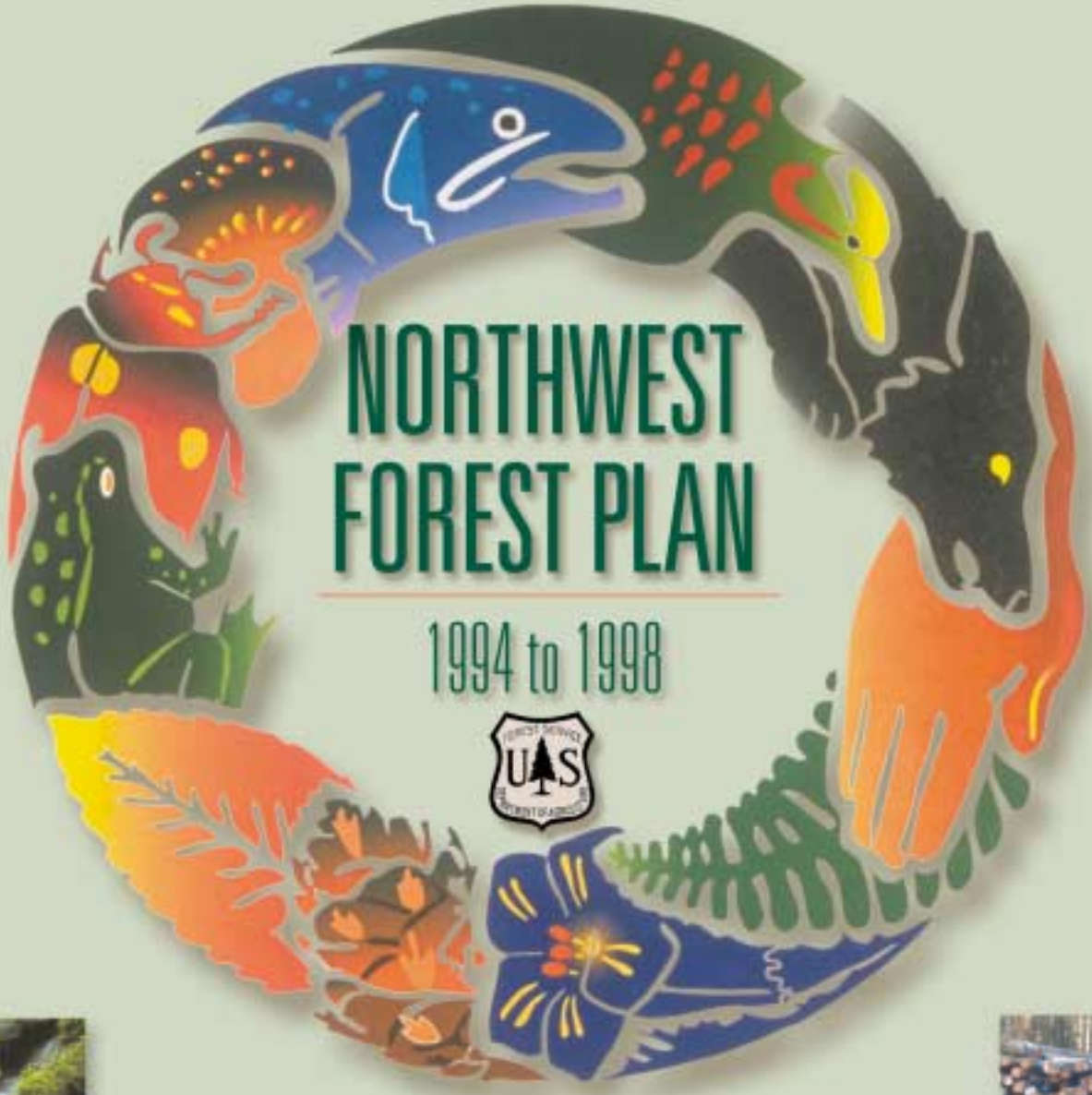
HIGHLIGHTS OF SCIENCE CONTRIBUTIONS TO IMPLEMENTING THE



NORTHWEST FOREST PLAN

1994 to 1998

AUTHORS

Nancy M. Diaz was an ecologist with the Pacific Northwest Research Station, when this work was done. She is now a branch chief with the U.S. Department of the Interior, Bureau of Land Management, P.O. Box 2965, Portland, OR 97208-2965. **Richard W. Haynes** is a research forester, U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, P.O. Box 3890, Portland, OR 97208-3890.

Highlights of Science Contributions to Implementing the Northwest Forest Plan 1994-1998

Nancy M. Diaz and Richard W. Haynes

This page has been left blank intentionally.
Document continues on next page.

ABSTRACT

Diaz, Nancy M.; Haynes, Richard W. 2002. Highlights of science contributions to implementing the Northwest Forest Plan—1994 to 1998. Gen. Tech. Rep. PNW-GTR-540. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 22 p.

During 5 years of research (1994-98) in support of the Northwest Forest Plan (NWFP), Pacific Northwest Research Station scientists and their collaborators have made significant progress in both validating some of the NWFP's major assumptions and providing research that sets the stage for further evolution of the plan. Studies have provided new information in the areas of wildlife conservation and population viability, aquatic conservation measures, adaptive management, the socioeconomic dimension, ecological processes and functions, landscape-scale issues, and stand-development strategies. A key theme in the findings is the need for NWFP implementation and research efforts to increasingly address the significant ecological variation throughout the region, the dynamic nature of our forest ecosystems, the need to integrate information across science disciplines, and the benefits of managing adaptively.

Keywords: Northwest Forest Plan, ecosystem management, conservation, land management, alternative silviculture, landscape ecology, adaptive management.

CONTENTS

1 Introduction

2 Research Findings

2 Wildlife Conservation and Population Viability

4 Aquatic Conservation Strategy

6 Adaptive Management Concepts and Decision Support

9 Socioeconomic Research

11 Ecological Processes and Functions

13 Landscape-Scale Issues

15 New Stand Development Strategies for the Douglas-Fir Region

16 Emerging Questions

17 Integrating Themes in Northwest Forest Plan Research

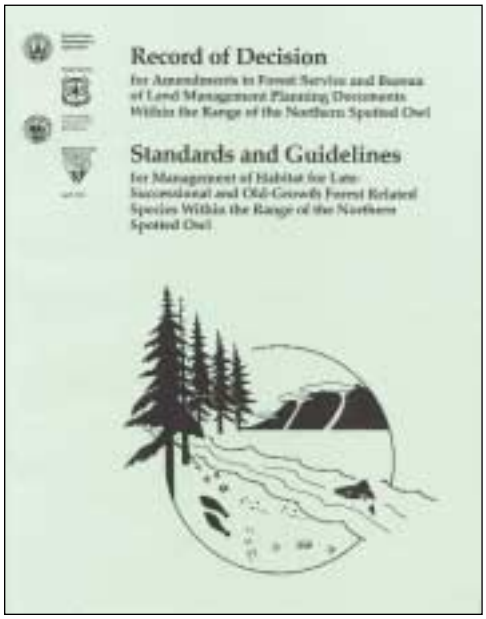
18 The Evolving Science-Management Partnership

