September 20, 2024

Director, Ecosystem Management Coordination
201 14th Street SW, Mailstop 1108
Washington, DC 20250-1124

RE: Amendments to Land Management Plans to Address Old-Growth Forests Across the National Forest System, Draft Environmental Impact Statement

The American Forest Resource Council (AFRC) is a trade association representing mills, wood product manufacturers, loggers, and purchasers of public timber in the Western United States. Put another way, AFRC represents the customers and partners of the Forest Service. We have member companies in Montana, Idaho, Washington, Oregon, Nevada, and California. Our members' expertise, employees, and equipment—and the vast, complex product supply chain of the forest infrastructure they help create, maintain, and support—are essential to achieving the Forest Service's management goals and missions. The health and productivity of National Forest System (NFS) lands is paramount to the viability of our membership and the family-wage jobs and communities they support.

The organizations listed below represent businesses, communities, workforces, neighboring and adjacent landowners, and county governments from across the United States. Along with AFRC's members, they are on the frontlines of responsible forest stewardship and would be directly impacted by the Amendments to Land Management Plans to Address Old-Growth Forests Across the National Forest System (the proposed Amendment). Many signatories will also submit individual comment letters that should be considered by the Forest Service as complementary to the below comments.

We share many of the philosophical positions and perspectives outlined in the draft environmental impact statement (DEIS) for the proposed Amendment regarding forest management on NFS lands.[1] Like the Forest Service, we support maintaining and restoring the ecological integrity of terrestrial ecosystems across every successional stage of development, including old-growth. We also recognize the importance of proactive stewardship to protect all forest types, including old-growth, from the many threats that they face. However, there is an

[1] U.S. Dep't of Agric., Forest Serv., *Amendments to Land Management Plans to Address Old-Growth Forests Across the National Forest System, Draft Environmental Impact Statement* (June 2024), https://www.fs.usda.gov/project/?project=65356 (last visited Sept. 17, 2024) (DEIS).

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unreconcilable contradiction between these values, the known and documented threats to old-growth forests now and into the future, and the substance of the proposed Amendment as outlined in the DEIS.

Forest Service practitioners and their partners already face a maze of burdensome, inflexible, and confusing processes when pursuing active forest management on federal lands. The proposed Amendment's standards and guidelines, which are ostensibly designed to respond to threats by promoting and accelerating active forest management, will in fact make active management even more time-consuming, publicly contentious, legally vulnerable, and expensive.

Forest Service practitioners are currently constrained by a complex, multilayered stack of restrictive Land Management Plan (LMP) standards, laws, regulations, and court precedents developed over many decades that hamper the Forest Service's ability to effectively implement meaningful forest management. In short, Forest Service practitioners need existing obstacles *removed*, not added, to attain the level of active management that the proposed Amendment intends to enable. While the DEIS professes to "foster" and "promote" such management, it misses the mark by burdening Forest Service practitioners with *additional, restrictive* standards to navigate. Indeed, the DEIS clearly states that "the proposed action also sets forth standards and guidelines that provide constraints for decision making at the project-level." DEIS at S-7. It is puzzling that the Forest Service agrees that the agency must accelerate and increase active forest management to "protect" old-growth, but proposes a solution that constrains active management with more restrictions.

One example of the additional burden the proposed Amendment would put on Forest Service practitioners is the uncertainty it creates regarding old-growth identification. Researchers have stressed the need to define "old growth" based on context. For example, in a seminal research paper from 2012 by Drs. Norm Johnson and Jerry Franklin titled, *A Restoration Framework for Federal Forests in the Pacific Northwest*,[2] the authors identified a need to discuss and define "old growth" in Pacific Northwest forests in different contexts based on ecological processes largely driven by historical fire regime. The authors deemed it necessary to "divide [Pacific Northwest] federal forestlands into moist forests and dry forests because these contrasting environments require *fundamentally different policies and practices*, including approaches to old-growth conservation." Franklin and Johnson at 430 (emphasis added). Those "fundamental differences" manifested as profoundly different approaches to how old-growth is characterized—namely, the difference between managing for "old trees" versus "old stands." The authors state that "management of old trees and stands would vary as a function of forest type." *Id.* at 432.

This document has influenced the current management paradigm on NFS land governed by the Northwest Forest Plan (NWFP) and largely served as the blueprint for the Bureau of Land Management's (BLM) 2016 Resource Management Plan revisions in Western Oregon. Yet the DEIS completely ignores this document and the context-driven approach to defining old-growth it proposes because of the proposed Amendment's sweeping scale. As a result, nuances like trees vs. stands, dry vs. wet forest types, *etc.* are not addressed. Instead, the proposed Amendment's

[2] Jerry F. Franklin and K. Normand Johnson, *A Restoration Framework for Federal Forests In the Pacific Northwest*, 110 J. of Forestry 429, 429-439 (2012), https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5428878.pdf (last visited Sept. 18, 2024)..

standards and guidelines simply refer to old-growth "forests." This language will burden Forest Service practitioners with uncertainty regarding old-growth identification: for example, is a mid-seral forest stand with five 300-year-old remnant trees per acre considered an old-growth "forest" and subject to this proposed Amendment? Is a ¼-acre patch of old-growth forest subject to this proposed Amendment? What about an old-growth forest that covers only 1/20th of an acre?

