Chapter 3: Synthesis: Interpreting the Northwest Forest Plan as More Than the Sum of Its Parts

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Introduction

Chapters 5 to 10 interpret the status and trend reports and available science for each of the six major Northwest Forest Plan (Plan) elements (socioeconomic implications; the conservation of old-growth forests; listed and other species; aquatic systems; and adaptive management and regional monitoring). Each element was individually addressed, partly as a way to help understand and explain them, and partly because science is organized by discipline. Here, we consider the elements collectively. We also take the liberty to examine broader contextual factors and look for patterns in available data extending back as far as 50 years. Then we turn our attention to examining possible directions for federal forest management in the next 50 years. We also explore how these perspectives can be integrated with management and policy. Integration starts by recognizing that federal land managers and researchers have very different roles and perspectives. Managers are responsible for developing and applying coherent management strategies to meet complex societal goals, with legal, funding, and personnel constraints, and through public input. Management strategies also seek to integrate various researchers' disciplinary perspectives and be consistent with management experience and knowledge. We seek here to help with this difficult task by revisiting principles of science-based management and by illustrating the debate needed to integrate science and policy, from our perspective as researchers, through specific examples.

Interpreting the Collective Evidence From the Plan's First Decade

Our condensed tabulation of Plan performance (table 3-1) suggests a collection of met and unmet expectations, each depending on individual points of view. People most concerned with ecological conditions may be pleased with many of the changes. People concerned mostly about timber-dependent communities and adaptive management processes will likely be less pleased but may also believe that outcomes could have been much worse. The decline of northern spotted owl (see appendix for scientific names) populations in the southern part of their range was at the low end (2 percent per year) of the wide range of expected decline (0.7 to 8.4 percent per year; chapter 7), but at the high end (7.5 percent) in Washington for reasons not well understood—possibly related to increasing barred owl populations. The decade saw a net increase in older stands that may eventually support more owls. The area of stands that grew into large size classes was greater than losses of older stands from harvesting and fire, even with the 500,000-acre Biscuit Fire. Marbled murrelets appeared to maintain their population, although monitoring is limited to the last 4 years and results may be confounded with changing ocean conditions and a variety of other factors. Multiple interpretations suggested that older and riparian forests did better than expected, a result of harvest lower than expected in the matrix and changes as forests grew into larger size classes. At the time the Plan was written, species habitat models were often seen as a way of determining population trends more efficiently and less expensively than by direct measures. We have learned that building habitat models to predict populations is frequently as complex and difficult as estimating actual populations

Table 3-1—Coalesced key short findings from Plan monitoring (see other chapters for details)

Indicator	10-yr expected[1]	10-yr findings[2]	10-yr deviation	Relevance to the Plan and its implementation
Older forests (FEMAT definition)	Annual increase (1.2%) (reserve lands only)	Annual increase (1.9%) (all land allocations)	Rate of increase higher than expected	The Plan slowed old-forest harvest; implementing nearly stopped it (chapter 6)
Older forest losses from fire	Moderate (2.5%)	Dry provinces (1-9%) Wet provinces (0-1%)	Average over all provinces (1.8%) near expected	Losses were mostly in dry provinces, and fuel reduction was less than planned (chapter 6)
Realized owl populations in northern range	Slight to large decline (0.7-8.4% loss per yr)	Large decline (7.5% loss per yr)	High end of range	Declines may have resulted from habitat loss, barred owls, and other factors (chapter 7)
Realized owl population in southern range	Slight to large decline (0.7-8.4% loss per yr)	Slight to no decline (2.0% loss per yr)	Low end of range	Owl use of brushy habitat appears important (chapter 7)
Plan-wide owl habitat	5% loss to harvest and fire	Slight decline (1.3% loss)	Rate of decline less than half	The Plan slowed habitat loss; gains in older forest do not yet meet habitat standards (chapter 7)
Plan-wide murrelet habitat	Conserve most remaining habitat	Little (2.3%) lost on federal lands	Near expected	The Plan slowed habitat loss and implementing curtailed it further, but other factors are likely involved (chapter 7)
Plan-wide murrelet populations	About a 35% decline	No change in 4 years	Less decline than expected	Ocean conditions and recruitment may explain unexpected stability (chapter 9)
Other older forest species	Maintain with annual review	Many new sites discovered and species protected	Site protection as expected; population trends unknown	Although abandoned in 2004 through a SEIS and new ROD, the Survey and Manage program was reinstated in 2005 by court order following lawsuits brought by environmental groups. A new SEIS is currently in progress that continues the intent to abandon the Survey and Manage program (chapter 8)
Watershed condition scores	Maintain or increase	Of 250 watersheds monitored 60% increased, 39% maintained	As expected	The Plan curtailed most riparian harvest leading to desirable scores (chapter 9)

Table 3-1—Coalesced key short findings from Plan monitoring (see other chapters for details) (continued)

Indicator	10-yr expected	10-yr findings	10-yr deviation	Relevance to the Plan and its implementation
Road decommissioning	Unspecified	10 miles for every mile built	Large ratio; low miles	The Plan generally decommissioned few miles of riparian roads in any given watershed (chapter 9)
Altered riparian boundaries	Many	“Very few”	Fewer than expected	Modifications of boundaries was hindered by reluctance of managers to make decisions during watershed analyses (chapter 9)
Timber production in matrix	8.5 BBF distributed evenly over the decade	<0.5 BBF per yr	Harvest much lower than expected	Implementing ran into various problems, including lawsuits and protests (chapter 5)
Timber production in late-successional reserves	Allow some salvage logging	Thinning in some reserves	More thinning volume than expected	Thinning in late-successional reserves made up for some of lost matrix harvest (chapter 6)
Community stability	Stability	Two thirds changed	Both positive and negative changes	The Plan had less positive or negative influence than expected (chapter 5)
Interagency and agency-citizen collaboration	Improve relations	Interagency, yes; agency-citizen-mixed	Interagency better than expected; agency-citizen less than expected	Interagency collaboration worked well in many, but not all, places (chapter 5)
Adaptive management areas (AMAs)	10 AMAs providing changes to the Plan	Few active AMAs remaining	Much less than expected	As implemented, AMAs were insufficiently flexible or institutionalized (chapter 10)
Adaptive management process	Not well specified	A few projects outside of AMAs	Unknown	The process was not widely integrated into agency missions (chapter 10)
Regional monitoring	Not well specified	Five modules are functioning well	Near expected	Regional monitoring was well institutionalized and funded (chapter 10)
Employees-Forest Service (as capacity indicator)	Slight decline	Large decline (40-60%) in OR NF	More than expected	Plan goals hampered by sharply declining FS workforce (chapter 5, 10)
Employees-BLM	Slight decline	Slight decline	As expected	Capability was continued (chapter 5)
Manager-researcher collaboration	Improved at least on AMAs	Improved relations generally	More than expected	The Plan was more science based than before (chapters 5, 10)

[1] Few well-quantified expectations were included in the Plan. Here, we reconstruct expectations from FEMAT, the Record of Decision, and participant’s recollections.
[2] Findings are derived from data in background monitoring reports. Percentages are per decade unless otherwise noted.

The Biscuit Fire in southwest Oregon burned nearly 500,000 acres in 2002.

thus, models may not be good substitutes for population estimates. In general, the Plan can support conservation and restoration of habitat, but wildlife populations may respond to a variety of other factors, only some of which are driven by habitat.

Continuing lawsuits and other expressions of dissatisfaction suggest that desired consensus and trust in management have yet to be fully achieved. Timber production was far less than expected in the matrix allocation; some of this loss was made up by greater than expected production from thinning in plantations in late-successional reserves. Interviews suggested that timber-dependent communities were disappointed in the Plan, but census data suggest that a

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Stevenson, Washington, is a former timber-dependent community; community action and residents transformed it to meet changing recreation demands.

relatively small number of communities were severely affected. Some job losses were offset by unexpected factors such as a generally good regional economy and new services and development to accommodate inflowing retirees. Pronounced losses of federal jobs were observed, more than 50 percent on some Oregon and Washington national forests (Charnley and others 2006). Losses in Plan-area national forests in northern California were somewhat less, and USDI Bureau of Land Management (BLM) district jobs were relatively stable. Average national forest nonfire budgets in the Plan area dropped about $250 million or 50 percent during the 1990s, driven by reallocation of national funding.

