Institute
for
Natural
Resources

Managing Dynamic Forest Ecosystems

Final Report of the Dynamic Ecosystems Project
December 1, 2009

EXECUTIVE SUMMARY

The Oregon Department of Forestry (ODF) contracted with the Institute for Natural Resources (INR) to carry out the Dynamic Ecosystems Project in 2007. The Oregon Department of Environmental Quality (DEQ) joined the project as a cooperating partner in 2008. The project's goal is "describing the relationship and experiences between the administration of natural resource laws, policies, or regulations to the current management of ecosystems and the scientific understanding of ecosystem dynamics, with particular focus on Pacific Northwest forest ecosystems."

To accomplish this goal, INR launched a three-phase process that consisted of: 1) An initial report synthesizing relevant science; 2) a series of seminars that involved 31 different presenters and 195 participants; and, 3) a final policy summit that convened 73 different agency leaders and key stakeholders. The intent of this process was to create a social learning environment that calibrated scientific recommendations to the social, legal, political and economic realities that constrain managers. During this process, participants discussed the results of recent scientific research, findings from recent landscape ecology studies, the results of experimental management, and the practical experiences of managers. Important findings from these discussions included:

- Applying fixed rules for "protecting" certain values (e.g., creation of a wildlife reserve), or fixed rules for producing commodities (e.g., setting particular levels of timber harvest or cattle forage) may not greatly affect ecosystem function in the near term, but may lead to serious disruptions in the long-term delivery of desired conditions, goods and services when forests experience episodic disturbance.
- Many forested systems historically experienced large oscillations in age structure and mortality and can be expected to experience large oscillations in the future.
- To be sustainable, management of ecosystem structure, function and composition must be based on future (not past) environments and needs.
- One-size-fits-all forest management will not work in Oregon, which has very diverse forest landscapes encompassing a wide variety of disturbance regimes.
- The most important part of ecosystem dynamics management is goal setting.

These findings form the basis for "ecosystem dynamics management." Unlike most current and historic management paradigms, which focus on maintaining static conditions and outcomes over time, ecosystem dynamics management:

- Focuses on ecological processes and the changes in ecosystem composition and structure that are imperfectly predictable results of these processes.
- Accommodates changing conditions by planning for objectives (e.g., wildlife habitat and timber) to be accomplished at variable spatial and temporal scales.
- Uses fine-scale, spatially explicit information about landscapes to develop management strategies that account for the diversity of ecosystem communities and changes to these communities over time.

Our growing understanding of ecosystem dynamics teaches us that the results of past anthropogenic and non-anthropogenic influences are difficult to disentangle and must be carefully integrated into future planning. The ecosystem dynamics management approach is well suited to perform this integration and is also an appropriate response to the uncertain effects of climate change.

Translating science findings about the dynamic nature of ecosystems into policy is difficult for a number of reasons, including bureaucratic inertia to maintain the status quo and uncertainty as to the implications of this new research among scientists and managers. Another problem at the forefront of this project was the lack of an overarching, widely agreed upon set of values and criteria for interpreting scientific research among participants in the project. As is often the case in policy-making, what appear to be debates about evidence are, upon closer inspection, differences of values, opinion, or preferences as to what outcomes are most important and what actions are appropriate in the face of imperfect evidence. Science alone cannot resolve these differences.

During the Dynamic Ecosystems Project research and synthesis process, dozens of initial policy recommendations were narrowed to nine final recommendations, many of which underwent significant change through the course of the project.

These final recommendations are:

- Encourage active management in riparian areas that mimics desirable future disturbance patterns.
- Restore the functionality of stream disturbance processes by further softening the line that current policy draws between riparian and upland areas, using fine-scale, spatially explicit landscape analysis to “set the stage” for disturbance events.
- Focus on large geographic areas when managing for water quality to reflect the temporal and spatial scale of disturbance processes. Evaluate and modify water quality standards as necessary to reflect the variable range of conditions that result from disturbance processes.
- Promote a diversity of vegetation treatments and replanting practices that vary tree density and species, reduce above-ground biomass on drier sites, and maintain a range of seral conditions to increase resilience to the uncertain effects of climate change and better provide a full range of wildlife and habitat conditions.
- Continue to work with federal land managers to address a wide range of policy changes needed to accommodate ecosystem dynamics, including acceleration of fuels management on dry sites on federal lands, increased use of natural and prescribed fire, limiting fire suppression expenditures, and creation of variances for air quality standards and legal liability to allow needed fire and fuel management.
- Continue to develop biomass technology and markets that will utilize forestland fuels.
- Develop collaborative land use and rural conservation plans.
- Develop ecosystem services markets in Oregon.
- Develop alternate vehicles for implementing policy in addition to administrative rules and regulations.

It is intended that the overarching ecosystem dynamics management framework that we describe in this report, as well as the specific policy recommendations above, will inform future strategic plans as well as the day-to-day work of managers. It is also hoped that our work on this project will initiate additional research and further dialog.