This proposed Amendment's disconnect between its stated goal of encouraging active management and clear effect of burdening active management partly stems from the unprecedented scale of the proposed Amendment. It seems impossible for policy makers at the national level to develop a single Amendment designed to address forest threats through active management across 155 National Forests when each unit faces unique challenges. For example, National Forests whose LMPs were amended by the NWFP manage over 7.5 million acres for the objective of old-growth and late-seral habitat recruitment and maintenance.[3] These are referred to as Late Successional Reserves (LSRs), and they consume over 30% of the NFS lands in the Pacific Northwest. Standards specific to LSRs restrict management of all forests to treatments that protect and enhance conditions of late-successional and old-growth forest ecosystems. If these LSR objectives sound familiar, it is because they are nearly identical to the *Adaptive Strategy for Old-Growth Forest Conservation* described in the proposed Amendment. This type of redundancy is to be expected with a sweeping Amendment of this national scale.

For these and many other reasons, the proposed Amendment would burden active management instead of furthering its stated goal of encouraging active management. This fundamental error is primarily the product of a flawed need identified in the Notice of Intent (NOI) and DEIS to create a consistent framework to guide management of old-growth across the NFS.[4] Had the threat assessment been completed ahead of the NOI, as Executive Order (EO) 14072 directed, the Forest Service may have identified the complexity and geographical uniqueness of the threats and recognized that creating "consistent" solutions would be ineffective, inappropriate, and scientifically unjustified.[5] The Forest Service may have also identified a need to address obstacles in existing LMPs that obstruct Forest Service practitioners from mitigating wildfire and insect and disease threats on millions of acres of NFS lands, instead of adding additional layers to what is already a complex management environment. What, exactly, in law, regulation, and/or land planning is prohibiting the Forest Service from taking immediate action to achieve the stated objectives of the Forest Service?

Indeed, the Threat Assessment, which was published ***one week prior*** to publication of the DEIS, confirmed that wildfire and insects and disease have caused the highest loss of old-growth forests over the past 20 years and continue to pose the most significant future threat to those forests.[6]

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[3] U.S. Dep't of Agric., Forest Serv., *Regional Ecosystem Office (REO) - Northwest Forest Plan, Land Use Allocations,* https://www.fs.usda.gov/r6/reo/landuse/ (last visited Sept. 17, 2024).
[4] U.S. Dept of Agric., Forest Serv., *Land Management Plan Direction for Old-Growth Forest Conditions Across the National Forest System*, 88 Fed. Reg. 88,043 (Dec. 20, 2023) (NOI).
[5] Proclamation No. 14072, *Strengthening the Nation's Forests, Communities, and Local Economies*, 87 Fed. Reg. 24,853 (Apr. 27, 2022) (EO 14072).
[6] U.S. Dep't of Agric., Forest Serv., and U.S. Dep't of Interior, Bureau of Land Mgmt., *Mature and Old-Growth Forests: Analysis of Threats on Lands Managed by the Forest Service and Bureau of Land Management, in Fulfillment of Section 2(c) of Executive Order No. 14072* (June 2024),

The Threat Assessment also concluded that old-growth loss was greater in areas reserved from timber harvest (wilderness, inventoried roadless areas (IRA), national monuments) than in areas where timber harvest is permitted and encouraged. In fact, while the amount of old-growth decreased in reserved areas, it *increased* by 7.8% in areas where timber harvest is permitted and encouraged.

We believe that Forest Service leadership and practitioners know these truths and believe that active forest management, including timber harvest, is integral to not only sustaining old-growth forest conditions but also to attaining the agency's overall mission. AFRC and its members routinely interact with local Forest Service employees through the project development process. We routinely see well-crafted projects designed to improve ecological integrity, provide timber products, reduce wildfire risks, and support rural communities derailed by cumbersome processes, restrictive LMP standards, misdirected regulations, lawsuits focused on process and paperwork technicalities, or threats of lawsuits. Unfortunately, this proposed Amendment does not ameliorate those issues, but instead compounds them.

On February 2, 2024, AFRC submitted substantive comments in response to the December 20, 2023 NOI to prepare an EIS on Land Management Plan Direction for Old-Growth Forest Conditions across the NFS. In that letter, we raised numerous concerns with the proposal's alignment with components of certain statutes and regulations; namely, the National Environmental Policy Act (NEPA) and the 2012 Planning Rule (36 C.F.R. Part 2019). We also highlighted inconsistencies between the directives in EO 14072 and the course of actions taken by the Forest Service in response. In particular, we emphasized the flawed approach of issuing a NOI to create policies that address threats to old-growth prior to completion of an assessment of those threats. After reviewing the DEIS, those concerns, as outlined in our comments, remain largely unchanged. In fact, our review of the DEIS has raised additional concerns with the adequacy of the analysis as it pertains to NEPA's "hard look" standard. Moreover, we have identified issues with the Forest Service's failure to comply with the Endangered Species Act (ESA) and EO 12866, which requires the Office of Management Budget (OMB) to review significant regulatory actions.[7] We appreciate the opportunity to reiterate our initial concerns and expand on takeaways from our review of the DEIS.

We have organized our comments based on how the proposed Amendment and DEIS comports or conflicts with certain statutes and regulations.

2012 Planning Rule

Levels of Planning

We continue to disagree with the scope and scale of the proposed Amendment and believe that the course proposed by the Forest Service represents a violation of Section 219.2 of the Planning Rule. *See* 36 C.F.R. § 219.2. That section outlines the different organizational levels of the agency where planning occurs, as well as the types of planning appropriate for each level.