The specific interpretations of these observations reside in the chapters in part II and in the status and trend reports. Of interest here is the general result that some changes were greater than expected and others less. A noticeable range exists in the strength of evidence with which conclusions can be drawn (discussed in chapters 5 through 10). This range is attributable to the nature of available information and how it was evaluated.

Recent scientific developments add to our understanding of Plan assumptions and help to interpret Plan implementation. Key findings from relevant research studies include:

- Areas with diverse early-successional forest will likely decline in the future with current strategies on public and private lands (see chapter 6).
- Diverse pathways of succession lead to older forest condition; a common one has low conifer densities at young ages developing into multiaged stands with closed canopy at old age (see chapter 6).
- Definitions of old growth by scientists and society are changing and diverging (see chapter 6).
- Thinning plantations to move in the direction of older forest habitat appears promising (see chapter 6).
- Successful adaptive management is generally rare in natural-resource management (see chapter 10).
- Active adaptive management at large scales, although rare, is possible with sufficient leadership and collaboration (see chapter 10).
- New approaches to public participation and adaptive management have evolved (see chapter 5).
- The importance of monitoring in facilitating productive dialogue about management possibilities was recognized (see chapter 10).
- Aquatic systems are far more dynamic than has been realized; benefits from some kinds of fire and landslides are newly recognized in some systems (see chapter 9).
- A new, mixed-severity fire regime is recognized; numerous older forests thought to be in high-severity regimes are now in mixed regimes (see chapter 6).
- Federal lands have a small proportion of the best coho salmon and murrelet habitat (see chapter 9).
- Barred owls may be replacing spotted owls, especially in the northern range (see chapter 7).
- Owls in the checkerboard lands in their southern range may have fared well because of adjacent, brushy foraging habitat (see chapter 7).
- Nonfederal lands have important regional effects in contrast to Plan assumptions (see chapter 5).
- The timber industry has adapted to changes, and some of the adaptations benefit regional employment (more manufacturing jobs per volume of wood processed; see chapter 5).
- Communities express different degrees of adaptability (see chapter 5).
- New kinds and magnitudes of complexity and uncertainty are recognized (see chapter 5).

Most notably, ecosystem complexity and dynamics, both social and ecological, are emphasized in many studies. We also see some surprises, such as unanticipated mechanisms associated with changes in owl and fish populations. Some of the unexpected changes—such as new industry and community strategies—appear to be adaptations to the Plan. These findings are discussed in detail in part II chapters. Later, we look across the findings to seek emerging themes that might apply to the Plan as a whole, rather than to individual Plan elements. Before we try to draw many conclusions, we next place these findings in a broader, longer term context.

Interpreting the Evidence in a Broad Context Over the Last 50 Years

Changes, whether induced by the Plan or other factors, are best understood when placed in the context of the large physical, biological, and societal complexity of Pacific Northwest landscapes, and by looking at the changes over timeframes longer than 10 years. Some of the spatial complexities are captured in the maps depicting older forests (Moeur and others 2005, fig. 12) and census data (Charnley and others 2006, fig. 2-5). We graphically examine available data to look for trends in the 40 years leading up to the Plan compared to trends observed in the Plan decade (figs. 3-1 and 3-2). We examine these graphs to see if longer term trends separate themselves from the noise of short-term variability.

National trends and within- and between-state migration in human population are known to drive many factors that influence management direction on federal lands (fig. 3-1a). Increased human presence in the wildland interface has increased demand for water and recreation and has increased the danger and costs of controlling wildfire and hindered reintroduction of low-intensity fire. Because managing federal lands has been ground zero for a societal debate over how these resources and values are collectively met, forestry has been elevated to the national political debate in recent decades. The volatility of social and political change (fig. 3-1b) makes long-term planning a challenge. Examining all of these graphs together, shows some interesting disconnects. For example, U.S. housing starts, although quite volatile, do not increase with U.S. population or decrease with Northwest harvest—no long-term trend is observed over the 50 years of data (fig. 3-1c).

Wood production from federal lands fluctuated moderately from 1960 to 1990, with only a small long-term declining trend (fig. 3-1d). The subsequent steep decline started just before the Dwyer injunction,[1] well before the Plan was implemented. Wood production by forest industry varied with market fluctuation until the late 1970s. Industry harvest declined from then until about the start of the Plan in 1994, and then leveled out during the Plan decade. The stumpage value of harvested Douglas-fir spiked after the Dwyer injunction and then began to decline during the Plan decade, but it remains well above historical prices. A major change occurred in the stumpage-price curves—previously large-diameter logs were worth two to three times more per unit volume than medium-diameter logs. This premium has disappeared, apparently because of increasing demand for small logs being processed in new, efficient mills and loss of mills able to process large logs. Short-term variability in lumber and wood-products jobs (fig. 3-1e) is smaller than variability in harvest or housing starts. Jobs were relatively steady up to 1980 and then began declining. The jobs per unit of harvest actually increased starting in the late 1980s and remains at a 50-year high. Economists think this increase came from increased mill efficiency, the loss of the log-export markets, and the associated increases in local manufacturing (see chapter 5).

The trends in owl populations[2] (fig. 3-2a) and late-successional old-growth forest, both major indicators for gauging progress, are mixed. Owl populations showed both continued declines and stable populations depending on differences in underlying factors and physiographic region. The areas of older forest are stable to expanding, and expectations are for continued increases (see chapters 6 and 7). The decisions not to cut as many older stands in the matrix as the Plan had called for, and to focus more on thinning plantations, yielded a double benefit to late-succession-dependent species—fewer large trees were cut and small-tree growth was accelerated.

Tree harvest (not counting thinning in plantations) was nearly stopped on federal lands during the Plan decade. Although aquatic specialists perceived that watersheds are generally in a poor state, cumulative harvest in riparian zones leveled off to about 5 percent (based on

[1] 1994. U.S. District Court. Seattle Audubon Society and others v. John L. Evans, Washington Contract Loggers Association and others.

[2] Data from Anthony and others, in press.