I. INTRODUCTION

A. Scope of the Dynamic Ecosystems Project

The Oregon Department of Forestry (ODF) contracted with the Institute for Natural Resources (INR) to carry out the Dynamic Ecosystems Project in 2007. The Oregon Department of Environmental Quality (DEQ) joined the project as a cooperating partner in 2008. The project's goal is "describing the relationship and experiences between the administration of natural resource laws, policies, or regulations to the current management of ecosystems and the scientific understanding of ecosystem dynamics, with particular focus on Pacific Northwest forest ecosystems."

Of particular interest to the ODF was the notion of "protection" of natural resources in the near term given that ecosystems are constantly changing over space and time. The ODF believes that recent scientific developments that describe the inherently dynamic nature of forests can be used to develop alternative policy frameworks and improved management strategies and/or tactics. INR has, in this report, created a rough outline of what alternative policy frameworks might look like and described some initial policy changes that should be considered.

B. The Dynamic Ecosystems Project research process

To complete the Dynamic Ecosystem Project, INR assembled a team of 8 principal investigators from within the Oregon University System and the United States Forest Service.[1] To address the ODF's broad stated areas of interest, the team turned to recent scientific findings in the fields of "non-equilibrium ecosystem dynamics" and "coupled human and natural systems." Research into the non-equilibrium nature of ecosystems suggests a model of nature in which the constituent elements of ecosystems are in flux because they are constantly sharing matter and energy with other systems (Rhode 2005). Coupled human natural systems are systems in which human and natural components interact, creating reciprocal effects and emergent novel properties (Liu *et al.* 2007). Both fields are concerned with maintaining ecological resilience, the capacity for systems to renew themselves in a dynamic environment, providing flexibility in the face of uncertainty and a buffer against a variety of future stressors (Gunderson 2000).

The team also relied on findings from recent landscape ecology studies undertaken in Oregon that are illustrative of concepts from these fields. Much of the vocabulary used in this report is in increasingly wide use in these new science fields. We believe that this and other reports prepared for this project provide enough definition and context for this vocabulary. However, throughout INR's work on this project, participants have challenged our use of words like "degradation," "protection," "risk," and "resilience" because their experiences provide different meanings for these and other terms. Resolving ambiguity about terminology is itself a lengthy research and synthesis task that was not accomplished by this project.

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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).

From the beginning, INR's work on the Dynamic Ecosystems Project has attempted to integrate pure science findings with the practical experiences of managers and the social, economic and political constraints that bound their work. To accomplish this integration, INR's work proceeded in three phases. First, we produced a synthesis paper in October 2008 that summarized scientific literature about ecosystem dynamics, presented nine case studies that examined implementation of ecosystem dynamics principles, and offered a number of different policy change recommendations. Second, between February and May 2009 we hosted four seminars to explore the implications of ecosystem dynamics research in four different topic areas: Management of aquatic systems, management of fire and fuels, mitigation and adaptation to climate change, and habitat protection strategies. These seminars featured presentations from 31 researchers working in a wide range of fields and 195 total participants from a broad spectrum of industry, research, government and non-governmental affiliations.[2] Four white papers were prepared as summaries of these seminars.[3]

Finally, on September 8, 2009 the ODF, INR and DEQ convened a policy summit that drew together 73 individuals, including participants in earlier seminars, leaders of non-governmental organizations, academics, timber industry owners and operators, local elected officials, members of the Oregon Board of Forestry, and leaders of other natural resource agencies, including DEQ, Oregon Department of Fish and Wildlife, U.S. Fish and Wildlife Service, U.S. Forest Service, and Bureau of Land Management. This summit considered the results of the INR team's research and brainstormed ways to translate these findings into policy change. There was constant dialog between participants in the project throughout these three phases.

Translating science findings about the dynamic nature of ecosystems into policy is difficult for a number of reasons, including bureaucratic inertia to maintain the status quo and uncertainty as to the implications of this new research among scientists and managers. Another problem at the forefront of this project was the lack of an overarching, widely agreed upon set of values and criteria for interpreting scientific research among participants in the project. As is often the case in policy-making, what appear to be debates about evidence are, upon closer inspection, differences of values, opinion, or preferences as to what outcomes are most important and what actions are appropriate in the face of imperfect evidence (Atkins *et al.* 2005). Science alone cannot resolve these differences.

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[2] Seminar presenters were (in order of appearance): Gene Foster (DEQ), Gordie Reeves (USFS), Stan Gregory (OSU), David Hulse (UO), Barb Bond (OSU), Brent Steel (OSU), Denise Lach (OSU), Mark Harmon (OSU), Eric Sproles (OSU), Gordon Grant (USFS), Chris Dunn (OSU), Glen Howe (OSU), Matt Betts (OSU), Darrel Ross (OSU), Klaus Puettmann (OSU), Fred Swanson (USFS), John Bailey (OSU), John Campbell (OSU), Michael Vandenburg (OSU), David Hibbs (OSU), Mike Messier (OSU), Emily Comfort (OSU), Olivia Duren (OSU), Matt Trappe (OSU), Rob Titcomb (OSU), Adam Novick (UO), Bill Ripple (OSU), Paul Hessburg (USFS), Jerry Franklin (UW), Norm Johnson (OSU), and Tom Spies (USFS).