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https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/MOG-threat-analysis.pdf (last visited Sept. 17, 2024) (Threat Assessment).

[7] Proclamation No. 12866, *Regulatory Planning and Review*, 58 Fed. Reg. 51,724 (Oct. 4, 1993) (EO 12866).

Section 219.2 states that "Forest Service planning occurs at different organizational levels and geographic scales. Planning occurs at three levels—national strategic planning, NFS unit planning, and project or activity planning." *Id*. Development and preparation of this proposed Amendment is clearly occurring at the "national strategic planning" level. Section 219.2(a) makes it clear that national-level planning includes actions like "preparation of the Forest Service strategic plan required under the Government Performance and Results Modernization Act of 2010 … that establishes goals, objectives, performance measures, and strategies for management of the NFS."

By contrast, Section 219.2(b)(1) states that "development, ***amendment***, or revision of a land management plan" is the result of ***NFS unit planning.*** (emphasis added). The proposed Amendment would, obviously, amend land management plans. Therefore, under the regulation's plain language, the proposed Amendment must be accomplished through local, NFS unit-level planning, not at the national scale.

The Forest Service does not address this departure from the Planning Rule's direction regarding levels of planning, other than to assert the need for a "consistent framework" across the entire NFS. But Section 219.2 does not provide a "consistent framework" exception to the rule that land management plan amendments must occur at the NFS unit level. The unit-level planning rule is important to ensure local stakeholders' are adequately involved and local differences—including ecological, economic, and cultural differences across planning areas—are adequately considered. The Forest Service's improper, national approach short circuits this process and undermines meaningful involvement of underrepresented, economically disadvantaged, forest-dependent rural communities.

Public Participation

Section 219.4(a) of the Planning Rule requires the Forest Service to consider "the accessibility of the process, opportunities, and *information*" to allow meaningful public participation. 36 C.F.R. § 219.4(a) (emphasis added). The December NOI clearly failed to provide the public with essential information to ensure meaningful review because it solicited public feedback on developing policies to address threats to old-growth before threats to old-growth were identified through the completion and publication of the Threat Assessment. Instead, the Forest Service made the Threat Assessment available to the public one week before it published the DEIS. The Forest Service's delayed release of the Threat Assessment prevented the public, including AFRC, from providing meaningful comment on the Forest Service's NOI and prevented the Forest Service from considering relevant information in preparing the DEIS.

The Forest Service's process is also completely at odds with the process envisioned by EO 14072, which guided the preparation of the proposed Amendment.

EO 14072 directs the Forest Service to:

1. Define mature and old-growth forests on federal lands,
2. Complete an inventory and make it publicly available,

3. Identify threats to mature and old-growth forests, and
4. Develop policies to address threats.

There is a deliberate chronology to these above-mentioned action items, as the execution of each item is dependent on the completion of the item prior. The Forest Service could not conduct an inventory of old-growth forests (#2) until it defined "old growth forests" (#1). And the Forest Service could not conduct an analysis of threats to old-growth forests (#3) until it inventoried those forests (#2). And finally, **the Forest Service cannot develop policies to address threats (#4) until it identifies those threats (#3)**.

Following the April 22, 2022 issuance of EO 14072, the Forest Service initially progressed through this list of action items chronologically. The Forest Service published its mature and old-growth forest definition and subsequent inventory in April 2023. Following this publication, the Forest Service indicated its intention to complete a threat analysis.

However, this chronological progression came to a sudden halt on December 20, 2023, when the NOI was published proposing "policies to address threats" prior to completion of an assessment that identified those threats. Figure 1 from the DEIS, copied below, illustrates this flawed chronology as the Forest Service progressed from the inventory immediately into a "decision" on "how to amend land management plans."

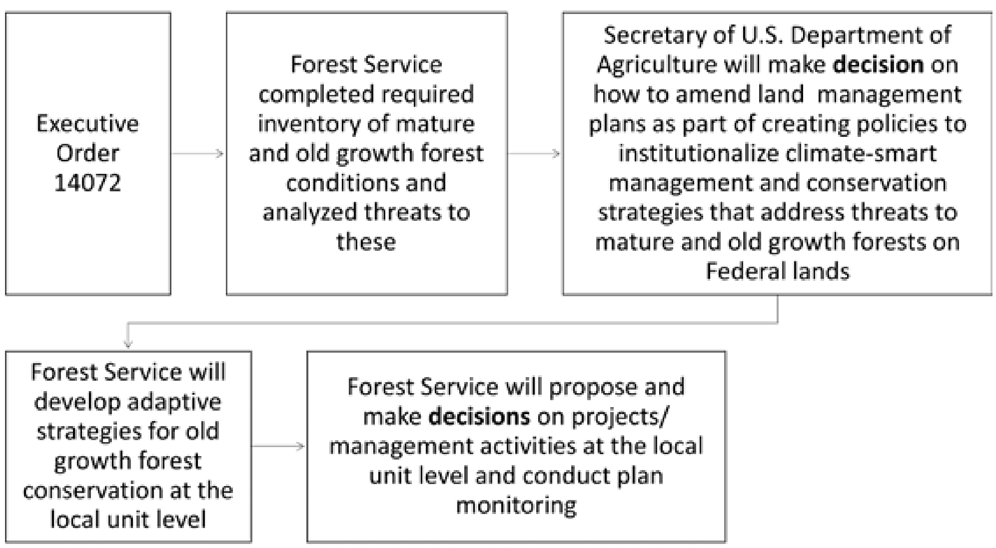

Figure 1: Chronology of the decision-making process

Without a Threat Assessment based on current science and empirical evidence, AFRC and other stakeholders could not develop and submit well-informed comments on the NOI's strategies for addressing threats. The failure to provide the public with relevant information about threats to old-growth forests plainly violates Section 219.4(a)'s public participation requirements and EO 14072. The public was not provided the "accessibility of . . . information" noted in section 219.4(a) of the Planning Rule to adequately provide input on this proposed Amendment due to the failure to adhere to the chronology of EO 14072, namely the failure to develop and publish a Threat Assessment.