19 Conclusion

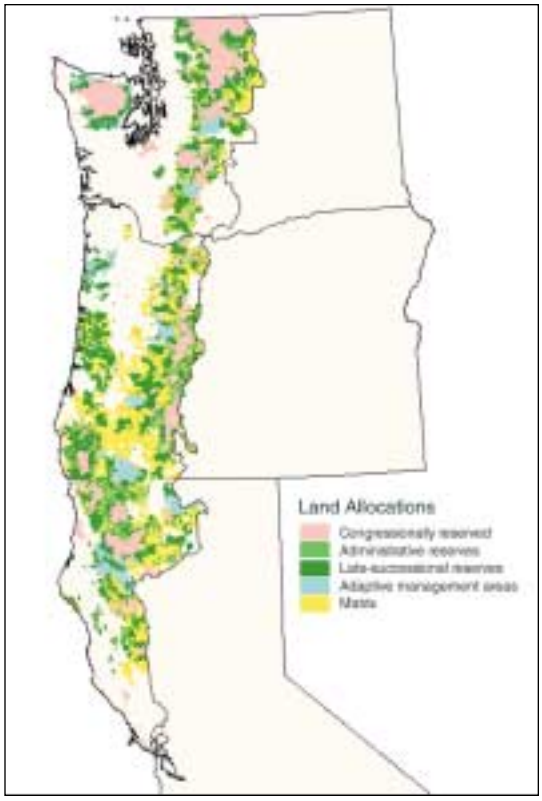
22 Acknowledgments

INTRODUCTION

In 1993, President Clinton directed the U.S. Department of Agriculture, Forest Service and U.S. Department of the Interior, Bureau of Land Management to develop a balanced and comprehensive long-term policy for managing 24 million acres of federal lands (about 20.4 million acres of which are forested) in the range of the northern spotted owl. A team of scientists, the Forest Ecosystem Management Assessment Team (FEMAT), was convened to develop options, and they prepared a report that became the basis for the Northwest Forest Plan (NWFP), approved in February 1994. The NWFP established measures to protect late-successional and old-growth forests, including a land allocation framework consisting of late-successional forest and riparian reserves, matrix lands managed for multiple uses, and adaptive management areas (AMAs); standards and guidelines; and an aquatic conservation strategy. It created the Northwest Economic Adjustment Initiative designed to help communities adjust to economic and social changes that would result from lower timber harvest levels. It also called for a paradigmatic change in the level of collaboration among the federal management, regulatory, and research agencies that oversee public lands in the Pacific Northwest. The research agendas for a generation of scientists connected to federal natural resource agencies were significantly altered by participating in FEMAT, meeting information needs for carrying out the NWFP, and assisting in plan implementation.



The Record of Decision is the legal document that implements the Northwest Forest Plan.



Land allocations within the Northwest Forest Plan area.

This publication highlights the contributions to the NWFP effort of scientists and professionals affiliated with the USDA Forest Service Pacific Northwest Research Station between 1994 and 1998.[1] These scientists assumed diverse roles as the NWFP was implemented. For example, they worked with the AMAs to develop scientifically designed management experiments that tested predictions and assumptions in management plans. They participated in developing protocols for effectiveness monitoring and "survey and manage" guidelines for species of concern, and coordinated research with other agencies. They conducted (and continue to conduct) research to fill gaps in knowledge on existing and emerging questions that span the range of disciplines in the social, physical, and biological sciences. They also provided technical assistance to managers, facilitating the transfer of new knowledge to on-the-ground application.

Much of the science reported in this publication is built on a foundation of ecosystem management-related research, from the Pacific Northwest and other areas, that has been accumulating for decades. We have not attempted to summarize all of

[1] This booklet reports on science specifically conducted by PNW Research Station scientists and their collaborators. We wish to acknowledge that many researchers from other agencies and universities have also made significant contributions to the science underpinnings and implementation of the NWFP.

Various agencies are clients of Northwest Forest Plan research.

this research. Rather, our focus is on specific work that attempted to test certain NWFP assumptions, fill critical knowledge gaps identified by the NWFP, "localize" generalized findings to particular environments, or develop implementation tools. This booklet also highlights some of the remaining challenges to the agencies charged with implementing the NWFP, and points out opportunities for scientists to engage in its further evolution.

Scientists and managers have a closer working relationship under the Northwest Forest Plan.

RESEARCH FINDINGS[2]

The research findings from 5 years of NWFP research are categorized into seven thematic areas: wildlife conservation and population viability; aquatic conservation strategy; adaptive management concepts and decision support; socioeconomic research; ecological processes and function; landscape-scale issues; and new stand-development strategies for the Douglas-fir region.

WILDLIFE CONSERVATION AND POPULATION VIABILITY

Research affirmed some of the basic FEMAT assumptions about ecosystems. Studies provided more evidence that certain plants, vertebrates, invertebrates, and fungi play key ecological roles that can influence the diversity, productivity, and sustainability of ecosystems. In particular, information on the importance of the small, often obscure members of the ecological community has grown rapidly. For example, studies underscored the role of mycorrhizal fungi in the regulation of plant community development and ecosystem composition and structure, and also the importance of insects and pathogenic organisms in the formation of gaps and early-seral communities in forests.

Such functional roles across taxonomic classes of organisms cannot be understood or fully addressed by focusing only on rare or threatened terrestrial vertebrates of viability concern. The single-species approach to biodiversity conservation was found to be fraught with problems, including difficulties in identifying little-known organisms, taxonomic uncertainties, lack of standardized sampling techniques, and perhaps most importantly, lack of information on the role of species of concern as functional members of an ecological community.

Research provided insights into facets of a successful conservation strategy. The FEMAT effort assumed that large reserves alone could not ensure viability for many species, and that connected habitat through the intervening matrix is also essential to provide for dispersal; research has added support for this assumption. Other research showed that although reconstruction of near-term presettlement landscape patterns may reflect conditions under which species have recently persisted,

[2] A more complete synthesis is found in Haynes and Perez (2001), Northwest Forest Plan Research Synthesis, USDA Forest Service, PNW Research Station, GTR-498. For additional information and citations of individual studies discussed in this booklet, please see the corresponding sections in GTR-498.