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

This final report is intended to be a concise summary of important findings. It does not serve as a comprehensive report on all aspects of INR's work on this project. The reader is directed to the documents referenced above to gain the necessary background for consideration and implementation of our recommendations.

C. The contribution of the Ecosystem Dynamics Project to future natural resource management

Bradshaw and Borchers (2000) point out that science will likely never produce a degree of certainty great enough to satisfy all stakeholders in contentious policy-making. They suggest development of social learning frameworks that foster a shared understanding of areas of uncertainty between scientists and stakeholders. They believe that a shared understanding of areas of uncertainty itself constitutes knowledge that can be the foundation for policy making.

Reflecting this advice, INR has declined to engage in traditional scientific reporting in which researchers summarize and present information in isolation from consumers of that information. Instead, we have worked to create recommendations that reflect a shared understanding of science findings developed jointly by scientists, managers and stakeholders through the three phases of the project.

Engaging a broad audience in formulating policy recommendations does not have a natural end point. Although INR's work on this project is officially concluded as of completion of this report, participants in the process continue to weigh in with feedback and there is not a consensus about our findings. We have captured some outstanding unresolved issues surrounding this final report as comments and our responses to comments in Appendix II.

It is unlikely that our work on this project will result in immediate, dramatic changes to state natural resource policy. We hope that our work will inform future strategic plans, as well as the day-to-day work of managers. It is further hoped that our work will initiate future research, collaborative decision-making, and further dialog.

II. SUMMARY OF FINDINGS

A. Overview of ecosystem dynamics concepts

There is widespread recognition among scientists that forests are not static systems that typically remain in equilibrium over long periods of time (Botkin 1990). Nor is change in forests always directional or gradual as assumed by many traditional forest succession models. This does not mean that change is chaotic or random. Instead, change in forests is typically episodic, with periods of accumulation of "natural capital" (i.e., biomass, physical structures, nutrients) punctuated by abrupt release of this material and reorganization of the system into a state poised for future change (Franklin and MacMahon 2000; Wallington *et al.* 2005; Hobbs 2004).

The release of natural capital is generally triggered by disturbance, defined by White and Pickett (1985) as "any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substrate availability, or the physical environment." These disturbances are processes that transform and restructure natural capital not unlike the way a human economy transforms capital and labor into finished products for consumption.

Common disturbance processes in forest systems in Oregon include wildfires, windthrow, landslides, insect outbreaks, timber harvest, road building, diseases, storms, floods and the occasional volcano. These disturbances can be troubling to society because of significant investments in infrastructure and a preference for predictability in the landscapes in which people live and make a living. Because it often creates large patterns of tree mortality, disturbance may conflict with some landowners' desire for a regulated forest with little "waste." However, the variability caused by the non-equilibrium nature of forests is not just an inconvenience that should be tolerated, it is an essential driver of system structure and productivity that managers should embrace (Gunderson and Holling 2002). The most important finding of INR's research is that scientists, mangers and the general public must adopt a fundamentally different worldview of how nature works—eschewing expectations of stability, predictability and control—in order to manage resources effectively in an ecosystem dynamics framework.

Throughout our work on this project, INR has referred to these properties of forest systems as "non-equilibrium ecosystem dynamics," "disturbance dynamics" or simply "ecosystem dynamics." Management that accounts for these dynamics is referred to as "ecosystem dynamics management." This approach contrasts with historic and most current management paradigms that focus on narrower and static goals, for example, sustainable production of commercial goods or maintenance of viable populations of certain species (Johnson 2007; INR 2008).

B. Key findings of the research

The following are key messages from INR's review of the scientific literature that describe forest non-equilibrium dynamics. INR's 2008 synthesis paper describes in detail the limited attempts to translate non-equilibrium theory into practice. That paper also provides an extensive literature review.

These key messages should serve as principles upon which future management plans are developed.

Δ Applying fixed rules for “protecting” certain values (e.g., creation of a wildlife reserve), or fixed rules for producing commodities (e.g., setting particular levels of timber harvest or cattle forage) may not greatly affect ecosystem function in the near term, but may lead to serious disruptions in the long-term delivery of desired conditions, goods and services when forests experience episodic disturbance (Holling 1995). Management must plan for certain objectives (e.g., wildlife habitat and timber) to be accomplished as a range of outcomes at variable spatial and temporal scales. Rules must be flexible to account for this variation.