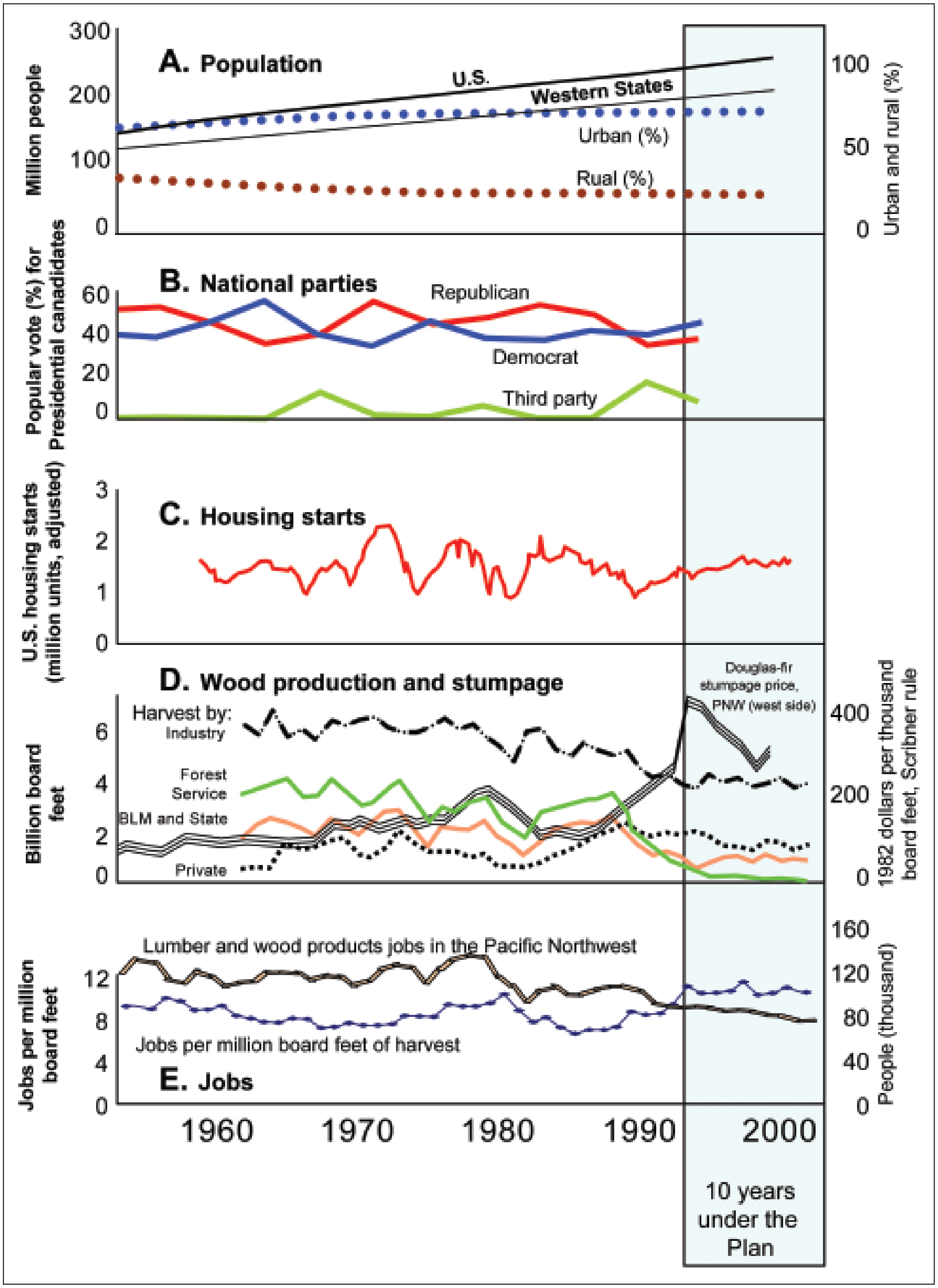

Figure 3-1—Fifty-year variability and change in (a) U.S. population, (b) voting patterns, (c) housing starts, (d) wood production and stumpage price, and (e) forest-sector jobs. Figures a to c are from Caplow and others 2000; d and e are from our chapter 5.

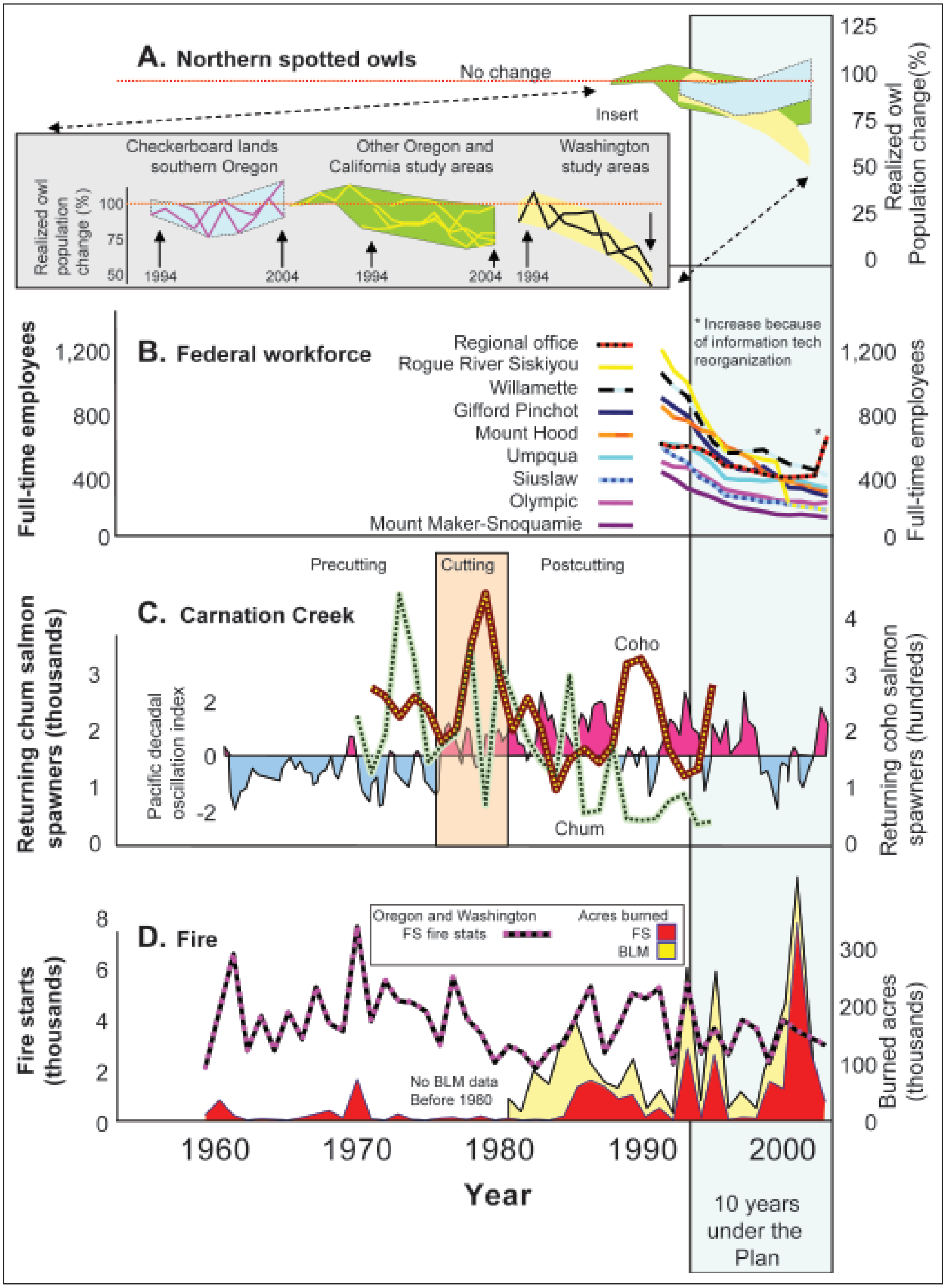

Figure 3-2—Fifty-year variability and change in (a) owl populations (the insert separates population groups; from Anthony and others, in press); (b) management capability expressed as workforce size (FS data); (c) fish populations, tree cutting, and ocean conditions (from Tschaplinski 2000); and (d) wildfire starts and Forest Service (FS) and Bureau of Land Management (BLM) combined burned acres in Oregon and Washington (Forest Service data). Missing data from early years was not collected or was not available.

a sample of 250 watersheds; Gallo and others 2005), and a small number of riparian roads were decommissioned. The quality of aquatic habitat, defined by these factors, therefore improved in the 1990s. Issues arise with a more indepth analysis (see chapter 9). For example, although direct funding for road maintenance has remained fairly steady, lack of surface replacement funds from timber sales resulted in an estimated 70 to 80 percent shortfall in needed resources for basic maintenance.[3] Unfortunately, no long-term data on fish populations are available in the Plan area to verify that habitat and populations are empirically well linked. The closest, most reliable data come from the Carnation Creek study on southern Vancouver Island (fig. 3-2c), where fish were monitored before and after 41 percent of the watershed was harvested. Clearly, returning salmon populations have high short-term variability making trends difficult to discern. As more is learned about controlling mechanisms and their interactions and variability—including ocean conditions—the emerging story is that stressors and populations are highly dynamic so that fluctuations cannot be attributed with much confidence to single causes, such as forest harvesting (Tschaplinski 2000). Extrapolating the Carnation Creek evidence (significant negative correlation of tree harvest to returning chum; little correlation to coho) across entire regions is likely further confounded by the type and extent of harvest, the local geomorphology, and many other factors. Research and monitoring may help us to better understand these assumptions and better anticipate new mechanisms, such as instream food availability, long-term disturbance effects, delayed effects, and factors limiting salmon during population dips. A network of more controlled management experiments, with aggressive treatments and taking perhaps 20 years, is likely needed to substantially improve our understanding to better manage these resources. Many partners will be required and institutional barriers overcome to accomplish this task.

[3] Personal communication. Michael Furniss, Redwood Sciences Laboratory, 1700 Bayview Drive, Arcata, CA 95521-6013.

Two young spotted owls.

The federal-land acres in Oregon and Washington that were burned in wildfires increased dramatically in the early 1980s—relative to the 1960s and 1970s—although the number of fire starts appears reasonably steady (fig. 3-2d). The recent increase in wildfire is widely thought to result from fuel accumulation, caused in part by fire exclusion (see chapter 6). A broad look at the wildfire evidence provides insights into the difficulty of associating change with specific management actions. Uncertainties arise from numerous interacting factors, statistical interpretations, and temporal perspectives. For example, the disconnect between starts and area burned is obscured by the interactions of increased fuel, weather, ignitions, and fire-response capacity. Although the average acres burned during the Plan decade increased, compared to the decade before the Plan (1985 to 1994), the confidence intervals around these averages strongly overlap.[4] When the historical record is extended from 1954 back to 1916, new conclusions emerge, such as that recent wildfire acres are actually less than those observed from 1916 to 1945 (fig. 3-3). Looking further back, wildfires in the first 15 years of the 20th century in Oregon and Washington have been reported to be quite low

[4] Rates for the Plan decade are 1.7 times those of the decade before, but the 95 percent confidence intervals strongly overlap (a valid, simple statistical test is not possible because of the likelihood that autocorrelation in the time-series data would increase or decrease the variance estimates). Further, this increase disappears when the 2002 fire year, with the 500,000-acre Biscuit Fire, is not considered.