The Forest Service's delay in completing the Threat Assessment also contributed to the substantive issues with the proposed Amendment we identify throughout this comment letter. If the public and the agency had access to the Threat Assessment's findings sooner, consistent with the intent of the Planning Rule, the Forest Service could have crafted an Amendment based on accurate threat information and informed public input.

Notably, the **Threat Assessment confirmed that wildfire and insects and disease infestations have caused the highest loss of old-growth forest over the past 20 years and continue to pose the most significant future threat to those forests**. The Threat Assessment also concluded that old-growth loss was greater in areas reserved from timber harvest—such as wilderness areas, IRAs, and national monuments—than in areas where timber harvest is permitted and encouraged.

In fact, while old-growth decreased in reserved areas, it *increased* by 7.8% in areas where timber harvest is permitted and encouraged. The Threat Assessment noted that these results suggest that strictly reserving old-growth forests may not always ensure that they are protected from future losses. Had the Forest Service and the public known that old-growth conditions are improving in areas where timber harvest is allowed and encouraged, the Agency may have, for example, focused on changing current regulations that explicitly restrict timber harvest and other active management in IRAs (Table 7 in the DEIS indicates that there are 9.6 million acres of old-growth in IRAs (DEIS at 79)); reducing timber harvest restrictions in LSRs in Region 5 and Region 6 LMPs (the Threat Assessment states that "LMPs generally include components limiting the threat of tree cutting to old-growth forest"(Threat Assessment at 39); and providing Forest Service practitioners with tools for accelerating timber harvest to improve old-growth conditions.

Ultimately, none of these options were considered by the Forest Service or the public because neither were provided with access to pertinent, complete information as required by the Planning Rule. Instead, contrary to the Threat Assessment's findings, the Forest Service proposed an Amendment that stands to increase old-growth loss by making timber harvesting and other active management in old-growth forests more difficult.

Public Notifications

Compounding the violations of Section 219.4(a) and EO 14072, the Forest Service further undermined the public's ability to meaningfully participate by violating Section 219.16(c)(5) of the Planning Rule. That provision states that "[i]f a plan, plan amendment, or plan revision applies to two or more units, notices must be published in the Federal Register *and the newspaper(s) of record for the applicable units*." 36 C.F.R. § 219.16(c)(5) (emphasis added). Because section 219.16(a)(1) requires notices "to initiate the development of a proposed plan, plan amendment, or plan revision," and subsection (a)(2) requires notices for draft EISs, both should have been published in the newspapers, according to subsection (c)(5).

The Forest Service periodically identifies and updates the newspapers of record for each National Forest unit in the Federal Register. We identified several such newspapers in Regions 1, 4, 5, and 6, and conducted a search for notifications during the comment period for both the NOI and DEIS.[8] We were unable to locate any notifications in any newspaper of record for either the NOI or DEIS through our searches.

The Planning Rule's local notice requirement reflects the Rule's intent (as provided in section 219.2(b)) that forest plan amendments would be conducted at the local unit level, as explained above. Publication of notifications in local newspapers, as opposed to the Federal Register, is important to ensuring notice to the interested and affected public, especially in rural communities. Most citizens do not know what the Federal Register is, let alone check it constantly. On the other hand, many citizens are familiar with their local newspaper and publication of relevant notifications related to the management of their local National Forest published in those newspapers has a higher likelihood of reaching those citizens and impacted communities than similar notifications in the Federal Register.

The Forest Service's failure to provide local notice of the proposed Amendment violates the Planning Rule and demonstrates that the Forest Service's improper, national approach to a plan amendment unlawfully undermined public notice, review, and participation.

Need For Change

Section 219.13(b)(1) of the Planning Rule directs the Forest Service to "base an amendment on a preliminary identification of the need to change the plan." 36 C.F.R. § 219.13(b)(1). The preliminary need for change identified in the NOI was to "create a consistent set of national plan components and direction for the development of geographically informed adaptive implementation strategies for the long-term persistence, distribution, and recruitment of old-growth forest conditions across the National Forest System." NOI at 88,045. We noted in our comments in response to the NOI that this statement did not amount to a legally required "need for change." Instead, this statement was simply a declaration of what the Forest Service intended to do. Additionally, as explained above, the Forest Service irrationally asserted this need for change in the NOI without first completing the Threat Assessment required to inform what changes, if any, are needed.