Δ Many forested systems historically experienced large oscillations in age structure and mortality, and can be expected to experience large oscillations in the future. Managers may seek an optimal landscape pattern or structure, e.g., “old-growth,” and attempt to maintain this condition over time, but a single landscape pattern or structure will not persist except over large areas at multi-century time frames (Haeussler and Kneeshaw 2003). Managers must accept the loss of certain forest conditions in any particular fixed location. If particular forest conditions are determined to be critical to society, managers should manage for the re-establishment of these conditions at alternate spatial and temporal scales.

Δ To be sustainable, management of ecosystem structure, function and composition must be based on future (not past) environments and needs. Because future environments and needs are uncertain, future management should be designed to accommodate uncertainty by accomplishing multiple alternative goals. Future management should focus on rehabilitation and maintenance of ecosystem functions, e.g., fire resilience, rather than maintaining a particular species or physical appearance (Choi 2007).

Δ One-size-fits-all forest management will not work in Oregon, or anywhere else that has diverse topography and landscapes encompassing a wide variety of disturbance regimes. Fundamentally, managing in an ecosystem dynamics framework involves development of management techniques tailored to the diverse ecosystem dynamics at work on different sites. Future management should rely on fine-scale, spatially explicit information about landscapes to adapt management practices to different areas and different goals.

Δ The most important part of any successful forest management is goal setting. There is not a social consensus about the desirability of many important natural disturbance processes at all the temporal and spatial scales that these processes occur, and little agreement about how natural disturbance regimes should be emulated (Long 2008). Management of timberlands and rural residential areas should be undertaken with a clear understanding of how management goals will modify disturbance processes. Tools and techniques should be developed to mitigate those consequences where appropriate.

There are a number of problems translating our new awareness of the importance of disturbance dynamics into on-the-ground policy. Field observations have not verified all of the relationships suggested by theories of non-equilibrium systems, in part because many of the relationships can be observed only over long time scales (Wallington *et al.* 2005). There has been little field experimentation, in part because experiments over large landscapes and long time periods would be needed to test many of these theories and complex experiments may require entirely novel approaches to hypothesis formulation, testing and analysis. Although many important disturbance dynamics occur across ownerships, e.g., in large watersheds managed by federal agencies, private industrial landowners and private non-industrial landowners, these different ownerships are usually managed according to different goals. Synchronizing management objectives to test ecosystem dynamics concepts may not be feasible.

Ecosystem dynamics management based on the above principles should:

- Focus on ecological processes and the changes in ecosystem composition and structure that are imperfectly predictable results of these processes.
- Accommodate changing conditions by planning for objectives (e.g., wildlife habitat and timber) to be accomplished at variable spatial and temporal scales.
- Use fine-scale, spatially explicit information about landscapes to develop management strategies that account for the diversity of ecosystem communities and changes to these communities over time.

C. Implications of concepts for salmon habitat restoration and fire protection

Restoring salmon habitat and providing fire protection—two major drivers of forest policy in Oregon—are used here to illustrate implications of non-equilibrium theory and sketch out directions for future management.

Productive salmon habitat includes complex stream morphology and large quantities of wood and gravel. These habitat components and their arrangement in streams are the product of the interaction of geomorphology and landslide disturbance events over time. Although most Oregonians think of clean, blue-green waters when they think of prime salmon habitat, it may be just as accurate to picture roiling brown waters and tons of debris. Both conditions represent points on a continuum that, taken as a whole, create the habitat we desire from productive river systems (Reeves *et al.* 1995).

Over time and space, stream channel and habitat conditions vary from less productive to more productive given time since disturbance and the capacity of the stream to process wood and sediment (Reeves *et al.* 1995). Salmon habitat management and restoration should focus less on point-in-time stream conditions and instead be designed to accommodate patterns of accumulation and depletion of natural capital, (i.e., large wood), disturbance processes (i.e., fires and storms) and the resulting arrangement of material (i.e., wood in streams) over long time frames.

Fire in forests creates variability in forest types and structure over time. Managing forests without consideration of fire processes will result in greater amplitude of fuel structure, greater amplitude of wildfire disturbance, and considerable uncertainty about future forest dynamics and productivity (Barbour *et al.* 2007). Experience indicates that in many forest types in Oregon, fire suppression without fuel management will result in greatly increased fire suppression costs that may not be economically sustainable.

Managing fire in an ecosystem dynamics framework would replace the risk avoidance paradigm that underlies current fire protection strategies with a risk and hazard management approach. Forest resilience or "forest health" is not, in the risk management context, a matter of avoiding fire disturbance. Instead it is a matter of promoting, maintaining and/or emulating the disturbance processes that continually dissolve and reorganize the structure and composition of forested systems, providing the goods and services that society expects at different spatial and temporal scales. Management that tries to prevent disturbances will usually result in undesirable system changes over the long run (Gunderson and Holling 2002). Accommodating fire will not eliminate risk, but it will manage risk and fire effects better than excluding the effects of this disturbance at all times.

