar involved 96 individuals, including the INR team, other members of the OUS community including faculty and students from a variety of fields, state and federal natural resource managers, private timberland managers, non-governmental organizations and the interested public. This was the third of four seminars INR has convened for the Oregon Department of Forestry (ODF) and Department of Environmental Quality (DEQ) as part of a multi-year Dynamic Ecosystems Project that is investigating the policy implications of ecosystem dynamics.[2] The seminars and resulting white papers will inform the final step in this project: a policy summit and final policy paper.

All of the recommendations offered in this paper are grounded in the realization that, as one seminar presenter put it, "we aren't yet able to turn information about climate change into policy decisions." The effects of climate change are important enough to take action, but because the most important effects of climate change will come from complex interactions at a wide variety of spatial and temporal scales, there is no one program of action that accounts for all possible outcomes. Although regulation to protect at-risk resources is one strategy for adapting to climate change, the flexibility required for dealing with uncertainty is one reason why we recommend development of non-regulatory incentives to encourage Oregonians to prepare for climate change.

Variation in climate change effects

The effects of climate change in Oregon will not generally be uniform or directional, and the degree of change will vary considerably from one area to the next. Storm tracks are expected to shift, bringing more rain to some areas and less rain to others. Temperatures will be warmer in some areas but remain the same in other areas. Changes will vary

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[1] The team consists of John Bailey (OSU), Barbara Bond (OSU), Sally Duncan (INR), David Hulse (UO), James Johnston (INR), Gordon Reeves (USFS), Brent Steel (OSU), and Fred Swanson (USFS). Presenters at the seminar were Matt Betts (OSU), Barb Bond (OSU), Chris Dunn (OSU), Gordon Grant (USFS), Glen Howe (OSU), Denise Lach (OSU), Mark Harmon (OSU), Klaus Puettmann (OSU), Darrel Ross (OSU), Brent Steel (OSU), and Eric Sproles (OSU).

[2] A description of the Ecosystem Dynamics Project and INR's 2008 synthesis paper can be found at http://www.oregon.gov/ODF/STATE_FORESTS/FRP/RP_Home.shtml#Dynamic_Forest_Ecosystems.

temporally, for instance, stream flows may decline substantially from their previous averages during part of the year, but may increase from the previous average during other times in the year.

Oregon's mountainous terrain will have a significant influence on the temporal and spatial variation in climate change effects. Cold air pooling in mountain valleys will tend to maintain cooler temperatures while ridge areas will become warmer (put another way, some landscape features will be strongly coupled to regional atmospheric temperature changes while other landscape features will be decoupled from regional trends). The impacts of change at local scales will be complex. Although scientists have made considerable progress characterizing this complexity, we are still a long way from being able to forecast climate change at spatial scales that are relevant to managers.

The impacts from climate change will in most cases not express themselves in linear fashion. Impacts will often come instead from abrupt perturbations like wildfire, insect infestations, and invasion of exotic species driven by changes in climate. In the wake of climate change-driven disturbance, forest regeneration may resemble the pre-disturbance composition, or forest stands may regenerate to a different suite of species.

The implications of variability in change are far reaching. There is no one strategy for mitigation and adaptation. Instead, fine scale analysis of local change must inform management, with overall management objectives developed for landscape scales. The same ecosystem services may continue to be provided, but at different places or at different times of year. Oregon's response to climate change must involve adapting human practices to match new spatial and temporal patterns of ecosystem services.

Water

"The Pacific Northwest is golden when it comes to warming because we are likely to have water when others don't."

—Gordon Grant

The effects of climate change on Oregon's water supplies will also be highly variable, reflecting different geological influences. The Oregon Cascades have a "warm" snowpack (close to melting temperatures even at its coldest) that is particular susceptible to earlier and faster melting. There has been a dramatic decline in "snow water equivalence" (essentially the amount of water contained within the snowpack) in the western Cascades. For example snow water equivalence has decreased by 50% in the Santiam Basin, an important source of water for the Willamette Valley. Snow is also melting earlier (an average of 18 days earlier at one site studied in the western Cascades), compounding the loss of water available for human consumption and altering the hydrologic regimes to which aquatic life is adapted.