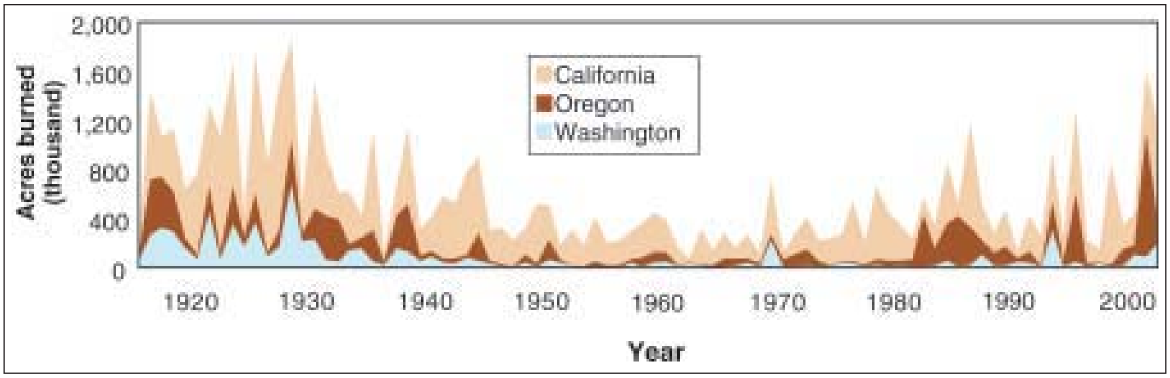

Figure 3-3—Estimates of total acres burned in wildfire on all ownerships from 1916 to the present, divided among Washington, Oregon, and California. Note that California data mostly come from fires outside the Plan area. Data compiled by David L. Peterson, Pacific Wildland Fire Sciences Laboratory, 400 N 34th St., Suite 201, Seattle, WA 98103.

(although the data are less certain), and changes appear related to shifting climate—leading climate modelers to theorize that wildfire is driven substantially by climatic shifts (McKenzie and others 2004). The distribution of wildfires may be shifting as well. Although wildfire rates are close to that expected for the entire Plan area, most of the fires were in the drier provinces (see chapter 6).

The only data we found that reflect the long-term capability of agencies to carry out the complex directives of the Plan were budget and personnel data dating back to 1990 (fig. 3-2b). Reductions in USDA Forest Service (FS) personnel were steep, beginning some time before the Plan started. Numbers of BLM personnel were much more stable. These changes in capacity are likely related to the other changes (Charnley and others 2006) but evidence of direct connections are difficult to find.

Some patterns under institutional control (for example, FS employee numbers) appear to have less short-term variability than market-driven factors like stumpage price. Patterns influenced by the broader economy, such as housing starts, harvest on industrial lands, and wood-products jobs have intermediate variability. Patterns influenced by natural processes, such as fire, ocean condition, and animal populations, appear most variable. People's lack of control over dynamic natural processes will continue to challenge institutions.

Richard Haynes

Timber harvest in the Pacific Northwest declined, but lumber production for domestic markets increased, mitigating employment declines

Patterns in some outcomes clearly rise above the inherent noise of their short-term variability, but few can be cleanly linked to the Plan itself. Looking at these patterns together, eight changes are most notable (table 3-2). Other smaller changes are clear, and perhaps no less important. The perspectives gained from available long-term data on outcomes (effects) suggest that the Plan is but one of many interacting processes (causes) at play. An important lesson from the Plan monitoring is that simply monitoring effects without learning about their causes will not offer much guidance when outcomes turn out to be undesirable.

Table 3-2—Big changes in the last 50 years, descending in magnitude (from variables displayed in figs. 3-1 and 3-2)

Outcome	Observed change	Pattern as related to the Plan
Older forests	Loss of older forest stands in the last 5 years is less than 5% of the late 1980s peak losses.	The decline in loss began 5 years before the record of decision (ROD) was signed.
Wood production	Production in the last 5 years is less than 10% of the late 1980s peak.	Production is shifting to thinning of young stands in reserves.
Wildfire	Acres burned 1950 to 1980 were about 10% of burns 1980 to the present.	Long-term trends and variability obscure direct relation to Plan.
Returning chum salmon, Carnation Creek	Returns in the mid-1990s are about 20% of the mid-1970s returns.	The variability, location, ocean changes, and cutting intensity do not relate well to the Plan.
Capacity, using FS employee numbers	Forests now have 30 to 40% of the permanent employees in 1990.	The decline began at least 5 years before the Plan.
Owl populations in Washington	About 60% of owls are left at present, compared to 1993.	No pre-Plan data are available to make any inference.
Douglas-fir stumpage prices	Prices before 1990 were about 65% of prices during the Plan decade.	Prices appear related to regional timber production.
Regional wood-products jobs, all ownerships	About 70% of jobs remain at present, compared to the peak in 1980.	A steady decline started in 1980 and continues through the Plan decade.

Considering Other Issues and Emerging Perspectives for the Next 50 Years

Our review of regional monitoring and recent research was not intended to be comprehensive or to provide much information about emerging issues. So next, we seek to make monitoring more useful to future management direction by interpreting the results from monitoring and research in a broad context (above) to reveal crosscutting perspectives (below).

Our Evolving Understanding of Science-Based Management

The Plan in the past decade has often been looked upon as a model for large-scale ecosystem management (see Busch and Trexler 2003, Johnson and others 1999, Sexton and others 1999), and it will likely continue to do so. Specifically, the Plan has influenced discussions on the role of science, the role of assessments covering broad geographic areas, sustainability of ecological and social processes, and the need for multijurisdictional and adaptive-management approaches. We hope the experience we are describing in this 10-year interpretive report continues to contribute to the broader debate. In this section, we examine how the experience with the Plan has shaped our understanding of some of the issues surrounding managing complex ecosystems.

Role of federal lands—

Keeping changes on federal land in a holistic ecosystem perspective is important. For example, Oregon published a state-of-the-environment report (Oregon Progress Board 2000), where they concluded that:

> The greatest opportunity for improving Oregon's environment in this generation occurs on lands that Oregonians control: on state, county, and private lands. Much of what potentially can be achieved on federal lands is already reflected in new policies and plans for managing forest and range lands. Private lands have become increasingly important to solving many of Oregon's environmental problems for this generation.

Placing the federal lands in context with private timberlands in meeting Plan intentions is also important. The impression that federal lands can solve the significant issues that led to the Plan is false. Federal lands are only part of the solution toward achieving broad societal goals such as conserving biodiversity, maintaining forest productivity, or maintaining and enhancing socioeconomic benefits to meet societal needs (table 3-3). New cooperative relations between federal and other landowners might be expected in the future.

Many people believe that Oregon, Washington, and northern California have a better state of the environment than many other states or countries around the world. Thus, one interpretation is that the federal lands in the Pacific Northwest represent the best of the best. "Saving the best" is a legitimate approach, albeit perhaps with different consequences than "fixing the worst."

Complexities of multiple scales—

The evidence from monitoring and research affirms that ecosystems are changing in complex ways and are rarely constant in time or space. The area covered by the Plan—established to follow the range of the northern spotted owl—includes 12 distinct provinces classified by their differences in climate, vegetation, geology, and landforms. Designers of the Plan recognized this variability and included options for modifying standards and guidelines even as they attempted to develop regional direction for the sake of efficiency. One of the Plan's biggest challenges was and is how to implement a regional vision, one local project at a time. Several issues deserve discussion.

Midscale transitions—

In reviewing the Plan's first decade, we have observed some potential gaps in the spatial scale of planning and activities. For example, many acres were thinned to meet regional needs such as owl habitat, fuel reduction, and timber production, but how much landscape thinking went into those activities is not clear. Many ecological and social processes are only important at the middle scales of provinces, larger watersheds, and diverse landscapes; for example, in dry provinces, meeting owl habitat needs and reducing the risk of high-severity fire. Midscale analyses are intended to help make the transition between scales, by being more spatially explicit and more site specific than regional plans. Midscale analyses could also play a role in defining monitoring needs at this scale, helping to develop a hierarchy of information. The opportunity exists to make the next round of forest and resource unit plans facilitate both management and monitoring activities across this hierarchy.