Some of the NWFP assumptions about wildlife conservation and population viability:

- The size and distribution of reserves and connectivity corridors provided by riparian zone protection would provide sufficient transport and dispersal habitat for spotted owls and other old-growth dependent species.
- The principal conservation benefits for old-growth protection, endangered species, and noncommodity values derive from the reserve system.
- There will be the social, technical, and scientific capacity to use disturbance regimes in the management of the reserves; management of disturbance regimes is essential to the viability of both old growth and endangered species.
- The land allocations in the NWFP and their intended management, along with mitigation measures like Survey and Manage, will contribute to the sustainability of all rare, old-growth dependent species.
- A buffer is the appropriate action whenever a Survey and Manage organism is found.
- The Survey and Manage guidelines reduce the risk of extirpation of listed species.
- Population viability for Survey and Manage species must be assessed at multiple scales.
- Implementation of the Survey and Manage system would not have a significant effect on the projected Probable Sale Quantity of the NWFP.

they may not necessarily depict conditions under which species have evolved over long periods. This suggests that more work is needed to determine how management strategies can provide for both evolutionary capacity as well as persistence of existing communities of organisms. Studies of disturbance processes reveal that species native to PNW forest ecosystems are adapted to a characteristic set of disturbance regimes that have shaped the ecosystem over time, suggesting that conservation efforts could be built around a more dynamic model of forest conditions.

The variation in results from different parts of the region suggests that a one-size-fits-all conservation strategy is not likely to succeed. For example, one study found canopy density to be correlated with breeding bird diversity and abundance, but the responses varied among sites with different climatic regimes, and also by species. Another study found that differences in the geomorphology of coastlines between Washington and Oregon seem to influence the ways in which marbled murrelets interact with late-seral stands near the coast.

New findings for particular species of concern suggest that FEMAT assumptions about the importance of the

Highway corridors act as a barrier to migration of some species and pose visual management challenges.

Research includes studies of species, biotic communities, and their functional roles.

amount and pattern of late-seral forest habitat were correct. For example, lynx and grizzly bears in northern Washington were found to be detrimentally affected by the I-90 highway corridor and associated forest fragmentation. Marbled murrelets were shown to be more abundant where there was late-seral or mature forest (nesting habitat) near the coast, but preferred it in combination with forest edge habitat, especially that provided by irregularly shaped forest openings. In southwest Oregon, northern spotted owls were found to be strongly influenced by both landscape pattern and prey base, and clearcuts acted as barriers to the dispersal of young owls. Finally, truffles, an important food source for small mammals, which are prey for owls and other predators, were found to be strongly associated with patches of late-seral forest.

AQUATIC CONSERVATION STRATEGY

Many of the assumptions in the NWFP regarding the protection of aquatic and riparian resources have been affirmed by research. Studies have highlighted the variation in stream systems across the landscape and the need to tailor conservation strategies to the function and potential of particular sites. The view of streams and riparian areas as highly dynamic over both space and time has been underscored, suggesting that the framework for management could focus on maximizing the beneficial effects of natural changes, rather than attempting to buffer streams from the effects of change.

Studies of streamside areas generally supported the NWFP assumption about the ecological distinctiveness of riparian areas. They also validated projections of microclimate effects within one tree height of the channel but found varying effects with increasing distance from the stream. Valley profile was shown to influence the area within which microclimate is affected by streams, indicating that effects occur within a narrower area (20 m or less from the channel) in sideslope-constrained reaches than in unconstrained flood plains. Research confirmed many of the assumptions about the importance of large wood for

Some of the NWFP assumptions about aquatic conservation strategies:

- In riparian reserves, potential site tree height was initially used to define buffers, but onsite analysis will be undertaken to customize boundaries and management strategies to accommodate local conditions and needs.
- Riparian reserves are not strict nature preserves, but will accommodate various other uses and values, e.g., use of fire and timber harvesting for restoring late-successional forest conditions, and public uses such as recreation.
- Riparian reserves act as transportation and dispersal corridors for various old-growth dependent terrestrial species.

both habitat and riffle-step pool formation in streams, and further revealed that landslide-prone tributaries (many of which are intermittent streams) are more important as source areas for wood, boulders, and substrate materials (relative to forests adjacent to main channels) than originally thought. The importance of intermittent streams was further underscored by studies that showed they often tend to be "hot spots" for biological diversity and critical source areas for organisms and organic matter to restore downstream areas affected by floods. Taken together, these findings suggest further testing be undertaken of strategies that allow adjusting buffer widths or management standards for streams with different profiles

Stream ecosystems are naturally dynamic, and their organisms are adapted to change.

Understanding the natural variation in microhabitats is crucial to the protection of riparian organisms.

or functional relations with the main channel. One study that modeled such an approach within the context of landscape patterns created through natural disturbances showed that the basic intent of the NWFP could be met, even though the approach departs significantly from the standard FEMAT "Option 9" scenario.

ADAPTIVE MANAGEMENT CONCEPTS AND DECISION SUPPORT

Adaptive management was a crucial underlying element of the NWFP. Research has both underscored the importance of rapid, systematic learning to sustainable land management (because there is no existing, well-established template) and highlighted areas for improving its success.

Studies of various efforts to manage adaptively showed that collaboration among the primary players (land managers, regulators, researchers, and citizens) is essential, and that no one group can, without the cooperation of the others, achieve success in adaptive management. Overcoming biases about the roles of the various players (for example, that learning is the domain of researchers, or that nonexperts do not have anything useful to offer in technical discussions) may be essential to establishing such cooperation. Furthermore, both research and practical experience underscored the benefits of continuing the partnership between researchers and land managers in carrying out projects that allow the scientifically rigorous testing of multiple management pathways. Such partnerships are probably the only practical and economical way that large-scale management regimes can be scientifically evaluated. In such a partnership, an important negotiating point is

The adaptive management "loop" requires institutionalization of the steps of planning, acting, monitoring, and evaluating, and of the connections between them.

the additional cost of measurements and other features associated with research, making it essential that low-cost experimental designs be developed. A primary benefit of the science-management partnership in adaptive management is a better understanding of (and thus support for) the rigorous application of scientific principles that lead to more credible management practices and more well-grounded decisions. In addition, scientists become better able to articulate management-relevant questions and to develop options and strategies. The development of decision-support systems, where scientists and managers together build connections between decisions and the underlying evidence, was demonstrated to be an effective forum for achieving these objectives.

A "sticking point" for the testing of multiple pathways, and for adaptive management in general, has been the perceived need to adhere strictly to standards and guidelines, which often prevents true experimentation from occurring. This was found to be particularly true of landscape-scale experiments; it seems to be easier to implement research studies at the stand scale, both because the effects occur across a smaller area, and because managers have more experience with stand-scale research. Failure to solve this problem could seriously jeopardize one of the key tenets of the NWFP: that adaptive management would be the primary means for evolution and improvement of the NWFP over time.

Additional keys to success of adaptive management include recognizing the necessity of specifically articulating learning as a goal for management projects (not as an end in itself, but as a means of informing subsequent actions) and creating the organizational structures and processes (for example, purpose-and-need statements in environmental documents) to ensure results are analyzed and communicated. Projects with a learning orientation are often less likely to be challenged by members of the public than other projects.