D. Balancing disturbance-based management with a history of ecosystem modification

Because the goods and services we expect from forests—including wood products, clean water, and wildlife habitat—are products of disturbance processes, our primary conclusion is that managers should emphasize restoration and maintenance of desired ecological processes rather than recreating specific point-in-time conditions. Managers must engage in robust goal setting that determines what are desired processes over time. However, this conclusion must be offered with some important qualifications that will be illustrated using old-growth forests, riparian forests and water quality goals as examples.

Although systems change over time and desired conditions, e.g., old-growth forests or endangered species habitat, cannot be expected to persist over long periods of time, these facts by themselves are not reasons to accept anthropogenic degradation of the ecological resilience of systems. Although the spatial and temporal extent of old-growth forests can be expected to vary considerably over time, modeling suggests that timber harvest over the past 150 years has already reduced the extent of old-growth forest in western Oregon to the lowest levels in thousands of years (Wimberly and Spies 2000; Ripple *et al.* 1991). The loss of a habitat type that supports significant biodiversity will have negative consequences for a broad range of ecosystem services. Given the paucity of older forests, it makes sense within the context of ecosystem dynamics to protect old-growth forests from further anthropogenic disturbance. It may even make sense to protect Douglas fir-western hemlock old-growth forests from naturally occurring disturbance events until old growth occupies a greater portion of the landscape.

INR's white papers about aquatic management and fire and fuel management suggest that current concepts of riparian area "protection" need to be modified to reflect the important role that disturbance plays in maintaining aquatic ecosystem function (INR 2009a; INR 2009b). Fire was an important disturbance agent in many of Oregon's riparian forests and managers need to develop science-based methods for creating heterogeneity in riparian forests where fire is an important periodic disturbance agent. Water quality in Oregon streams also historically varied dramatically over space and time (Reeves and Duncan 2009; Poole *et al.* 2004).

However, although there was always considerable variability in the extent of old forests along streams, as well as variation in water temperature, sedimentation, etc., evidence suggests that Oregon streams and rivers have far less productive salmon habitat than the historical range of variability, and that declines in salmon populations are the result not of the variation expected from desirable natural disturbance dynamics but from a variety of anthropogenic stressors. Streams found in ownerships managed for intensive timber harvest generally have been structurally simplified, have higher levels of fine sediment, and lower levels of large wood relative to reference sites (Rodgers *et al.* 2005; Thom and Jones 1999). These facts suggest that regulation of activities that negative affect stream system functions are necessary and appropriate.

Disturbances like landslides, erosion and debris flows are important processes in forest systems, but this does not necessarily mean that human-influenced landslides, erosion and debris flows are appropriate. The pattern of disturbance and landscape conditions matters. Although salmon are well adapted to "catastrophic" disturbance and quickly re-colonize disturbed stream systems from nearby systems, they cannot re-colonize when habitat has been degraded by human action in most stream systems in a large geographic area.

Although landslides, erosion and debris flows help create salmon habitat, these events are typically in the nature of episodic "pulses." When these disturbances occur in a chronic or "press" pattern as a result of human management, e.g., an extensive poorly designed or maintained road system, the productive capacity of salmon habitat may be reduced. The ecological value of "pulse" disturbance events is in the delivery of habitat components such as large wood and gravel to streams and the arrangement of these structures in a constantly shifting, structurally complex mosaic as habitat elements move downstream over time. When these disturbance events take place in a landscape where the availability of trees as a source of large wood has been significantly reduced, gravel will move through the system more quickly, likely reducing habitat productivity.

Striking a balance between the need to accommodate desirable disturbance processes and undesirable anthropogenic degradation informs many of the specific policy change recommendations that INR has carried forward to this final report, including the recommendation to use fine-scale analysis to strategically identify areas to retain trees that can deliver large wood to streams, as well as the recommendation to take a regime standard approach to water quality management under the Clean Water Act (see specific policy change recommendations below).

E. Beyond traditional natural resource conflict

The emerging understanding of the dynamic nature of Oregon's forests has been cited in support of contrasting political agendas. Environmental advocates appeal for protection of forests from resource extraction so that disturbance processes can take place unimpeded by human influences. Resource production industries advocate for increasing production from forests, arguing that timber management is, like fire, floods and other disturbance, an agent of change that creates desired variability in forest structure (Langston 1996).

Although both interpretations are valid to a certain extent, both are oversimplifications and an inadequate basis for future policy. Both points of view tend to entrench the false dichotomies that have underpinned decades of conflict over natural resource management in Oregon. These dichotomies encompass a narrative about wild and pristine nature versus a nature managed for utilitarian purposes, and a polarizing and false political choice between economic prosperity versus natural amenities.