Site specificity—

Substantial knowledge of local conditions and the flexibility to respond to this understanding are not optional in multiscale management. Regional standards and guidelines—for example, 10 down logs per acre—enforced everywhere fail to take advantage of the critical knowledge of local agency specialists. Local adjustment processes (for example, to change riparian buffers and to allow active adaptive management) had mixed success for a variety of reasons. Site specificity is not possible without such processes. The concept of site specificity is highly developed in silvicultural research and practice. For example, Hawley (1921), when discussing the reasons so little was known about silviculture, noted that "... silvicultural practice is

Table 3-3—How older forests, habitat, and timber harvest are distributed between public and private lands as a percentage of area over the Plan area

Ownership	Older forests	High-quality owl habitat	High-quality murrelet nesting habitat	Timber harvest
			Percentage	
Federal and state	77	59	50	15
Private	23	41	50	85

Note: see chapters 5 through 7. Data represent 2000-2005

essentially a local consideration, varying in important details from forest to forest." This observation remains true today. Scientific inference to complex goals across complex terrain remains limited. For example, research ecologists often develop general hypotheses and can rarely test them in many locations, and research silviculturists have a tradition of testing hypotheses in locally unreplicated blocks, often on accessible, gentle terrain. Only the local agency specialists can think about how well these ideas will work in specific sites. Multiscale managing could come to terms with this disconnect. We are concerned that sharp reductions in field personnel may limit understanding of site specificity and hence the successful merging of general principles with local knowledge.

Challenges of managing complex systems with simple rules—

One of the biggest challenges of ecosystem management is the complexity of its application. The uncertainties arising from multiple dynamic processes playing out over an initially variable landscape are large, and they cannot be easily dealt with by overly simplistic strategies developed to be efficiently applied. The concepts of land-use designation, boundaries, and best practice are involved.

Bruce Marcot

Although heart rot fungus is not desirable in trees grown for timber, it can create hollow standing trees and down logs, which are important habitats for many species of wildlife including swifts, pileated woodpeckers, fishers, raccoons, bobcats, coyotes, and black bears.

Dynamic forests and fixed management boundaries— When the FEMAT options were developed, scientists knew that the landscapes of the Pacific Northwest were dynamic at all scales. Incorporating this dynamism into a 100-year plan with mapped land-use designations was a major challenge. Many old-growth forests in the region required centuries without high-severity fire to develop, and others required low-severity fire every 20 years or so. Although fixed land-use designations—reserves and matrix—formed the basis of the Plan, the hypothesis was that Plan goals could be met despite the disturbance and succession that would alter the structure and composition of the forests in those designations. The Plan anticipated that silvicultural activities were needed in many of the biodiversity-oriented reserves (80 percent of the federal lands), as well as the timber-production-oriented matrix lands (20 percent of the federal lands). The chosen boundaries were strongly influenced by the patterns of existing older forest, but also by a vision of a future, altered distribution of forest conditions, designed to better meet Plan goals. This reserve-matrix strategy has not been tried before at this scale; thus, the long-term success is by no means assured. Continuing to evaluate the strategy, as well as reasonable alternatives to it, would be wise. Based on only one decade of evidence from monitoring and other sources, we cannot say whether a different spatial arrangement of reserves and matrix would have been more or less effective. We also cannot say with confidence, at this point, whether another management option—such as FEMAT option 1 or 5—would have produced a different outcome. Given the large Plan area, and slow changes in forest conditions, alternatives that may result in different outcomes at 100 years may appear relatively similar in the early decades.

Midscale assessment of the consequences of the current pattern of reserves and matrix allocations—where changes to boundaries or activities in designations were considered—was rare while the Plan was being implemented. Given the threats from high-severity fire, insects, disease, and uncertainties about reaching desired outcomes in the dry provinces, we see reasons to reexamine the mid-scale designations in these provinces, not only from the standpoint of boundaries, but also from the perspective of the kind and intensity of active management needed in all land-use designations to better reach the goals of the Plan. This debate includes the boundaries of adaptive management areas. Should these boundaries change in response to their effectiveness or changing ecological or social conditions? The areas were chosen for a variety of reasons, not strongly considering regional and local institutional capabilities or how well they represented broader areas (Stankey and others 2003a). Some of the more successful adaptive management projects happened outside of the adaptive management areas (chapter 10).

With few differences between how reserves, matrix, and adaptive management areas were implemented, whether land-use designation makes sense seems to be an appropriate question. Perhaps a strategy that just sets goals for protecting old forest and providing some commodity production for local communities, without drawing lines on a map, would have been equally effective—assuming that society could grant this much flexibility to federal agencies.

Challenges of managing under high uncertainty— When all of the evidence is examined, several questions come to light: How well do we know and can we know these systems? How well can we attribute the various outcomes to the Plan itself or, for that matter, to the Plan's implementation? How can planning and managing respond to large uncertainties?

Across all perspectives, evidence of uncertainties and their effects is considerable:

- Spatial variability in the Plan area is known to be large, driven by variation in geology, climate, biota, elevation, and disturbance history (see Moeur and others 2005 fig. 11), which is why physiographic provinces were created by the Plan.
- Monitoring and other evidence exposed large year-to-year variation in owl and salmon population estimates, wildfire acres, stumpage prices, and ocean conditions.

- Some outcomes were surprises, such as owl population shifts, a 500,000-acre wildfire, various lawsuits, changes in the stumpage price, loss of the export markets and industrial infrastructure, community adaptations, retiree relocations, and major FS employee and funding reductions.
- New mechanisms were hypothesized in various chapters, including effects of barred owls and wood rats on spotted owls, different watershed dynamics in larger watersheds, and ecological importance of disturbances and native, early-successional pioneers.
- More complexities were recognized, such as large local variation in fire history, and the need to treat mixed-severity regimes differently.
- Unforeseen future trends also came to light, such as long-term changes in seral-stage distributions, not recognized before (chapter 6).
- Improvements in habitat models were not sufficient to substitute for direct monitoring of population changes.
- The effects of climate change on species and ecosystems in the next decades are potentially large, but also uncertain.

The conclusion that uncertainties are high is supported by recent developments in ecology. Ecologists are increasingly stressing the uncertainty associated with ecosystems and their dynamics (Hubbell 2001, Lande 1991, Lemons 1996, Ludwig and others 1993, Shaffer 2000). As a consequence, both scientists and managers have to contend with uncertainty more than ever and, perhaps, more than they would like. Implications extend to the Plan (Bormann and Kiester 2004).

Clearly, both FEMAT (1993) and the Plan authors recognized high uncertainty in the assessments themselves by invoking adaptive management, adaptive management areas, monitoring, and riparian adjustments as ways to change course as more was learned. Implementing this strategy to respond to uncertainty, however, showed mixed results (chapter 10). Thus, reflections on the magnitude of uncertainties and how to implement strategies to respond to them are both needed. This debate is not limited to forestry. For example, the business management literature uses a term "environmental uncertainty" (extent of unpredictable changes in the external environment, Buchko 1994). A major debate continues on the need for changes in strategy and planning when companies face high uncertainty, such as shifting international trade and manufacturing patterns (Galbraith and Kazanjian 1986). The theory states that decisionmakers operating in highly uncertain environments will adopt a planning process consisting of comprehensive data collection, systematic data evaluation, and decision-making based on analytic outcomes, and managers operating in predictable environments are more likely to rely on experience (Dean and Sharfman 1996). Forest management under the Plan is clearly based on substantially uncertain ecological and social processes; thus, new approaches to planning may be needed to better adapt to changes. The business model suggests that planning could be better based in adaptive management, monitoring, and evaluation closely linked to decisions. Agencies appear to be starting down this path.

In this uncertain environment that Plan implementers are managing in, how they respond to uncertainty is more important than how much uncertainty exists. We offer two strategies to consider: improved, systematic adaptive management and monitoring; and diversified practice.