The stated need for change was modified in the DEIS as follows:

- "Demonstrate compliance with Executive Order 14072 to institutionalize climate-smart management and conservation strategies that address threats to mature and old-growth forests on Federal lands;
- Respond to the clear congressional intent outlined in section 23001(a)(4) of the Inflation Reduction Act; and

[8] Each state's newspaper association offers a free search engine for public notices. *See, e.g.*, Nat'l Ass'n of Idaho, https://www.idahopublicnotices.com/; https://www.capublicnotice.com/; Mont. Newspaper Ass'n, https://www.montanapublicnotices.com/; Wash. Newspaper Publishers' Ass'n, https://www.wapublicnotices.com/; Or. Newspaper Publishers Ass'n, https://www.publicnoticeoregon.com (last visited Sept. 17, 2024).

- Create a consistent framework to manage for the long-term persistence, distribution, and recruitment of old-growth forests across the National Forest System (NFS) in light of the interacting biophysical and social factors that threaten the persistence of older forests on NFS lands across the Nation."

DEIS at S-6, 7.

Section 219.13(b)(1) of the Planning Rule also states that "the preliminary identification of the need to change the plan may be based on a new assessment; a monitoring report; or other documentation of new information, changed conditions, or changed circumstances." 36 C.F.R. § 219.13(b)(1). Although this is not a requirement, it is noteworthy that the Planning Rule identifies items that may trigger and inform a need for change. Among those items is a "new assessment." The Forest Service did indeed publish a new assessment when it released its Threat Assessment. However, the assessment did not and could not inform the "need for change" because it was not completed in time for the public or the Agency to review it.

Furthermore, the Forest Service did not articulate the need for "consistency" across the entire NFS regarding the management of old-growth. In fact, contrary to the stated need for change, the Threat Assessment and portions of the DEIS show that the Forest Service fully understands that mandating a "consistent" management framework for ecologically diverse landscapes across the entire NFS would be impracticable and counterproductive.

The DEIS states that "there are differences in threats and conditions in different regions and ecosystems across" the NFS. DEIS at 3. The Definition, Identification, and Initial Inventory report described old-growth definitions for more than 200 unique forest vegetation types across the NFS.[9] Inventory Report at 5. The DEIS also notes that each region "recognizes important ecological variation by defining unique old-growth criteria for different vegetation types." DEIS at S-3, 4, 57. This information does not substantiate a need for consistency in old-growth management policy across the NFS. It confirms the opposite: the need for flexibility, adaptability, and <u>unique</u> management approaches based on diverse geographies, landscapes, and forest types across 193 million acres.

Finally, section 23001(a)(4) of the 2022 Inflation Reduction Act does not demonstrate a need for change. This section of the 2022 Inflation Reduction Act cited in the need for change simply provided the Forest Service with $50 million "for the protection of old-growth forests and to complete an inventory of old-growth" on NFS land. DEIS at S-4, 1. This allocation of funding does not represent "clear" congressional intent. The Forest Service could utilize these funds for any number of actions that inventory and protect old-growth forests, and at a local planning scale that makes ecological sense and complies with planning requirements.

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[9] U.S. Dep't of Agric., Forest Serv., and U.S. Dep't of Interior, Bureau of Land Mgmt., *Mature and Old-Growth Forests: Definition, Identification, and Initial Inventory on Lands Managed by the Forest Service and Bureau of Land Management, in Fulfillment of Section 2(b) of Executive Order No. 14072* (Apr. 2024) https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/Mature-and-Old-Growth-Forests.pdf (last visited Sept. 17, 2024) (Inventory Report).

For example, that funding could be directed to support vegetation management projects in high fire-prone landscapes that would not otherwise be economical. Or it could be directed to accelerate the implementation of fuel breaks authorized under section 40806 of the 2021 Bipartisan Infrastructure Law to protect old-growth stands at risk of high severity wildfire. Either of these alternatives would protect old-growth forests from fire, insects and disease more effectively than embarking on a nationwide plan Amendment that is not tailored to local conditions. We also point out that "protecting" old-growth through active management would require indefinite congressional appropriations since these would be ongoing actions. No such funding has been authorized or appropriated by Congress since the 2022 Inflation Reduction Act.

Ultimately, the Forest Service did not establish a need for change that is consistent with the Planning Rule, and it failed to consider viable alternatives for protecting old-growth and mature forests that are consistent with the 2022 Inflation Reduction Act and EO 14072. Instead, it sought foreclose alternatives by building in an alleged need for a consistent, nationwide management framework for old-growth forests into its proposal's stated purpose and need, in conflict with its own findings that local differences make a nationwide management direction unworkable. The inappropriate timing of the Threat Assessment, misguided interpretation of congressional funding, and failure to consider existing barriers to old-growth management, all contributed to the unlawful and unwise process.

Timber Suitability

The DEIS asserts that the proposed Amendment "does not change lands suitable for timber production." DEIS at S-14, 121. However, the standards proposed in the proposed Amendment, and the language and direction in both the Planning Rule and the National Forest Management Act (NFMA), show otherwise.

Section 6(k) of the NFMA requires that the Secretary "shall identify lands … not suitable for timber production." 16 U.S.C. § 1604(k). Section 219.19 of the Planning Rule defines "timber production" as "the purposeful growing, tending, harvesting, and regeneration of regulated crops of trees to be cut into logs, bolts, or other round sections for industrial or consumer use." (emphasis added). Section 219.11 of the Planning Rule states that "the responsible official shall identify lands within the plan area as not suited for timber production if any one of the following factors applies," including: "[s]tatute, Executive order, or regulation prohibits timber production on the land" and "[t]imber production would not be compatible with the achievement of desired conditions and objectives established by the plan for those lands." For lands suitable for timber production, section 219.11(b) requires the inclusion of "plan components, including standards or guidelines, to guide timber harvest for timber production or for other multiple use purposes on such lands." (emphasis added).