Adaptive management areas—Adaptive management areas (fig. 1) were established to give land managers and scientists latitude in undertaking studies designed to fill gaps in knowledge and to test NWFP assumptions and standards and guidelines; they also were intended to provide a forum for heightened collaboration ("collaborative learning") among scientists, citizens, and land managers. The explicit inclusion of the public in AMA planning and implementation was an objective of most AMAs. Local land managers and their science partners were given great latitude in determining how individual AMAs would be studied and managed, resulting in significant differences in the kinds of research and collaborative efforts that have been undertaken.

The many and diverse studies conducted in AMAs are oriented toward:

- Improving understanding of, and processes for, developing late-successional forest conditions.
- Developing innovative approaches to validation monitoring at the operational scale.
- Developing alternative strategies and approaches for managing riparian buffers.
- Improving understanding of natural disturbance regimes as the basis for landscape planning.
- Studying social acceptability of various forest management conditions and prescriptions.

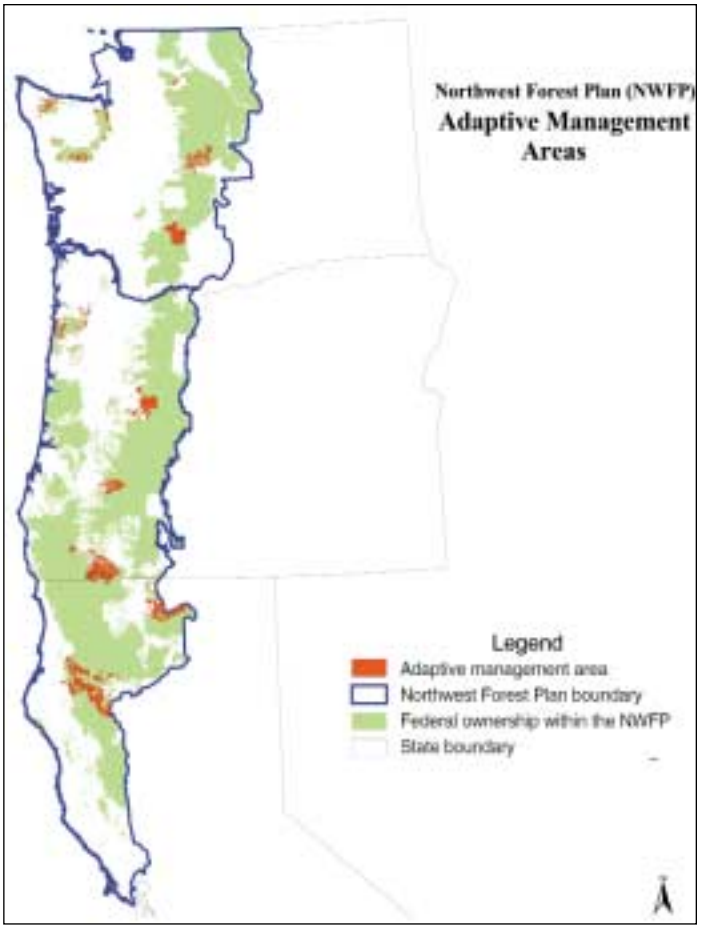


Figure 1—Adaptive management areas within the Northwest Forest Plan area.

Some of the NWFP assumptions about adaptive management:

- There is adequate understanding among managers, citizens, and other stakeholders of the philosophy, goals, and actions needed to achieve the objectives of the NWFP, including commitment to the conception of the NWFP as a phased and adaptive approach.
- Managers will use flexibility after implementing initial allocations and standards and guides.
- Results of experiments conducted in the AMAs will drive changes in allocation boundaries and standards and guides in the reserves and matrix.
- The AMAs will allow experimentation with approaches that combine scientific, economic, and social objectives.
- The geographic distribution of AMAs provides adequate biophysical, social, and economic representation across the region.
- Managers, citizens, and regulatory agencies will understand and support the role of the AMAs and engage actively in their implementation.
- Regulatory agencies will work with managers and researchers to determine criteria to use in judging when departures from initial allocations and standards and guides are warranted.
- Research is necessary but not sufficient for achieving adaptive management.
- Current organizational structures are adequate for implementing adaptive management, including operating under conditions of risk and uncertainty, integrating different forms of knowledge, and facilitating learning behaviors.

Adaptive management involves collaboration among land managers, scientists, and the public.

Although a significant number of studies (many of which were established before the NWFP) have been conducted in AMAs over the past 5 years, limited progress can be cited in the objective of validating the FEMAT assumptions with consequent changes in policy or management practices. This can be attributed to several factors: the short tenure of the studies, failure of the participating agencies to provide adequate funding or leadership to complete some projects, inability to engage all the participants equally, and the constraining effects of certain legislation (e.g., the Endangered Species and Federal Advisory Committee Acts). An ongoing barrier has been the risk-averse environment (both inside and outside agencies) of today's public land management arena, making it difficult to obtain agreement among all interested parties on activities that may be innovative or experimental.

Possibly the most significant lessons gained in the process of implementing the vision for AMAs have been in the arena of collaboration among partners with different missions and cultures. Although lessons have been learned about how to work together across agencies, ownerships, and multiple values, expectations of how much progress can be made, and how quickly, toward the vision of collaborative learning have had to be significantly scaled back. Flexibility, much local discretion, and the ability to quickly adapt to

new information were found to be essential to achieving the goals of the AMA network. In the Applegate AMA, the social coherence that has developed around the AMA projects has improved the ability of land managers to collaboratively craft management strategies that will be accepted. The AMA experiment has the potential to have major payoffs over time; premature closure, driven by pressures for immediate results, may result in lost opportunities in the long run.

Monitoring–Monitoring is central to adaptive management because it provides necessary information on the outcomes of management practices. In the NWFP area, monitoring occurs at the regional, provincial, watershed, and project scales, with little effort currently given to integrating information among scales. Research has focused on formulating regional-scale monitoring protocols for those items mandated in the NWFP. The methods for monitoring plan implementation, northern spotted owl and marbled murrelet populations, aquatic and riparian resources, and late-successional/old-growth forests have been completed. Protocols for assessing social and economic effects, tribal relations, and biological diversity are still underway. The NWFP agencies continue to struggle with connecting the information gained through monitoring to decision- and policy-making processes, with the technological challenges of building data layers across ownerships, and with integrating and balancing resources among the various scales of monitoring.