Systematic adaptive management—

In many attempts under different conditions, adaptive management often is disappointing (Walters 1997). The Plan efforts are largely no different (chapter 10). The institutionalizing of regional monitoring and this mandated, 10-year report does, however, represent major steps forward. Adaptive management was viewed as a cornerstone of the Plan, largely as a mechanism to deal with recognized uncertainties. No alternative to moving forward with developing and implementing an improved adaptive management and monitoring system has emerged. A systematic and fully institutionalized approach could make Plan implementation more dynamic by increasing the rate of learning through a balance of regional monitoring and management experiments on or off the adaptive management areas (fig. 3-4). A systematic approach could be driven by a small set of corporate questions, geared to focus learning activities, and periodic interpretive steps to integrate disparate knowledge sources in broader and longer term perspectives. Monitoring, management experiments, and periodic interpretation steps would be driven by forward-looking questions because of the time needed to detect changes in complex forest systems. Annual interpretative workshops could help institutionalize adaptive management and respond to the dynamic nature of our understanding by considering changes in approaches to better meet longer term learning objectives. The path is clear to move from opinion-based toward evidence-based interpretation of the vital questions about federal forest lands. We can be optimistic, with strong leadership and a professional focus, that adaptive management can be implemented to bring together managers, regulators, researchers, field specialists, and multiple constituencies in a dialogue more constructive than the current debate. Adaptive management and associated monitoring can be refocused on preparing for future interpretive reports by refining the questions future managers may face.

Diversified practice—

A concept not well appreciated in early versions of ecosystem management is diversifying approaches to spread risks. The concept of diversified practice in response to high risk and uncertainty is simple on the surface: just do not put all your eggs in one basket. Why diversifying is important and how to apply it are much less clear. Putting all eggs in one basket is a risk especially where outcomes are fraught with surprises. Diversified investment portfolios also help illustrate the problem—successful portfolios spread the risk of failure across fundamentally different investments (such as stocks, bonds, and real estate), so that if one type of investment fails another is not likely to follow, thus evening out large fluctuations. Similarly, risk is lessened in forest management when multiple valid

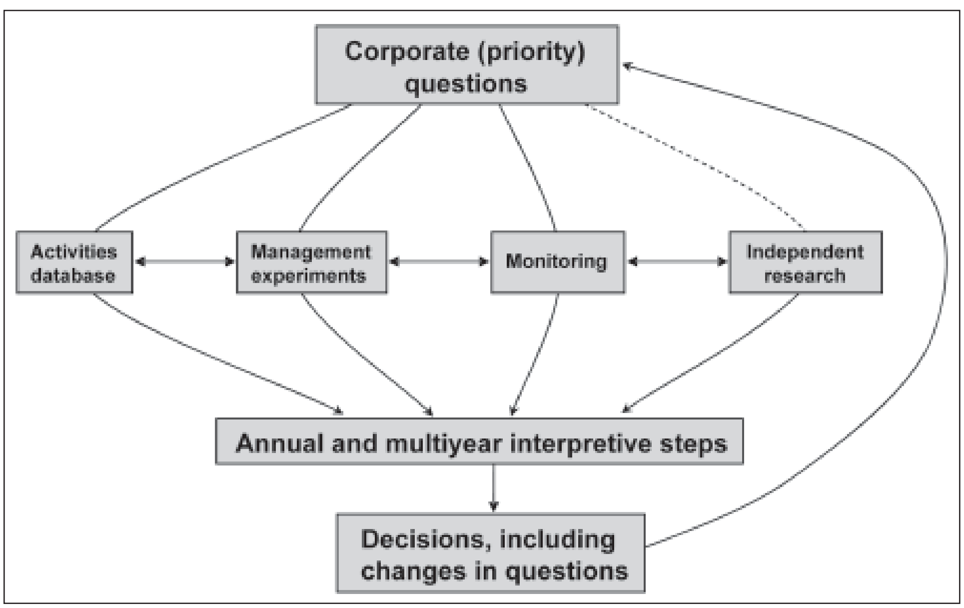

Figure 3-4—A conceptual model for more systematic learning, where corporate questions drive various learning activities that feed into interpretive steps facilitating decisions on whether course changes are needed, as well as on whether to revise the questions.

Best Practice Versus Diversified Practice

Best practice and diversified practice in some ways are genuinely contradictory. A best practice is typically defined when researchers and managers agree on the effects various practices will have on the ecosystem and can choose the single practice ranked best. This choice does not mean that the practice will prove to be the best—after all, taking logs out of streams was once a best practice, as is putting them back now. Diversified practice makes sense either when consensus cannot be reached or when scientists agree that the existing evidence is insufficient to distinguish between alternative hypotheses with confidence. Under these circumstances, ranking practices does not make sense, and in the spirit of not putting all of your eggs in one basket, managers can logically decide to take multiple approaches. When uncertainty is high, diversified practice follows from, and is consistent with, the well-known scientific method of multiple working hypotheses (Chamberlain 1897).

An example: How could forests and salmon habitat be managed to sustain salmon populations? Our understanding of the mechanisms by which forest stream habitat condition affects numbers of salmon is not well developed. We know watersheds vary in important ways and that many factors affect population numbers. We can certainly say that salmon spawning and rearing habitat is necessary, but not sufficient, for salmon populations. Beyond that, more quantitative relations have proved elusive. Is this a failure of the scientists to solve a research problem? No, the problem is simply too complex and too variable to admit easy answers. Does this mean that the appropriate philosophy of science here is the method of multiple working hypotheses? Probably so. These, then, are issues in the conduct of science that may also be relevant input for managers.

approaches to achieving an objective are simultaneously applied. Risk tolerance can be expressed by allocating space to various approaches, which in turn affects the magnitude of the gains and losses. Diversification does not mean adding new objectives in a land-use designation to be achieved by a wide variety of approaches, nor does it insist that widely unacceptable approaches be included. It simply means that the uncertainties are often high enough to warrant trying multiple creative approaches at the same time in the same land-use designation. The Plan did not prohibit such variability, and the Plan also did not encourage it. Clearly, this new paradigm will need to overcome best-practice inertia, and will need to be clearly articulated to regulatory agencies and the courts.

Importance of planning language—

During the 1990s, we have seen concepts and associated terms developed by scientists used generically in societal debates about natural resource management. What scientists often thought to be technical issues became determinants of public opinions. As all concepts mature, many definitions gain clarity; some remain ambiguous by design; and some appear misleading. Herman Daly speaks about the roles of vagueness and clarity in language (Daly 1996):

> While not vacuous by any means, the [World Bank] definition [of sustainable development] was sufficiently vague to allow for a broad consensus. Probably that was a good political strategy at the time—a consensus on a vague concept was better than a disagreement over a sharply defined one. By 1995, however, this initial vagueness is no longer a basis for consensus, but a breeding ground for disagreement. Acceptance of a largely undefined term sets the stage for a situation where whoever can pin his or her definition to the term will automatically win a large political battle for influence over our future.

One lesson from the Northwest Forest Plan is the importance of communicating clearly and frequently.

Here, we examine how some terms have matured and how they may affect the future of the Plan.

"Old growth" is no longer just a forestry or ecological phrase—it has grown into a highly value-laden phrase (Helms 2004, Spies 2004). Some of the more recent uses—forests that lack a history of management and forests with trees older or larger than trees found in plantations—now have little scientific basis. At the same time, forest ecology has advanced to recognize the complexity and variability in all forests, including old growth (see chapter 6). The older forest monitoring module (Moeur and others 2005) accommodated multiple perspectives by analyzing a range of potential definitions. This step is important in facilitating a more informed and connected debate.

Management objectives have sometimes included ambiguous terms to describe intent and rationale. We have seen this practice backfire during the first decade of the Plan. "Forest health" was cited as the major need in many environmental impact statements (EISs) implementing the Plan on matrix lands, rather than timber production (for example, on the Eagle Creek EIS in 1996 on the Mount Hood National Forest; Franklin and others 2001). Forest health, to agency silviculturists, meant thinning to reduce insects and disease, perhaps reduce fuel load, and to promote growth of residual trees; it meant natural progression toward older forest to some people; and others thought a healthy forest was one without human intervention. The lesson, however, is that using "restoring forest health" as a cover for Plan-directed timber harvest in the matrix is not acceptable to the public. We suggest that simple direct language will also help us to write better, shorter National Environmental Policy Act (NEPA) documents that clearly explain proposed direction by connecting rationale and evidence to decisions.