The proposed Amendment plainly reclassifies lands suitable for timber production. The proposed Amendment establishes "desired conditions" for old-growth forests and then makes clear that proactive stewardship for the purpose of timber production is inconsistent with those conditions. Standard 3 (NOGA-FW-STD-03) states that "proactive stewardship in old-growth forests shall not be for the purpose of timber production, as defined in 36 CFR 219.19." DEIS at

32, 49 (emphasis added). Clearly, the proposed Amendment prohibits timber production across an unknown number of NFS acres.

The DEIS, however, states that the Forest Service is not modifying timber suitability because "[o]ld-growth forests will remain forested lands as a part of this amendment process." DEIS at S-14, 121. This makes no sense. Any given acre of NFS land being suitable for timber production is not simply a function of whether that acre is technically "forested." There are millions of acres of "forested" land in the Pacific Northwest and beyond that are currently deemed unsuitable due to LMP standards and guidelines that prohibit timber production. As a result of this proposed Amendment, even more acres will be unavailable for timber production.

Even assuming the proposed Amendment has not reclassified lands as suitable for timber harvesting, it still does not comply with section 219.11(b) of the Planning Rule, which requires the Forest Service to include "standards or guidelines, to guide timber harvest for timber production or for other multiple use purposes on such lands." (emphasis added). If, as the Forest Service claims, it is not redesignating the suitability of timber for harvesting, it is required to develop standards or guidelines to guide timber production, as defined by the Planning Rule, on those lands it deems suitable. In particular, the Forest Service must develop standards and guidelines that address the purposeful growing, tending, harvesting, and regeneration of lands suitable for timber production, including those lands that contain old-growth forests.

NEPA

NEPA establishes procedures by which federal agencies must consider the environmental impacts of their actions but does not dictate substantive results. *Robertson v. Methow Valley Citizens Council*, 490 U.S. 332, 350 (1989). NEPA requires federal agencies to prepare an environmental impact statement (EIS) for "major Federal actions significantly affecting the quality of the human environment . . . ." 42 U.S.C. § 4332(2)(C). An EIS "shall provide full and fair discussion of significant environmental impacts and shall inform decision makers and the public of reasonable alternatives that would avoid or minimize adverse impacts or enhance the quality of the human environment." 40 C.F.R. § 1502.1. NEPA and its implementing regulations set forth procedures designed to ensure that federal agencies take a "hard look" at the environmental consequences of their proposed actions. *Robertson*, 490 U.S. at 350-51. The Ninth Circuit has interpreted a "hard look" to mean "a reasonably thorough discussion of the significant aspects of the probable environmental consequences." *Ctr. for Biological Diversity v. Nat'l Highway Traffic Safety Admin.*, 538 F.3d 1172, 1194 (9th Cir. 2008). To take the required "hard look," the agency may not rely on incorrect or incomplete assumptions or data. *Native Ecosystems Council v. U.S. Forest Serv.*, 418 F.3d 953, 964 (9th Cir. 2005); *see* 40 C.F.R. § 1500.1(b) ("The information shall be of high quality. Accurate scientific analysis, expert agency comments, and public scrutiny are essential to implementing NEPA."). The geographic scale of this proposed Amendment—128 Forest Plans, covering 193 million acres— makes satisfying the hard look standard difficult.

Violation of Public Notice Requirements

For reasons similar to those discussed above regarding public notification under the Planning Rule, the Forest Service has also not satisfied NEPA's public notice requirements. NEPA requires agencies to "[c]onsider what methods of outreach and notification are necessary and appropriate based on the likely affected entities and persons; the scope, scale, and complexity of the proposed action and alternatives; the degree of public interest; and other relevant factors." 40 C.F.R. § 1501.9(c)(3). As explained above, the Forest Service unreasonably failed to provide notification of the NOI and DEIS through local newspapers, which interested stakeholders are far more likely to review and be familiar with than the Federal Register. The agency's failure to provide notice through local newspapers was therefore inadequate to satisfy NEPA's public notification requirements.

Hard Look – Timber Production/Socioeconomic

The Forest Service failed to take a hard look at the proposed Amendment's effects to socioeconomic impacts and effects on timber harvest levels in the DEIS.

The DEIS indicates that only Alternative 3 would have measurable impacts to the timber industry, restoration-based economy, and rural communities. Specifically, the DEIS argues that "no economic effects to the timber industry outside of Alaska are anticipated because there will be no change in forest Allowable Sale Quantity (ASQ), Projected Timber Sale Quantity (PTSQ) or land suitability." DEIS at 121. It goes on to say that "the amendment also does not change ASQ or PTSQ because the projected timber sale quantity includes volume from timber harvest for any purpose from all lands in the plan area." *Id*. (emphasis added). This underlined portion is inaccurate for LMPs amended by the NWFP.