In the High Cascades, geology tends to somewhat insulate Oregon's water supplies from climate change. Precipitation travels through the volcanic rocks that compose the High Cascades relatively quickly and is stored deep underground. Reduced snowpack means that there will be less overall water in the High Cascades, and summer low flows will likely remain steady but with decreased discharge in these spring-fed systems. In the Western Cascades and Coast Ranges, winters will be flashier and summer low flows will begin earlier while remaining at roughly the same volumes. The High Cascades have considerable underground storage capacity, and rivers sourced by deep groundwater, which include some of Oregon's largest rivers such as the McKenzie River, will provide constant discharges even during droughts compared to other water systems.

Climate change is likely to have important consequences for aquatic life. For instance, bull trout require very cold water, and climate change will likely reduce the total length of stream networks currently capable of supporting bull trout. Bull trout also provide an example of how climate change interacts with land use to create cumulative environmental impacts. The presence of 13 flood control dams in the Willamette Basin already substantially limits migration through stream networks, and the "squeezing" of cold-water habitats by climate change will likely exacerbate threats to cold-water species.

In general, Oregon's close proximity to the Pacific Ocean (an enormous source of precipitation-bearing storms) and volcanic mountainous terrain (which stores vast amounts of water) means that our state may be *less* impacted by climate change than other parts of the United States. This may create important *indirect* environmental impacts that will be discussed in more detail below.

Forests and carbon

"If we want to make a difference in terms of carbon we have to add forest."
—Mark Harmon

There are many important feedbacks between climate and forests. The increase in wildfire activity in the last 15 years is closely correlated with earlier spring snowmelt. In general, warmer and drier conditions, earlier snowmelt, a longer fire season and larger fires are expected throughout the West as a result of climate change (Kitzberger *et al.* 2007).

There are significant opportunities for Oregon forestland owners, especially landowners in western Oregon, to sequester carbon to offset national consumption of fossil fuels. According to one study, western Oregon forests are capable of storing, on average, approximately 160 tons of carbon per acre more than they do now (Smithwick *et al.* 2002).

The most effective way for forestry practices to offset national carbon emissions is to plant trees where no trees were growing, or to increase the harvest rotations of existing trees. Creating a strong market for carbon storage will require development of sound measuring, monitoring and certification systems.

Genetic adaptation

Tests of phenotypic plasticity suggests that some common Oregon trees may not be highly adaptible to climate change. Projections of future forest productivity—and carbon storage—may be unrealistic if genetic adaptation is ignored. Assisted migration is one possibility for mitigating the effects of climate change that should be studied and developed.

The seeding zones commonly used to reforest harvested sites must be re-evaluated at fine scales given locally shifting temperature and precipitation patterns. Maintaining forest reserves—particularly small reserves—to protect species in perpetuity may not be viable, and managers should develop flexible and adaptive approaches to species conservation. This recommendation will be more fully developed in a subsequent INR white paper.

Species adaptation

Birds are one example of a class of species whose distribution, demography and behavior is likely to be altered by climate change in complex and intreactive ways. Birds exert a strong top-down influence on vegetation seeding and insect control. The wide ranging cascade of effects from disruption and re-establishment of thesse influences at different temporal and spatial scales are difficult to predict. There are probably important interactions between climate change and land use that effect bird migration and demographics that are currently poorly understood.

Insects also exert an enormous influence on the structure, function, composition and productivity of vegetation. Insects will likely have highly variable responses to climate change. In general, trees stressed by lack of moisture or higher temperatures are more susceptible to pest invasions. Increased temperatures may decrease overwinter mortality and increase ranges of some insects. It is also possible that decreased snow depth will cause greater overwinter mortality of other insects. There may be increases or decreases in the nutritional suitability of hosts, and an increase or decrease in the defensive chemicals produced by trees. There may be important indirect effects of climate change on insect distribution and behavior, for instance, species that depend on disturbance like wildfire may proliferate. It is possible that the large extent of Douglas fir plantations will be susceptible to bark beetle outbreaks as they grow into the size and age classes preferred by these insects.

The most important adaptation to climate induced change is diversity and heterogeneity in forests. Managers should encourage more gaps, patches and overall less forest density in response to an expected increase in disturbance events. Landscape level diversity, specifically diversity in age, species and composition of stands, will assist landscape-scale adaptation and resilience.