The phrase "adaptive management" was used extensively in the Plan with varying perceptions of success, including some critical reviews in the scientific literature including titles like, *Adaptive Management and the Northwest Forest Plan: Rhetoric and Reality* (Stankey and others 2003a). Much of this variation arose from the lack of effort to forge a common definition or understanding of the concept. That monitoring and adaptive management were considered separate activities initially points to conceptual confusion as well. We sought to more clearly portray a vision in the adaptive management and monitoring (chapter 10). More work is ahead.

The term "reserve" was chosen in the Plan to describe late-successional and riparian land uses that included some active management. Confusion arose from at least two sources. Reserve was not used to describe the matrix allocation or the adaptive management areas where even more-active management was planned. Reserve also sounds a lot like preserve, often used in association with wilderness and park lands. The term has a long and varied history and is now defined by international consensus to encompass both active and passive management (see chapter 6). Changing to a name without a double meaning would not be sufficient without the effort to clearly define and widely articulate what the land-use objectives are.

Lastly, we would like to clear up what is meant by the "Plan." To the public, much of what we describe sounds like a single overarching document that sets the context (and direction) for managing federal forest lands. But land management planners taking a NEPA-centric approach argue that no single plan exists; rather, it is a document that amended 24 forest and district plans.[5] This view suggests that we take care in how we represent future planning efforts if we want to avoid conflict with broader public perceptions.

Timber harvest protesters.

Issues of trust—
The implementation of the Plan has been slowed by a lack of trust between various citizen groups and land managers. Mistrust arises from questioned intentions, lack of clarity, unwarranted certainty in the debate, and differences between promises made and promises kept. Other forms of mistrust are more rooted in beliefs and social discord. People often have difficulty accepting the intent, objectives, or approaches presented by polar groups. Some of the adaptive management areas were able to assemble diverse stakeholder groups and, through personal interaction, come to consensus on controversial projects that were then opposed by national organizations (Stankey and others 2003b). Trust has a difficult scaling dimension—trust is or is not given at multiple, sometimes independent scales.

Key in this next decade is attending to the factors and processes that can enhance trust between and among people and organizations (Stankey and others 2003b). In the science community, we need to avoid presuming that trust is equivalent to high statistical confidence and association. On the management side, consider how trust can contribute to developing and implementing land management plans, to helping groups (networks) form, to engaging them in the process—including assistance in defining the range of acceptable options and the basis of compromise—and to developing public understanding and support. This last aspect is critical because, as Stankey and others (2003c) have argued, without public understanding and support, the political legitimacy and capacity of management agencies to act effectively is in doubt.

Uncertainties about ecological and social processes and institutional capacities could be articulated more openly and clearly than they have been in the past—in planning and decision documents—to manage expectations; a range of outcomes rather than a single outcome would often be more in line with what is known. Convincing people that managing ecosystems for complex resource objectives has considerable uncertainty should not be difficult; after all, if a plan—as ambitious and complex as this Plan is—has never been implemented before, why should people expect great certainty in whether it will or will not work well? Building institutional capacity focused on learning that connects to multiple constituencies may be an important way to build trust. This trust building appears to be happening in the Five Rivers project on the Siuslaw National Forest. After a 12,000-acre management experiment contrasting ways to manage plantations to achieve late-successional and riparian objectives was enjoined, along with many other projects in coastal forests in 1997, the environmentalist plaintiffs, after learning of the project,

[5] Personal communication with senior managers group (informal interagency committee).

asked the court to remove it from the injunction, and the court agreed—even though substantial commercial timber volume was to be sold. Forest industry interests have also enthusiastically supported the project even though it includes significant areas where thinning will not be allowed. Whether such trust-building can happen at larger scales remains unclear.

Bringing Science and Management Together

Integrated management strategies—
Any interpretation of monitoring results and new science cannot be applied without some concept of potential future directions managers might take. The role of science is to inform decisions about those directions. Here are several examples of possible future direction, mainly to illustrate how science and policy may be integrated. But first we need to recognize again that science is only one factor influencing decisions about how to manage federal land. Many people think the Plan is about saving old growth while maintaining lower timber harvests. A careful reading of the original list of the President's principles suggests a more complex set of goals, including economic, ecological, legal, intergenerational, organizational, and perhaps even emotional elements:

- Never forget the human and the economic dimensions.
- Protect the long-term health of our forests, our wildlife, and our waterways.
- Be scientifically sound, ecologically credible, and legally responsible.
- Produce a predictable and sustainable level of timber sales and nontimber resources.
- Make the federal government work together and work for you.

National forests and BLM districts are expected to provide recreation, aesthetic landscapes, hunting and fishing opportunities, firewood, wilderness, special forest products, and many other values not addressed explicitly in the Plan but specified in forest and district plans. Legally, the Plan is an amendment to these plans that deals with a limited range of societal objectives thought to be met only through regional oversight.

Managers understand that scientific information is rarely well integrated in support of their complex management objectives. Fragmented knowledge coming from different disciplines may lead to artificially fragmented approaches, each geared to a specific problem. Managers of federal lands respond to meet multiple public values, but values cannot be efficiently addressed one at a time. Management efficiencies can be found when multiple values can be met together—although not necessarily at the same time or place—which is easier said than done.

In effect, managing federal forests can be thought of as a strategy of strategies, seeking to meet a blend of societal objectives by applying the broad scientific understanding of how to achieve those objectives combined with local on-the-ground experience and knowledge, and within institutional capacities and constraints. Flexibility is the key because all of these factors change through time. The chapters on policy context, socioeconomics, and adaptive management touch on some of the complexities and uncertainties other than those associated with scientific understanding of forest ecology. The dynamics of these social processes have strong similarities with the dynamics of ecological processes discussed in the older forest, species, and aquatic chapters. The full appreciation for the difficulty of the job is understood when the interactions of all of the social and ecological processes are combined.

Examples of integrated approaches—
We develop and discuss a range of potential approaches to pressing issues, to think about how science and policy might be better integrated. These approaches are necessarily vague and incomplete; our discussions are not a scientific assessment of them. The scenarios simply provide a way to think about the integrative problems managers face. The discussion represents the kind of debate that will likely lead to wise policy.

Salvage logging in late-successional reserves—
Salvage logging in late-successional reserves—a contentious issue in implementing the Plan—is a good example of the complexities of the science-policy interface, and the limits to which science can guide management. The Plan allowed for "some" removal of dead trees from late-successional reserves to meet additional nonecological objectives (USDA and USDI 1994):

> Salvage guidelines are intended to prevent negative effects on late-successional habitat, while permitting **some** commercial wood volume removal. In some cases, salvage operations may actually facilitate habitat recovery. For example, excessive amounts of coarse woody debris may interfere with stand regeneration activities following some disturbances. In other cases, salvage may help reduce the risk of future stand-replacing disturbances. While priority should be given to salvage in areas where it will have a positive effect on late-successional forest habitat, salvage operations should not diminish habitat suitability now or in the future.

With our current state of knowledge, ecological science cannot help much in determining what "some" means and in determining at what rate or extent salvage removal would diminish habitat suitability (see chapter 6). For example, although we know that large dead trees have many ecological functions in postwildfire stands (Lindenmayer and others 2004), we cannot predict how species composition and ecosystem function will change over the long run when only some of the commercially valuable dead trees are removed, leaving various amounts of snags and downed wood. Furthermore, only managers can decide how to weigh the tradeoffs between the uncertain ecological effects and known economic benefits of commodity production from salvage logging. The issue is further complicated by the fact that timber receipts from salvage logging FS land can be used for other fire recovery efforts, such as planting, replacing culverts, restoring trails, reducing fuels, and monitoring. A guiding principle of the Plan was to provide for legally sufficient protection for species and ecosystems and, having done that, to provide for economic and social well-being. This tradeoff was well specified in the record of decision by designating reserves and matrix. Only a few situations remained where managers had some options for additional weighing of ecological and economic values—salvage logging in late-successional reserves is one of them. The pro- and anti-salvage arguments—articulated by different groups of researchers after the Biscuit Fire (for example, Lindenmayer et al. 2004, Sessions and others n.d.)—reflect the scientific uncertainty, multiple interpretations of Plan nuance, and disjointed societal mandates.