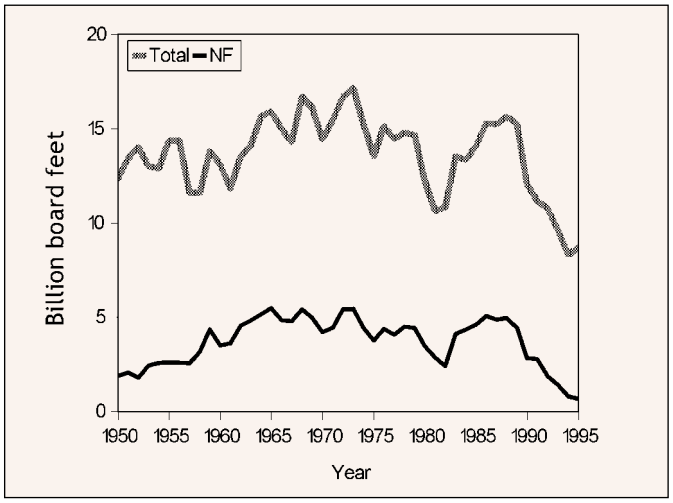


Figure 2—Harvest levels for the Pacific Northwest region as a whole (total), and for national forests within the region (NF).

SOCIOECONOMIC RESEARCH

The interaction among declines in timber harvest that have occurred under the NWFP (fig. 2), demographic shifts in public values and uses, the general economy, and private sector timber supplies, has produced a complicated set of social and economic effects in which it is difficult to both discern direct causes and to evaluate the performance of the NWFP and its various policies (e.g., the NW Economic Adjustment Initiative). Research showed that socioeconomic effects resulting from changes in land management have primarily affected communities that rely directly on forest resources (both commodity and noncommodity) for their well-being. Even within a small timber-dependent county, however, socioeconomic conditions under the NWFP differed greatly among communities. The economic well-being of these communities does not depend exclusively on the amount of timber harvest. For example, one study found that how forest work is contracted can be more important in determining effects in local communities than how much timber is harvested; larger service contracts and more complicated bidding procedures may inadvertently exclude smaller local firms.

Harvest of large logs was not uncommon in the 1940s but rarely occurs today. (photo from Roseburg, Oregon)

Timber-dependent communities differed in their response to changing economics brought about by the Northwest Forest Plan and other factors.

Although the economy of the region as a whole has outperformed that of the Nation during the tenure of the NWFP, there are various effects at the county and community levels. Even taking into account the loss of a large number of jobs in the timber products industry, the overall socioeconomic effects of the NWFP have been significantly less than expected. This led researchers to question the use of jobs as a proxy for economic well-being, and to ask further questions about what factors helped to economically buffer timber-dependent communities. This work is still underway, but early results suggest that many workers strongly identified (in terms of family history, occupational identity, and place attachment) with their local communities, and were able to adapt by being willing to work for lower wages, and change their traditional practices to more "light touch" methods. These findings are in accord with other research that has shown that timber-dependent communities often develop the ability to cope with the "boom and bust" nature of an extractive industry through various strategies. A concern remains that there may be a point at which this coping ability is overwhelmed by change resulting from the NWFP along with other social and economic factors.

The growing importance of nontimber forest products and an increase in watershed restoration work was (perhaps optimistically) envisioned to provide relief for some displaced workers, but it is too early to evaluate the results. Researchers have made a significant contribution in these

Some of the NWFP assumptions about social and economic factors:

- To effectively address the major biophysical, economic, and social questions in the region, an integrated strategy involving public and private parties will be necessary.
- Existing institutional capacity in the region is adequate to deal with the complex, cross-boundary, long-term, and multivalue issues driving the NWFP.
- The public will understand and support both the intent of the plan as well as its implementation.
- The phase 1 allocation, and the management of the reserves, matrix, and AMAs, would lead to a Probable Sale Quantity of 1.2 billion board feet (since revised to 0.81 billion board feet).
- The loss of timber from federal lands will not be completely offset by an increase in production from private lands, which is expected to rise somewhat in the first decade, and then decline. Declines from all sources will be greatest in Oregon.
- There will be near-term growth in the harvest of nontimber forest products, such as mushrooms, boughs, and ferns.
- The effects of the NWFP on communities, especially with regard to jobs, will be concentrated in rural, timber-dependent areas. The capacity of communities to respond depends on their access to transportation, markets, and raw materials, and the extent of their economic diversification. The effects on communities are likely to be more negative in Washington and California than in Oregon.

areas, for example by providing basic taxonomic work, survey methods, and sustainable harvest guidelines for forest fungi, and developing methods for watershed restoration and testing their efficacy.

ECOLOGICAL PROCESSES AND FUNCTIONS

Much of the ecological research under the NWFP has focused on the functional roles of key ecosystem features. Studies have affirmed many of the NWFP assumptions about the functional significance of large trees, coarse wood in streams and terrestrial sites, and mycorrhizal fungi as essential components of old forests. There is still significant work needed on potential "keystone" elements; that is, those items or processes, which, if lost, cause major disruption of the function of the system.

Research has established that native forests within the NWFP area have developed under varying disturbance regimes–landslides, floods, and fires. Species and communities are thus adapted to dynamic landscape conditions. One study found that a characterization of the nature (frequency, intensity, type, spatial distribution, and results) of disturbances provided a useful template for designing landscape-scale resource development strategies that conserve aquatic, riparian, and late-successional forest values.

King bolete, an edible mushroom.

Besides showing that PNW forests are more dynamic than previously thought, research demonstrated that there is considerable climate- and physiography-driven variation within the NWFP area with regard to how disturbances operate on the landscape. One set of studies helped to quantify how fire regimes range from low-intensity, relatively frequent events in the southern and eastern (drier) part of the NWFP area, to infrequent, stand-replacing events in the northern, wetter forests. This helps explain differences in old-growth structure and composition across the range of NWFP area environments, and suggests that prescriptions for managing forests to foster old-growth conditions (such as in late-successional reserves) could be tailored to harmonize with local disturbance regimes. Another study found that plant associations (potential natural plant communities that reflect effective environment) were good predictors of fire, insect, and disease disturbances, and that the intensity and frequency of changes increased east of the Cascade crest. Other studies have helped clarify what the target conditions might look like across this broad range of environments.

A significant implication of the research on disturbances in NWFP area forests is that while management within a framework of natural variation should be possible, the full range of conditions (for example, species) cannot exist on all sites at all times; in other words, any one component will likely wax and wane at a site through time. This has important consequences for management of reserve areas within a dynamic landscape, and argues for a systematic assessment of the temporal development and spatial array of the full range of habitat conditions.

Several studies have addressed questions about management techniques to foster or accelerate late-successional/old-growth forest composition and structure. Research suggested that current old growth developed at much lower densities than today's young stands, and that in many cases, unthinned plantations are unlikely to develop old-growth structure. Variable-density thinning combined with legacy (large live trees, snags, and logs) management tailored to the potential of particular sites seems to be an effective means of fostering old-growth structure and ensuring habitat for the various organisms associated with old forests. Studies also underscored the importance of a nearby seed source of shade-tolerant species (e.g., western hemlock) for the initiation of a secondary canopy layer. The NWFP assumptions about the value of leaving large green trees in plantations received support from research showing that such legacies, along with large logs, allow younger stands to have many of the same functions as late-successional forests with regard to certain lichens, birds, canopy insects, and mycorrhizal fungi.