Several documents, including the NWFP Final Supplemental EIS,[10] NWFP monitoring reports,[11] and the Forest Ecosystem Management Assessment Team (FEMAT) Report[12] are clear that the NWFP's Probable Sale Quantities (PSQ), which is the equivalent to the PTSQ referenced in the DEIS,[13]are calculated and derived only from lands designated as Matrix or Adaptive Management Area (AMA) whereas NWFP reserved lands (LSRs and Riparian Reserves) do not contribute to the PSQ:

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[10] U.S. Dep't of Agric., Forest Serv., and U.S. Dep't of Interior, Bureau of Land Mgmt., *Final Supplemental Environmental Impact Statement on Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl, Volume I* (Feb. 1994), https://www.fs.usda.gov/r6/reo/library/downloads/documents/NWFP-FSEIS-1994-I.pdf (last visited Sept. 17, 2024) (NWFP FSEIS)

[11] U.S. Dep't of Agric., Forest Serv., *Social and Economic Status and Trends* (Feb. 2016), https://www.fs.usda.gov/r6/reo/monitoring/downloads/socioeconomic/Nwfp20yrMonitoringReportSocioeconomic.pdf (last visited Sept. 17, 2024) (Monitoring Report).

[12] Forest Ecosystem Management Assessment Team, *Forest Ecosystem Management: an Ecological, Economic, and Social Assessment* (July 1993), https://www.fs.usda.gov/r6/reo/library/downloads/documents/FEMAT-1993-Report.pdf (last visited Sept. 17, 2024) (FEMAT Report).

[13] PTSQ is defined as "[t]he estimated quantity of timber meeting applicable utilization standards that is expected to be sold during the plan period. DEIS at G-2. PSQ is defined as "harvest levels for the various alternatives that could be maintained without decline over the long term if the schedule of harvests and regeneration were followed." NWFP FSEIS at Glossary 13.

The PSQ is based only on lands that are considered suitable for the production of programmed, sustainable timber yields. Timber suitable lands are those lands physically and economically suited to timber production that are outside of lands designated for forest uses considered incompatible with programmed, sustained timber harvests. Timber suitable lands are located only in the matrix or in Adaptive Management Areas. Lands designated as Congressionally Reserved Areas, Administratively Withdrawn Areas, Late-Successional Reserves, and Riparian Reserves are considered unsuitable for sustained timber yields. These lands are therefore not included in calculations of PSQ. NWFP FSEIS at 3&4-263.

Probable sale level - The annual amount of sawtimber likely to be sold outside of Reserves on a sustainable basis under an option. FEMAT Report at IX-27.

The calculation of PSQs under the NWFP relied on active management of all forest stands in the Matrix and AMAs, including old-growth, through a combination of intermediate thinnings and regeneration harvest. The proposed Amendment would prohibit regeneration harvest of old-growth stands and generally discourage intermediate harvests in certain other old-growth stands. This change would drastically alter the PSQs. The Forest Service failed to take a hard look at these drastic changes.

A supplemental report[14] by the FEMAT that accompanied the NWFP and outlined the modeling and processes for calculating the PSQs made this statement regarding old-growth forests:

Most of the harvest in Option 9 (and many other options) over the next decade will come from late-successional forest (over 80 years old). Close to 50 percent will come from forests over 200 years old. Supplemental FEMAT Report at 22.

Other NEPA reviews have recognized how management changes on NWFP lands could affect timber harvest volumes from these lands. For example, the 2000 Final EIS for Amendments to Survey and Manage explained[15]:

There are approximately 3 million acres of forest land within the Matrix and Adaptive Management Areas that contribute to PSQ. Approximately one-third of this, or 1.1 million acres, are late-successional forest. On most administrative units, the PSQ is heavily dependent on harvesting late-successional forest for 3 to 5 more decades until early-successional stands begin to mature and become available for harvest. Because of this dependence, harvest schedules indicate about 90 percent of PSQ over the next decade is

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[14] K. Norman Johnson, et al., *Sustainable Harvest Levels and Short-Term Timber Sales for Options Considered in the Report of the Forest Ecosystem Management Assessment Team: Methods, Results, and Interpretations* (1993) (Supplemental FEMAT Report).

[15] U.S. Dep't of Agric., Forest Serv., and U.S. Dep't of Interior, Bureau of Land Mgmt., *Final Supplemental Environmental Impact Statement For Amendment to the Survey & Manage, Protection Buffer, and other Mitigation Measures Standards and Guidelines* (Nov. 2000), https://www.fs.usda.gov/r6/reo/survey-and-manage/2001/surveymanage-2001-fseis-vol-i.pdf (last visited Sept. 17, 2024) (2000 FEIS for Amendments to Survey and Manage).

dependent on harvest of late-successional forest. 2000 FEIS for Amendments to Survey and Manage at 431.

The 2000 FEIS for Amendments to Survey and Manage also included a robust effects analysis on how the Survey and Manage Amendments <u>would</u> affect the PSQ. *Id.* at 432-37.

The DEIS's conclusion about the lack of effects on timber harvest volumes on NWFP lands is therefore premised on the inaccurate assumption that the proposed Amendment's active management restrictions would not affect such lands. To the contrary, because timber harvest volumes on these lands is based on active management strategies that the DEIS would restrict, the proposed Amendment would change the PSQs on these lands. The DEIS thus failed to accurately evaluate how the proposed Amendment would affect the PSQs, or the effects of reduced timber harvest levels on ecological and socioeconomic conditions, including increased fuel loads and risks to forests and communities. An accurate analysis would likely find that the proposed Amendment would significantly impact timber industry jobs in logging, wood product manufacturing, and pulp production, reducing critical revenue in rural communities and thus harming public services and causing other significant socioeconomic effects.