Our emerging understanding of ecosystem dynamics teaches us that anthropogenic and non-anthropogenic influences (i.e., climate, topography, landscape setting, fire and other disturbance events, etc.) have been inseparable in the past, and that human mediated disturbance regimes of carefully calibrated intensity and frequency may be able to simultaneously enhance biodiversity while providing goods and services to human society (Balée 2006; Peacock and Turner 2000).

In this spirit, the ecological synthesis and policy research conducted by the Institute for Natural Resources for this project has attempted to:

- Acknowledge that social and economic considerations, as well as ecological knowledge, must inform policy. Society may not want to maintain all of the ecological processes of the past and it may want to encourage new processes in the future.
- Encourage management of complex disturbance dynamics through utilization of new technology and methods. We need a sophisticated approach to management that plans for key processes at a variety of temporal and spatial scales.
- Suggest creative policy solutions that encourage the perpetuation of desired ecological processes over time and the physical components that make up these processes. Management needs to "set the table" for desired processes.

Transcending traditional natural resource conflict and implementing the recommendations in this report will involve the creation of a social learning environment with broad participation by diverse stakeholders (INR 2008). This is a long-term project that will require considerable time and effort on the part of managers, scientists and citizens. There are no scientific or technical solutions for complex social problems where value differences hinder consensus.

III. POLICY CHANGE RECOMMENDATIONS

A. Overview of policy change recommendations

As noted in the introduction, INR has not adopted a traditional approach to presenting science recommendations. We have attempted to balance what we believe to be the management implications of scientific findings with the views and concerns of stakeholders who must implement these recommendations. An iterative three-phase research process was used to calibrate the relevance and usefulness of INR's recommendations. To provide a full and necessary context for the final recommendations, we trace the evolution of recommendations throughout the project in a policy change matrix included as Appendix I. As shown in this appendix, many of the recommendations developed were abandoned as unfeasible, undesirable, or simply of less importance compared to other recommendations. Many recommendations were modified after discussion within the social learning framework that we created, while a few recommendations remain largely unchanged.

Reasons for abandonment or changes to recommendations were numerous, but could be grouped into three major categories: 1) Implementing the recommendation was judged to be unrealistic or undesirable given institutional constraints, which included budgetary constraints or seemingly intractable (i.e., unlikely to change in the foreseeable future) legal requirements; 2) implementing the recommendation was judged to be socially unacceptable and likely to engender significant public opposition, legal action and/or political backlash; and/or, 3) implementing the recommendation was judged to be undesirable given fundamental uncertainty about the science underlying the recommendation or uncertainty about the scientific basis for implementing the recommendation. In the rationale for abandoning policy change recommendations displayed in Appendix I, when a recommendation was abandoned in the course of our work the reason is notated as "IC" (institutional constraints), "SC" (social constraints) and/or "UC" (uncertainty constraints). A fourth category consists of those recommendations that were not judged to be relevant or significant enough to warrant further action, or that participants in the process believed were already accounted for within current management frameworks, or that simply did not attract the same level of interest as other recommendations. This category is notated as "NA" (no action).

Providing a comprehensive account of the exact nature of the concerns raised and the restraints identified would significantly lengthen this report. Much of the discussion that drove the evolution of INR's recommendations can be found in the white papers that followed the four seminars and a briefing paper prepared in advance of the final policy summit.

Another way to think about these recommendations is as follows: Final recommendations are those recommendations that can reasonably be expected to be implemented within a relatively short time span. Abandoned recommendations may have significant merit, and should be pursued at longer timeframes when advances in science are achieved, or when changes to economic, political, social or environmental conditions occur.

B. Specific policy change recommendations

The following are the specific policy change recommendations carried through the iterative research process:

1. Encourage active management in riparian areas that mimics desirable future disturbance patterns.

As noted in previous INR reporting, current concepts of riparian area “protection” need to be qualified to reflect the important role that disturbance plays in maintaining aquatic ecosystem function (INR 2009a). Fire was an important disturbance agent in many of Oregon’s riparian forests (Halofsky and Hibbs 2009). Many forest policies, including the Oregon Forest Practices Act, promote mature tree cover on fish-bearing streams through time while excluding fire. Managers should develop science-based methods for creating heterogeneity in riparian forests where fire was historically an important disturbance agent.

2. Restore the functionality of stream disturbance processes by further softening the line that current policy draws between riparian and upland areas, using fine-scale, spatially explicit landscape analysis to “set the stage” for disturbance events.

Related to the first recommendation, the Oregon Department of Forestry’s current management of riparian areas draws a distinction between the land in the immediate vicinity of fish-bearing streams, which are to be managed for mature forest conditions, and upslope areas, which are typically intensively managed for timber. There are two problems with this management strategy. First, disturbance processes are a critical part of the functionality of riparian forests and desired stream functions, including fish habitat, will not be achieved by maintaining all stream reaches in a static mature forest condition. Second, stream functioning depends on some degree of contribution of material from upslope sources (IMST 1999). These facts suggest that current management’s distinction between upland and riparian forests should be “softened,” allowing some active management in riparian buffer areas that creates streamside heterogeneity, and strategically retaining some upland forests to contribute material to streams via fire/storm/debris flow type disturbance processes.