Pacific Northwest forests have developed under various disturbance regimes.

Some of the NWFP assumptions about ecological processes and function:

- The allocation of land within the region across reserves, matrix, and AMAs, and the associated management actions within each allocation, will be sufficient to ensure legal compliance, species viability, economic stability, and protection of old-growth forests.
- The reserve system will be the principal provider of conservation benefits for old-growth protection, endangered species, and noncommodity values.
- Standards and guides are adequately defined to accommodate variation in ecosystems across the NWFP area.
- Effects of global climate change are assumed to be constant.
- Late-successional and riparian reserves are not to be strict nature preserves but will accommodate various other uses and values; e.g., use of fire and timber harvesting for restoring late-successional forest conditions and public uses such as recreation.
- Late-successional reserves will, over time and with active management, produce structural characteristics that function like existing old-growth stands.
- There will be the social, technical, and scientific capacity to use disturbance regimes in the management of the reserves; management of disturbance regimes is essential to the viability of both old growth and endangered species.
- Green tree retention in the matrix will provide connectivity among reserves, and adequate refugia in the managed portion of the landscape.

Hydrologic processes shape Pacific Northwest landscapes.

Other research focused on hydrologic processes. Early findings from research that studied road networks as water- and sediment-routing systems provided land managers with information useful for redesigning roads to reduce the amplification of the effects of intense storms and floods.

LANDSCAPE-SCALE ISSUES

Although land management agencies have been planning the development of public lands at larger scales for decades, the NWFP has initiated significantly greater focus on ecologically defined landscape units (watersheds, provinces, and regions) by both managers and researchers. The technical and logistical difficulties associated with conducting research at large scales caused the science underpinnings for landscape-scale management to lag until the last two decades or so, and the NWFP was strongly influenced by this new knowledge. Under the NWFP, landscape-scale research questions have focused on the variability of patterns and processes, the integration of ecological and socioeconomic forces, and methods for the acquisition, analysis, and display of larger scale information. (Because much of landscape-scale research is cross-disciplinary in nature, or has multiple objectives, some of the findings discussed in this section are repeated elsewhere in this document.)

Evidence of the ecological significance of both the abundance and spatial distribution of old forests continues to build. The FEMAT assumptions that remaining old growth is well below the natural range, and that federal lands have most of the existing old growth and habitat for northern

Some of the NWFP assumptions about landscape issues:

- Watersheds are an appropriate and useful unit of scale for analysis of spotted owls, old growth, and fish.
- Exclusion of private, state, and tribal lands from the FEMAT assessment and proposed solutions does not constrain the NWFP's effective implementation.
- The reserve system will be the principal provider of conservation benefits for old-growth protection, endangered species, and noncommodity values.
- The size and distribution of reserves and connectivity corridors provided by riparian zone protection would provide sufficient transport and dispersal habitat for spotted owls and other old-growth dependent species.
- There will be the social, technical, and scientific capacity to use disturbance regimes in the management of the reserves; management of disturbance regimes is essential to the viability of both old growth and endangered species.
- Green tree retention in the matrix will provide connectivity among reserves and adequate refugia in the managed portion of the landscape.

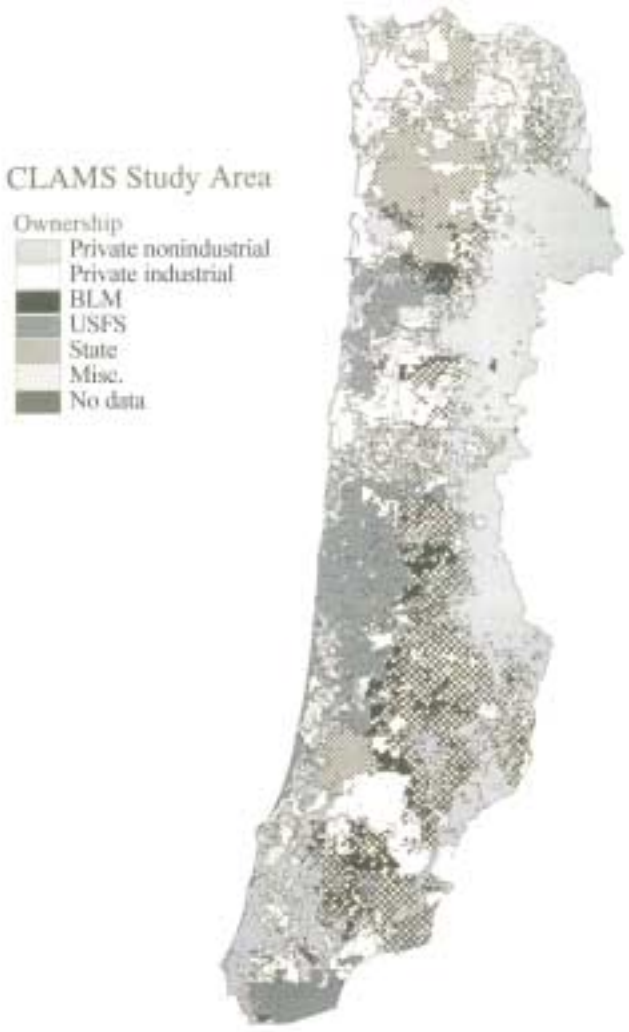
Past management practices had a significant effect on the distribution and amount of old growth.

spotted owl are well-documented. Research has further substantiated the importance of late-successional forest patches in the landscape for certain organisms (lichens, fungi that provide a food source for small mammals, canopy insects, and some birds). Other studies found that for certain birds, the amount of late-successional habitat may be more critical than the spatial pattern (i.e., fragmented vs. unfragmented).

Research on ecological variation across the NWFP area found significant differences across the region, with corresponding dissimilarities in disturbance processes. In the Snoqualmie Pass AMA, these differences were shown to be correlated with plant associations. Such correlations highlight the value of the plant association model as a regional ecological stratification tool. Other studies further documented the nature of the low-severity, high-frequency natural fire regimes in the eastern and southern portions of the NWFP area. Sorting out the variation in regime attributes (frequency, intensity, and effects) in these areas is providing managers with important background information for the prescription of management activities to maintain and restore late-successional forest characteristics at various scales. Research on the effects of landscape patterns on species of concern also tended to validate the NWFP assumptions about the importance of old-growth habitat. For example, in northern Washington, grizzly bears and lynx were found to be negatively affected by the I-90 highway corridor and surrounding forest fragmentation, and in southwest Oregon, clearcuts were found to be significant barriers to the dispersal of young spotted owls. Marbled murrelets increased in number where late-successional nesting habitat occurred in proximity to the coastline and where there was edge (mature forest/opening) habitat nearby.