Silvicultural adaptations

"It's very clear we have to accept some tradeoffs in terms of production efficiency."
—Klaus Puettman

Silvicultural adaptations to climate change will involve many traditional silvicultural techniques including thining to reduce density and underplanting with species expected to be genetically adapted to expected local conditions. A mix of different species from multiple provenances is recommended. Forest management should emphasize connectivity on the landscape to accomodate potential shifts in species migration patterns, as well as create options for assisted migration.

Many industrial forestlands are currently managed for a high efficiency of production in order to remain competitive in the global wood products marketplace. However, succcesful adaptation to climate change that maintains a range of desired forest processes and functions may require less efficient production—for instance less tree density than a site can potential grow, or maintenance of older, more resistant individual trees—in order to create more resilient forests and maintain future management options.

Diversity is an important feature of adaptation to climate change. Managers need to maintain the sources of diversity, which are ecological disturbance processes. Managers should target the functions and processes that are critical for ecosystem adaptations (for instance, pollination, natural pest control, and nitrogen fixation).

The human dimension

"Scientists, managers, policy makers and citizens need to be involved in this together."
—Brent Steel

Oregon, along with much of the rest of the country, has undergone a dramatic cultural and demographic shift from a primarily rural to a primarily urban population. 78% of Oregon's population is now found in six metro areas. 64% of Oregon's recent population increases have been from in-migration, and most in-migration to Oregon is to urban areas. A typical newcomer is affluent, educated and politically liberal.

As noted above, although Oregon is expected to experience significant impacts from climate change in certain areas, the effects of climate change overall are likely to be less severe in our state than in other parts of the nation. Oregon thus faces the prospect of increased climate change-driven in-migration of people from areas like the Southwest and the Colorado Plateau that can be expected to experience severe effects from climate change.

The management implications of dramatic population increases are uncertain, but increased population can be expected to place increased stress on resources and resource managers. If the political and cultural trends of in-migration to Oregon continue, Oregon residents are likely to demand more, not less environmental protection. Our state may become even more politically polarized, further complicating decision-making in the face of uncertainty. To accomodate these trends, managers need a persistent focus on trust building, collaboration and transparency in management. Enhanced cooperation between natural resource agencies in Oregon will be essential.

Although the exact impact of change is unknown, a range of options can be developed through long-term comprehensive land use planning. A recent long-term conservation strategy for the Puget Sound area is a useful example of long-range planning. The Cascade Agenda: A 100 Year Vision for Pierce, King, Kittitas and Snohomish Counties was the result of the "Cascades Dialogues" between stakeholders in the Puget Sound area convened by the "Cascades Dialogues Steering Committee," composed of local conservation organizations and elected governments. The final report identifies 1.26 million acres in rural and wildland settings that are targeted for conservation acquisition and proposes urban and rural design measures that will take population pressure off of rural areas.[3]

New markets

INR's previous white papers have pointed to the need to maintain important dimensions of ecological processes—such as older trees and lower forest densities—in order to "set the table" for important disturbance dynamics such as fires, floods and storms (INR 2009).

Regulations that require longer harvest rotations or lower the efficiency of production by requiring lower stand densities could make the Oregon timber industry less competitive in the global forest products market. Paradoxically, although these sorts of regulations may achieve important ecological objectives, they may also have a significant and important negative environmental effect by encouraging forestland owners to convert forestland to urban and rural residential uses, an effect that will be exacerbated by increasing population pressures.

The challenge for policy makers is to encourage diverse, resilient forest systems while maintaining the competitiveness of Oregon's forestry industry and the economic viability of private forest ownership. This will be aided by ecosystem services transactions that compensate land owners for practices that achieve desired ecological outcomes while maintaining the timber industry's economic vitality.

Accordingly, we recommend that Oregon policy makers develop fees, surcharges or taxes on carbon emissions and water consumption. Revenues from these charges should be dedicated to a trust from which payments will be made to landowners to provide a wide variety of ecological benefits, including carbon storage and clean water. This new funding mechanism for ecosystem services should be integrated into broader business plans to make Oregon a national leader in sustainable economic development.

[3] The complete Cascade Agenda report can be downloaded at www.cascadeagenda.org.

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