“Setting the table” for disturbance—providing for the material that is released by disturbance—is greatly aided by modern geospatial analysis tools. These tools enable planning for strategic retention of large wood and other material that can be expected to benefit fish habitat following disturbance. There are currently requirements in place to retain wood in debris-flow prone areas for public safety objectives, and, in limited instances, to provide wood to streams to meet habitat needs.[4] These provisions should be expanded to provide incentives to landowners to leave additional large wood in upland areas that is likely to interact with expected future disturbance processes (ODF and DEQ

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[4] See OARs at 629-623-0500, 629-623-0550, 629-623-0600, 629-623-0700, 629-630-0500 and 629-640-0210.

2002). Analysis of likely debris chutes and other landslide terrain can prioritize retention of large wood, achieving significant future environmental benefits with less economic impact than blanket regulation (Miller and Burnett 2007).

Similarly, mapping existing and potential refugia would enable strategic investments in restoration to reconnect habitat, for instance reconnecting rivers with historic floodplains (Baker *et al.* 2004).

3. Focus on large geographic areas when managing for water quality to reflect the temporal and spatial scale of disturbance processes. Evaluate and modify water quality standards as necessary to reflect the variable range of conditions that result from disturbance processes.

Researchers have suggested developing "regime standards," that encompass the desired characteristics of variable natural regimes. Regime standards would "describe a desirable distribution of conditions for water quality over space and time, rather than rely on a single threshold value" (Poole *et al.* 2004). These regime standards would be applied at broad geographic and temporal scales and would describe desirable conditions possible at different places and at different points in time. Accomplishing this result would require management of many streams as a single unit. The broader unit, not individual streams (which may be in a disturbed condition), would be analyzed for compliance or non-compliance with the regime standard (Poole *et al.* 2004).

Close coordination between land management agency plans and TMDLs would be required to ensure recovery of anthropogenically degraded stream systems. One possible example of this approach is the Umatilla River TMDL.[5]

Moving to a regime standard model for Clean Water Act enforcement might involve developing ambient water quality standards that are tailored to reflect the range of desired variability in stream disturbance processes. The DEQ's temperature standard currently incorporates natural variability. The standard includes maps, a table of natural maxima and a provision for natural thermal potential in different stream systems (i.e., if a stream's natural temperature is higher than the standard, the natural temperature becomes the de facto standard for that stream).[6] Creating regime standards for other pollutants such as sediment would further synchronize ecosystem dynamics with regulatory frameworks.

4. Promote a diversity of vegetation treatments and replanting practices that vary tree density and species, reduce above-ground biomass on drier sites, and maintain a range of seral conditions to increase resilience to the uncertain effects of climate change and better provide a full range of wildlife and habitat conditions.

Silvicultural adaptations to climate change will involve many traditional silvicultural techniques including thinning to reduce density and underplanting with species expected

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[5] See http://www.deq.state.or.us/wq/TMDLs/umatilla.htm.

[6] See http://www.deq.state.or.us/wq/pubs/imds/Temperature.pdf.

to be genetically adapted to projected future local conditions. A mix of different species from multiple provenances is recommended. Forest management should emphasize variable tree density and species composition, as well as connectivity on the landscape to accommodate potential shifts in species migration patterns (Aitken *et al*. 2007). Options for assisted migration should be studied.

Many industrial forestlands are currently managed for a high efficiency of production to remain competitive in the global wood products marketplace. However, successful adaptation to climate change that maintains a range of desired forest processes and functions may require less efficient production—for instance less tree density or maintenance of older trees—to create more resilient forests and maintain future management options (Millar *et al.* 2007; Anderson 2008).

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).

Changes to the Oregon Administrative Rules (OARs) that implement the Oregon Forest Practices Act, or incentive programs (see recommendation #8 below), could be developed to encourage flexibility in replanting requirements and other measures to encourage more diverse and resilient landscapes.

5. Continue to work with federal land managers to address a wide range of policy changes needed to accommodate ecosystem dynamics, including acceleration of fuels management on dry sites on federal lands, increased use of natural and prescribed fire, limiting fire suppression expenditures, and creation of variances for air quality standards and legal liability to allow needed fire and fuel management.

As noted in previous INR reporting, there is an urgent need for aggressive fuel reduction treatments in fire-prone areas throughout Oregon. Current treatment levels do not come close to meeting this need. There will be serious ecological and social consequences if managers, especially federal managers, fail to act to meet this need. Strategic, landscape-level treatments are needed to address undesired consequences of past actions, e.g., suppressing all fires and even-age management of some forest types, and adapt to future expected conditions (INR 2009b). Strategies for fuel treatment will be most effective and efficient if they are consistently applied at spatial and temporal scales that mimic likely wildfire disturbance events.