Other research focused on providing conceptual frameworks, methods, and tools for ecosystem-based, landscape-scale planning. The findings of some studies suggest a key challenge to ecosystem management will be the identification of "keystone" features of landscapes (e.g., riparian corridors, prey populations, disturbance processes such as fire, or accumulations of coarse wood) that have a disproportionate influence on other landscape attributes, and development of management strategies that sustain them. Another study found that the concept of "range of historical (or natural) variation" is most meaningful at the province scale; at smaller scales the range in conditions is too large (e.g., the percentage of old growth in a small watershed over time may vary from almost 0 to 100, depending on the fire regime), and at larger scales significant ecological differences may get averaged out.

The most prominent large-scale research project in the western portion of NWFP area is the coastal landscape assessment and modeling study (CLAMS). This project has produced many tools, including:



Land ownership patterns within the CLAMS study area are complex.

- Remote sensing and modeling methods for developing forest structure maps at landscape and regional scales.
- Effectiveness monitoring protocols for late-successional forests.
- The ecosystem management decision-support system for testing options.
- Methods to predict land use change at the province scale.
- An ecological succession simulator.

The modeling effort, designed to test the effects of alternative forest management policies across ownerships within the coast province, struggled with the integration of the social, economic, and ecological components. Researchers found it was relatively easy to model the individual components, but it was hard to link them, partly because the

components often are operating at different scales. Also, they found it difficult to quantify the social and economic values of the ecological components, such as biological diversity. One significant finding of the modeling effort is the existing and projected variation in landscape patterns produced by different landowners. Fragmentation of old-growth habitat tends to be less on federal than on private lands, and the disparity will likely widen under current land use policies, thereby resulting in highly contrasting landscapes. The resulting spatial array of forest habitats of different ages could have significant effects on the distribution of organisms that prefer either early- or late-successional conditions, with potential concentrations of the former on lower elevation private lands, and the latter in publicly owned mountainous areas. This analysis also showed an increasing "polarization" of forest age classes on public lands into very young and very old, with little mid-seral component to provide for old growth in the future.

NEW STAND DEVELOPMENT STRATEGIES FOR THE DOUGLAS-FIR REGION

New approaches to silviculture are a hallmark of the NWFP, and research continues to add to the array of options. For example, studies revealed more flexibility in Douglas-fir growth patterns than previously thought. In particular, models based on new growth and yield information showed a higher level of timber volume could be produced under longer rotations than previously believed, especially if multiple thinnings take place. Longer rotations have significant ecological and social benefits, as well as lower costs. Furthermore, Douglas-fir appears to be more capable of maintaining growth rates in low light than previously believed, which makes

Small logs used for fence posts and rails.

alternatives to clearcutting much more acceptable where volume production is a goal. Other studies documented the value of various silvicultural techniques (such as variable-density thinning) in achieving goals related to old-forest structure, wildlife habitat, and visual quality. Ongoing studies are providing information on growth and regeneration under leave-tree canopies and on managing older stands for old-growth characteristics.

Silvicultural research is focusing on techniques for fostering old-growth structure at multiple scales.

Some of the NWFP assumptions about stand-level management:

- Late-successional and riparian reserves are not to be strict nature preserves, but will accommodate various other uses and values, e.g., use of fire and timber harvesting for restoring late-successional forest conditions, and public uses such as recreation.
- Late-successional reserves will, over time and with active management (e.g., thinning, restoration, management of disturbance regimes), produce structural characteristics that function like existing old-growth stands.
- Green tree retention in the matrix will provide connectivity among reserves, and adequate refugia in the managed portion of the landscape.

EMERGING QUESTIONS

There are significant research areas identified in the FEMAT report and the NWFP that have not been fully explored. These include taxonomy, population dynamics, and habitat needs of little-known species (including soil organisms); risk-assessment techniques; integration of social, economic, and ecological disciplines; use of management experiments in AMAs; synthesis of management inferences from broad-scale experimental studies; effectiveness of fire as an ecosystem restoration tool; effectiveness of riparian buffers; effectiveness of snag and downwood guidelines; and the effectiveness (in terms of costs and benefits) of different approaches for restoring biotic communities and ecosystem processes. These and other researchable topics will continue to provide opportunities for scientists to contribute to strengthening the science underpinnings of NWFP implementation.

The link between social values and land use is an important facet of understanding ecosystems at broad scales.

INTEGRATING THEMES IN NORTHWEST FOREST PLAN RESEARCH

The management and planning questions emerging from implementation of the NWFP are creating a greater need for science that weaves together the ecological, social, and economic dimensions of land management policy and practices. This change is leading to discussions within the science community about scale, multiple land ownerships, and how to achieve integration among science disciplines. It has challenged researchers to examine how our organizational structures and processes either facilitate or constrain cross-disciplinary work. Processes (with regard to both scientific methods and working relations) for integration have been slow to develop. Early steps have included the development of conceptual models of system components that show how parts interrelate, and the expansion of empirical and analytical efforts that explore multifunctional relations.

The CLAMS project has incorporated cross-disciplinary science on several fronts, with an increasing emphasis as the study has progressed on the connections among the individual disciplinary components. This work has greatly improved understanding of ecological process and links at various scales and has revealed the complexities and difficulties of dealing with linked conceptual models, prototypes, the logistical need to simplify subsystem processes, and scarcity of large-scale indicators, in order to discern tradeoffs between social and biophysical elements. The CLAMS scientists have set the stage for further exploration of what cross-disciplinary science can provide.

One of the areas of greatest need for integrated research is that of biodiversity conservation. Research that integrates the science on species, habitats, multiscale ecological function,

Biodiversity research studies not only the habitats and population dynamics of individual species but also their roles in the overall biological community.

and human values to produce strategies for conserving biological diversity that are achievable within the current cultural, legal, and policy context would be extremely valuable. Concerns about individual species protected by the Endangered Species Act are what catalyzed the NWFP and initially drove NWFP scientific research. More recently, however, it has become apparent that the full complement (numbering in the hundreds) of species cannot be realistically protected by planning for one species at a time, and the research emphasis has shifted to alternate approaches. Although research continues for species of concern like spotted owls, marbled murrelets, amphibians and reptiles, fungi, arthropods, plants, and vertebrate carnivores, their protection within the context of overall biological diversity is gaining interest. Research has already offered several "nuggets" that provide a starting point for biodiversity conservation. For example, we know that many "hidden," seemingly unimportant species and elements have key ecological roles (e.g, mycorrhizal fungi and aquatic arthropods); that systems are adapted to change, and therefore fixed, static reserves probably will not provide the complete answer for the long term; that species cannot be fully understood apart from their context as part of a total biological community; that "unique" habitats (wetlands, rock outcroppings, etc.) have importance disproportionate to their area; that providing for dispersal capability is key. In addition, there are significant gaps in our knowledge of the social context for biodiversity conservation and of how to gain public acceptance for conservation approaches. These disparate ideas constitute "nuclei" around which new science can help build conservation strategies that resonate with public values; this is a key challenge for the adaptation of the NWFP.