We see opportunities for incorporating more science into these decisions, nonetheless. We start by suggesting that learning about postfire management on late-successional and riparian reserves is important, given the uncertainties in how systems will respond to salvage over the long term. Risk of serious flaws in thinking suggests that rigorous comparisons be made between areas not salvage logged, allowing natural processes to unfold; areas with some salvage logging, attempting to speed older-forest recovery and pay for associated actions; and areas with innovative strategies, for example, prescriptions for frequent underburning. Large fires present an opportunity where, by applying active adaptive management (chapter 10), enough initially similar lands can be found for replicating these comparisons. We also see many important research needs, to retrospectively reassess responses of forested landscapes to past fire and salvaging, to explore the effects of disturbance on long-term productivity and biodiversity, and to study poorly understood patterns and processes like the long-term roles of wood and pioneering and invasive plants.

Managing fire-prone forests—
The older-forest and species chapters present a rationale for substantially increasing and repeating fuel treatments over large areas in the drier parts of the Plan area, as a way to maintain important habitat. A new fire regime (mixed

severity) has been identified, and studies have shown that fire histories are more related to local terrain, vegetation, and climate than thought before. The Plan carries mixed messages about how to set priorities among fuel reductions on one hand and maintain owl habitat and avoid Endangered Species Act (ESA)-defined losses (take) on the other, and different scientists emphasize different messages. An active scientific debate is ongoing about the best ways to reduce the spread of severe fire over diverse landscapes. Managers are left with multiple understandings from science, multiple interpretations of Plan language, and not much on-the-ground experience in applying frequent low-intensity fire in these forests. They are also left with the reality that funds to reduce fuels are lacking and court rulings are unpredictable. And they are presented with national priorities to reduce dangers to local communities, as well as to meet other regional and local priorities. Again, the decisions managers make are only partly based on science. The feasibility of managing fire-prone national forest land lies, in part, in whether revenues can be generated in thinning sales to pay for uneconomic thinning, mulching, underburning, planting, and other needs. A major challenge in learning how to reintroduce frequent, low-intensity fire also exists, as does finding alternatives in areas where smoke violates the Clean Air Act. Potentially disconnected needs also require attention, such as maintaining roads and access for economic fuel reduction and for fighting future fire—and decommissioning roads to improve riparian habitat.

We see opportunities to reinvigorate multiscale analysis and management to approach this problem. Multiple interacting objectives are involved, such as protecting life and property, facilitating control of future fires, maintaining suitable habitat for owls and other species, facilitating recreation and hunting, increasing local employment, improving aesthetics, supplying firewood, and many other multiple-use objectives detailed in the local forest or district plans. Multiple interacting patterns and processes are also involved, such as current vegetation; variance in fire regimes; distributions of habitats, populations, and roads; places where backfires might be set; other disturbances; and invasive plants, to mention a few. Each of these objectives and factors scale differently. Multiscale analysis could be developed to examine tradeoffs across the full multidimensional objective-process space. Midscale analyses are central because most tradeoffs are between the regional and local scale. Midscale analyses are intended to help make the transition between scales by specifying approaches for sites to best meet broad-area objectives. Results from regional assessments could be incorporated into midscale analyses to provide context and identify possible issues at this scale. With midscale analyses in the dry areas where the risks to maintaining the ecological functions of reserves is high, considering how the Plan land allocations might be modified to better deal with these highly dynamic landscapes may be necessary. Such modifications need to be considered in light of landscape management strategies and deviations from expected Plan outcomes.

New approaches to managing fire-prone forests could better accommodate the uncertainties identified. For example, in dry forests near towns where fuel reduction is a priority, a range of fuel reduction methods might be tried. Because these communities have real concerns for their safety, they may be more willing to get engaged in a management experiment to rigorously compare alternate methods that they can help to develop and implement. They may also oppose lack of action as one of the methods compared. Management experiments that only include alternative fuel-reduction methods, without a no-action method, will produce valuable information nevertheless. Fuel reduction trials would be a great place to involve the regulatory agencies as full partner in the design and monitoring.

Managing for a distribution of seral stages—
The Plan was created to solve the problem of declining old growth, with the underlying issues of owls and biodiversity in general. Recent projections suggest that, by 2050, older

forests will occupy 75 percent of federal lands in the Plan area, up from 45 percent today (Mills and Zhou 2003). The consequences of a widening gap in ecological condition are poorly understood. Natural disturbance regimes have been used to justify policies seeking to increase older forest on the landscape. Yet those same studies also indicate that landscapes in the Plan area were not completely blanketed by older forest (Nonaka and Spies 2005); in fact, many areas were a complex of young and old forests, with the mixture varying across multiple spatial and temporal scales. As research on the owl in the southern part of its range suggests (Franklin and others 2000), landscapes with a blend of old and diverse early-successional forest may be better for native biodiversity than landscapes dominated by only older forests. Although private and industrial lands will likely continue to have a preponderance of young, managed plantations, diverse early-successional communities may become underrepresented. Vegetation management is very effective at shortening the time and space for pioneers, whereas natural succession often has a prolonged period when pioneer plants and their associates dominate. Many of these pioneer plants are known to control important processes affecting long-term soil productivity and biodiversity.

If a diversity of successional stages at broad spatial scales is desirable for maintaining native biological diversity, then the question becomes: Does the Plan provide for that diversity? Of course, natural disturbances, such as fire and insect outbreaks, will create diverse early-successional conditions in the Plan area. In the moist provinces and to some degree in the dry provinces, however, most high-severity fires will be suppressed, and the amount of diverse younger forests may not achieve what would have been expected under a natural disturbance regime. Consequently, creating some of this diversity in early-successional forest through active management might be desirable. The Blue River study (Cissel and others 1999) is an example of an alternative to meeting the goals of the Plan where active management was used to create a specified distribution and spatial pattern of successional stages across a federal landscape (this approach was actually intended to maintain mature-aged forest conditions and avoid a federal landscape with only young and old-growth stages). The state of Oregon is also trying to implement a variable-rotation-length approach that allows more timber production than on federal lands, while maintaining a portion of the landscape in older forest. A long-rotation approach, however, was initially considered by FEMAT scientists but rejected because of perceived high risk to terrestrial and aquatic species and ecosystems.

These different perspectives could be further developed into contrasting strategies that would be rigorously compared in large-scale management experiments. Involving people with different perspectives is essential and would allow creative approaches to coalesce and be seriously considered. We also see some opportunity to examine past management retrospectively to shed some light on these ideas.

Considerations

The current Plan course is the net result of the intersection of initial Plan objectives with the realities managers faced along the way. During the first decade of the Plan, we have concluded that the agencies did well, especially for biological objectives. Many expectations for timber production and adaptive management might have been overly optimistic, and perhaps were somewhat unreasonable. Better managing of expectations in the next decades is important. Budget reductions for federal agencies—especially the loss of funds from FS trust accounts, often from revenues generated from timber harvests—led to major reductions in permanent FS employees, which influenced agency capacity. Perhaps a timber program is required to meet the many other important agency functions—like keeping records, maintaining roads, and even providing for recreation and wildlife. We are also concerned whether minimal capacities are being maintained, such as the on-the-ground knowledge of the forest. The main question in the near future may be whether the current federal workforce can carry out the complex management strategies set forth in the Plan, and if such a workforce cannot be assembled, whether a different approach is needed. In the last few years of the Plan, managers appear to be dealing with these problems more successfully, especially with increased thinning volume from plantations in coastal late-successional reserves and fuller funding of and attention to a fully institutionalized and integrated adaptive-management and regional monitoring program.

Science from monitoring and research does not lead to specific prescriptive solutions. The evidence and its collective uncertainties do suggest that we cannot know for certain that another approach (for example, one of the other FEMAT alternatives) would have done better or worse than the approach applied, which is not to say that all approaches work equally well. In general, we think the goals of the Plan cannot be met by returning to the timber harvest rates in the mid-1980s or converting the FS and BLM lands into de facto national parks. The historical harvest rates would have quickly cut most old stands and impaired critical habitat for important late-successional and aquatic species, and continue to be unsupportable by current case law. Eliminating commercial harvest from the federal lands would not be in the interest of the timber-dependent communities or others, especially in fire-prone areas or forests requiring considerable institutional or financial resources to meet other objectives. Our understanding of ecological and social processes, their interactions, and their collective uncertainties suggests that a **range** of middle courses exists that is reasonably consistent with what we understand about how these forest ecosystems work. Middle courses might be found, not by more science, but by developing a new, positive vision of how the federal forests can meet diverse societal goals, rather than focusing on meeting regional standards and guidelines. Improving adaptive management and monitoring, risk management, and record keeping can increase the effectiveness of these middle courses and provide a more solid foundation for connecting to the diverse constituencies in the region.

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