Wildfire that undermines long-term forest resiliency is just one consequence of failing to proactively treat fuels in many areas in Oregon. Other impacts include loss of certain ecologically important vegetation communities, exacerbation of drought-induced mortality, and insect outbreaks. Stand- and landscape-level treatments should be designed to address these risks. Fuel reduction treatments, when integrated with other land management goals, will predominantly focus on creating diverse, heterogeneous landscape patterns.

Because many private lands are managed primarily for economic objectives that are often incompatible with landscape-level fire patterns, perpetuating fire disturbance processes is most relevant and appropriate on federal lands. Appropriate management for future fire and fuel dynamics on private lands may include use of fire on small scales to manage surface fuel accumulation, modest reduction of stocking densities to reduce risk of fire spread, and management of older fire resistant species and trees as fuel breaks. Management should balance economic considerations and risks.

The ODF and other state agencies should continue to work with federal agencies to accomplish needed fire and fuel management work. Previous INR reporting has noted potential conflicts between air quality management and fire and fuel management goals, and recommended policy changes including variances for smoke and legal liability waivers for fire and fuel management activities (INR 2009b).

6. Continue to develop biomass technology and markets that will utilize forestland fuels.

Fire is a ubiquitous disturbance process in Oregon forests that is central to the delivery of the goods and services we expect from these systems. Fire exclusion in many dry forest types has created undesirable future dynamics, favoring fire intolerant tree species and abnormal fuel structure, fueling larger and more severe fires. Fire suppression has significantly disrupted the spatial and temporal pattern of fire on a landscape scale, replacing fine grain mosaics of fire size and severity with larger, more homogenous patches of generally more severe fire events (Hessburg *et al.* 2005).

There is an overwhelming and urgent need for aggressive fuel reduction treatments in fire-prone areas throughout Oregon, summarized by INR (2009b). The ODF and other state agencies have emphasized working with federal land managers to accomplish needed work. However treatment levels do not come close to meeting this need. This is primarily a political failure on the federal level—there are no particular changes to state agencies' policies that will significantly improve this situation.

It is generally accepted that removal of fine fuels—including litter, brush, and small-diameter trees—is the key to moderating severe fire behavior (Agee and Skinner 2005). While some thinning projects that remove commercially merchantable small to medium diameter trees may pay for themselves, there is a recognized need to develop markets for currently unmerchantable material to leverage needed work in a time of constricted land management budgets and declining timber markets. One solution is to burn fine material to produce power or convert it to fuels such as ethanol.

One biomass utilization and technology assessment for Baker, Union and Wallowa counties found that there was significant biomass available for power or fuel production from agricultural and forestry practices in these counties. Siting biomass utilization facilities in close proximity to fuel sources, and matching the capacity of these facilities with available supplies was found to be important for successful development of a biomass market. A barrier to private sector investment in facilities was a lack of information about long-term supply, delivery costs, costs of biomass and suitable location (Oregon Department of Energy 2003). Future state agency work plans should devote resources to overcoming the barriers to greater utilization of biomass.

7. Develop collaborative land use and rural conservation plans.

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 over the past 100 years. 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 (INR 2008).

As noted in INR (2009c), 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 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 accommodate 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.[7]

8. Develop ecosystem services markets in Oregon.

Many of INR's recommendations have pointed to the need to maintain important dimensions of ecological processes—such as older trees and lower forest densities—in

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

order to “set the table” for important disturbance dynamics such as fires, floods and storms (INR 2009a).

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 (Kline 2006).

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 landowners 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 who go beyond regulatory requirements and provide additional ecological benefits, including additional carbon storage and habitat components. This new funding mechanism for ecosystem services should be integrated into broader business plans to make Oregon a national leader in sustainable economic development.

Development of effective ecosystem services markets will also require development of comprehensive systems measurement, analysis and reporting.

9. Develop alternate vehicles for implementing policy in addition to administrative rules and regulations.

A recurring theme in INR’s research has been the need for flexible and adaptive management to accommodate a new emphasis on dynamic disturbance processes. Although the ODF and other state agencies are adaptive, flexible, and responsive to emerging environmental challenges and opportunities to a certain extent, the extent to which they are not responsive and adaptive appears to have an institutional basis. The typical mechanism for enforcing environmental policies in Oregon is the Oregon Administrative Rules (OARs). For instance, the requirements of the Oregon Forest Practices Act, as well as the forest plans that govern state forests are codified in the OARs. These rules, created by a complex and lengthy process and designed to remain in place for long periods of time, are not a good mechanism for incorporating new science that replaces outdated concepts or for taking advantage of the opportunities that are identified through use of landscape analysis tools or the flexible silvicultural practices urged by this report.

Although some key policies should be codified as OARs, Oregon policy makers should explore new mechanisms for enforcing environmental policies, for instance, management councils drawn from broad stakeholders that collaboratively implement broad direction provided by OARs.

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