THE EVOLVING SCIENCE-MANAGEMENT PARTNERSHIP

From the perspective of land managers, the NWFP considerably increased the amount of contact with the research community and probably created expectations for more extensive and rapid transfer of new knowledge. At the same time, the sheer volume of new science information, some of which may appear conflicting, or may change as our understanding evolves, has the potential to occasionally

overwhelm and confuse the recipients. In spite of the difficulties, application of new information is occurring widely on the ground in several arenas, including disturbance and fire ecology, alternative silviculture techniques, large woody debris management, and adaptive management processes. On the other hand, there are areas where research was identified as lacking or not available in usable forms (see "Emerging Questions" section above).

Scientists and managers each bring their own type of expertise to natural resources research.

Building close relations between managers and scientists is a particularly effective tool for transferring new information to the ground. Joint participation in project design, including problem framing, is critical to later acceptance of and interest in science findings. Once solid relationships and networks are in place, the value of publications and other materials in transferring knowledge will be improved.

Some institutional restructuring of research has been spurred by the effect of the NWFP because of the nature of information needed to support land management. For example, greater attention is being paid to the speedy delivery of management- and policy-relevant science products, and managers and scientists are interacting collaboratively much more than before. Restructuring also is being spurred by the desire to practice adaptive management, although progress in this area has been affected by low funding levels and legal and policy constraints. Part of the legacy of the NWFP is a strong need for collaborative learning—a multiway learning process in which scientists work with managers and stakeholders to both share and gain information about natural processes and local values and use, and to jointly frame solutions to public land use problems.

The different cultures and training of the research and management branches present serious challenges. The long timeframes required by some types of research often do not mesh with policy- and decision-making needs. The different ways in which information is validated in the two cultures and the expanded use of scientists as purveyors of "expert opinions" have created tension. The greater demand for scientists to consult with field managers on project design and implementation has created time and workload demands that conflict with accomplishing fundamental research. For each group, scientists and managers, to understand each other and work as partners, greater commitment to a joint agenda will have to be made.

CONCLUSION

The research conducted in support of the NWFP affirmed many of the assumptions of the FEMAT group, especially with regard to the function of late-successional forests and riparian/aquatic systems. In addition, research provided new information to confirm what most land managers already knew—that there is significant ecological variation throughout the region—and has begun to develop new foundations for meeting NWFP goals within the environmental opportunities and constraints of particular areas. Research on both disturbance regimes and stand-level silvicultural practices can now be synthesized by local resource specialists and officials to determine the range of potential conditions and set of practices that will meet the objectives on their sites. Doing this synthesis in partnership with scientists, especially within the framework of testing multiple management pathways, would have significant benefits to both researchers and managers, and could help achieve the vision of adaptive management.

It has long been apparent that PNW forests are dynamic, but research has only recently begun to sort out the nature of and spatial variation in the kinds of changes that naturally take place. The need to craft a framework (e.g., range of historical or natural conditions) that can support and inform planning for changing forest conditions is becoming more and more compelling. Such a shift in thinking about ecosystems will significantly challenge both the policy and regulatory arenas, and sound science underpinnings will be essential.

The NWFP research identified some significant overarching problems that need attention before key questions can be answered. Among the most prominent of these is the problem of scale. In both the socioeconomic and ecological disciplines, not being able to either aggregate or disaggregate information between scales has presented serious difficulties to researchers and land managers. At some point, a systematic assessment of

The protection of aquatic and riparian resources is a major focus of the Northwest Forest Plan.

Emerging research will be shaped by the need to adapt land management to the values of rapidly expanding urban populations.

what questions can be answered at which scales, and how to forge links between them, would be profitable. Without such an assessment, researchers run the risk of creating a disconnect between the questions being asked and the answers being given.

Most would agree that the vision of adaptive management has been unevenly achieved, at best. Some elements of success seem to be within the grasp of the agencies: making "learning" a specific goal, adopting an inclusive stance with regard to participation by citizens, providing adequate funding to carry projects to completion, making sure all partners are fully committed, and crafting institutional structures and processes to communicate and benefit from lessons learned. There are also barriers that might not be possible to surmount: the overwhelming weight of bureaucratic process, the rigidity of regulatory systems, conflicting public values that cannot be reconciled, and a litigious environment that discourages risk taking and experimentation. There is a general sense, however, that it is profitable to learn from experience and to explore new avenues for improvement. Although it is too early to predict the outcome, recent efforts to reenergize adaptive management as a concept should encourage those who are willing to invest resources in making it successful. It is worth noting that research found "willingness to change" was a major determinant of success in implementing adaptive management.

Overall, the NWFP research program has produced significant findings in many areas. The NWFP research has involved scientists in the policy process, leading to more policy-relevant research and increased awareness of the need for integration. It also has allowed both scientists and managers to play a leadership role in developing conceptual frameworks to guide future research. A new level of partnership and interagency coordination has been generated in the research, regulatory, and management agency communities. Scientists have been challenged to maintain high standards of objectivity while functioning in closer proximity to decisionmaking and policy-formulation processes. How the nature of these relationships evolves given the ever-changing priorities of the various agencies will determine how well the research side meets its goal of focused delivery of policy-relevant science, and how well the land management side meets its goal of science-based decisions for the use of public forest lands.

ACKNOWLEDGMENTS

Much of the material in this booklet is paraphrased from Haynes and Perez (2001), "Northwest Forest Plan Research Synthesis," USDA Forest Service, PNW Research Station, General Technical Report PNW-GTR-498. We acknowledge the contributions of the following authors:

Wildlife Conservation and Population Viability
–Bruce Marcot

Aquatic Conservation Strategy
–David Hohler, James Sedell, and Deanna Olson

Adaptive Management and Decision Support
–Bernard T. Bormann, Martha H. Brookes, Keith Reynolds, George H. Stankey, and Roger N. Clark

Socioeconomic Research
–Cecelia Danks and Richard W. Haynes

Ecological Processes and Functions
–Frederick J. Swanson and Randy Molina

Landscape-Scale Issues
–Thomas Spies and Frederick J. Swanson

New Stand Development Strategies for the Douglas-Fir Region
–Dean S. DeBell, Bradley St. Clair, and Robert O. Curtis

Kate Snow, Laura Bergstrom, and Garland Mason also contributed ideas used in the development of this document.

This page has been left blank intentionally.

This page has been left blank intentionally.

The Forest Service of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives—as directed by Congress—to provide increasingly greater service to a growing Nation.

Pacific Northwest Research Station

Web site	http://www.fs.fed.us/pnw
Telephone	(503) 808-2592
Publication requests	(503) 808-2138
FAX	(503) 808-2130
E-mail	pnw_pnwpubs@fs.fed.us
Mailing address	Publications Distribution Pacific Northwest Research Station P.O. Box 3890 Portland, OR 97208-3890

United States
Department of Agriculture

Forest Service
Pacific Northwest Research Station

General Technical Report
PNW-GTR-540
July 2002