Additionally, the proposed Amendment's *Adaptive Strategy for Old-Growth Forest Conservation* has the potential to significantly alter the management objectives across an unknown number of NFS acres. This alteration, if occurring on lands designated for timber production, would also change the PSQs. As explained above, the PSQs were calculated on certain lands based on the principles of sustained-yield timber management. These principles include a cycle consisting of intermediate harvests followed by final regeneration harvest that would establish a new forest cohort. Application of the Adaptive Strategy on this land base would derail this cycle and render the PSQs irrelevant and unattainable. Lands that were previously designated for long-term sustained yield timber production would be relegated as quasi-reserves where permanent old-growth recruitment replaces timber production objectives. Such an alteration will have significant effects on timber supply and fuel loads that the DEIS fails to acknowledge or evaluate.

For the foregoing reasons, the Forest Service has failed to take a hard look at the proposed Amendment's socioeconomic impacts in violation of NEPA.

<u>*Hard Look – Carbon/Climate*</u>

The DEIS fails to take a hard look at the effects on management changes resulting from its proposed standards and guidelines. Specifically, the Forest Service failed to adequately analyze the impacts of implementing the Adaptive Strategy outlined in Management Approach 1.a. Implementation of the Adaptive Strategy requires each National Forest to identify an unspecified number of acres where existing management objectives would be altered. Even if it is currently unknown exactly how many acres would be subject to new restrictions, the Forest Service can and must make a reasonable forecast so that it can understand the effects of its action. The agency can't avoid its NEPA obligations and ignore effects simply due to the inclusion of an amorphous management approach such as the Adaptive Strategy. The failure to provide this effects analysis to the public also undermines the public's ability to understand and meaningfully inform the proposed Amendment and alternatives.

The provisions pertinent to the Adaptive Strategy appear in the DEIS as follows:

Management Approach 1.a (NOGA-FW-MA-01a); *Adaptive Strategy for Old-Growth Forest Conservation* of the proposed Amendment directs each National Forest to "develop and adhere to an Adaptive Strategy for Old-Growth Forest Conservation." The Management Approach lists eight elements that this strategy would accomplish, including the identification and prioritization of areas for the "recruitment, retention and promotion of old-growth forests."

Management Approach 1.b (NOGA-FW-MA-01b) directs each National Forest to locate these "areas" where forests "have the inherent capability to sustain future old-growth forest."

Objective 1 (NOGA-FW-OBJ-01) directs each National Forest to "create or adopt an Adaptive Strategy for Old-Growth Forest Conservation within 2 years of the old-growth amendment record of decision."

Objective 2 (NOGA-FW-OBJ-02) directs each National Forest to "integrate priorities identified in the Strategy into the unit's outyear program of work and initiate at least three proactive stewardship projects/activities in the planning area to contribute to the achievement of old-growth forest desired conditions within one year of completing the Adaptive Strategy for Old Growth Forest Conservation Strategy."

Objective 4 (NOGA-FW-OBJ-04) directs each National Forest to ensure that "forest ecosystems within the plan area will exhibit a measurable, increasing trend towards appropriate amounts, representativeness, redundancy, and connectivity of old-growth forest that are resilient and adaptable to stressors and likely future environments within ten years of the Adaptive Strategy for Old-Growth Forest Conservation being completed."

Guideline 1 (NOGA-FW-GDL-01) states that "in areas that have been identified in the Adaptive Strategy for Old-Growth Forest Conservation as compatible with and prioritized for the development of future old-growth forest, vegetation management projects should be for the purpose of developing those conditions."

The Adaptive Strategy clearly directs each National Forest to drastically alter the management objectives on, to date, an unquantified amount of NFS land that is not identified as old-growth. These NFS lands are governed by direction in existing LMPs that include objectives such as timber production, wildfire risk reduction, and wildlife habitat creation. The proposed Amendment would change these objectives and the direction in those LMPs. The DEIS failed to take a hard look at the effects of those changes. The management approaches, objectives, and guidelines outlined above provide no indication of the scale at which this "strategy" would be implemented. The only guidance provided to local units is that this "strategy" should be applied to "areas where forests have the inherent capability to sustain future old-growth forest." Every acre of NFS land that is currently growing forests has the inherent capability to "sustain old-growth forest." Although the DEIS is not clear on what "sustaining" means. Forests are dynamic systems. No seral stage of forest development is static and therefore none can be "sustained."

This ambiguity on the scope and scale of the application of this strategy makes the requisite hard look analysis impossible. The Forest Service violated NEPA because the DEIS failed to take the requisite hard look at the effects of implementing the preferred alternative, including the effects of changing how mature forests and "areas where forests have the inherent capability to sustain future old-growth forest" are managed. Those effects are not limited to reducing timber harvest levels and associated ecological and socioeconomic effects, as we outlined above, but also to an array of other key resources.

For example, the new management objectives and guidelines focused on old-growth recruitment associated with the Adaptive Strategy would have significant impacts on carbon and climate change. Many standards and guidelines in existing LMPs allow and encourage regeneration harvest of mature forests. In fact, the NFMA requires that the Secretary establish standards to ensure that timber harvest occurs after stands of trees have reached the culmination of mean annual increment (CMAI). The age that corresponds to CMAI varies by National Forest and by forest type but generally occurs during the mature phase of stand development. This phase also generally coincides with the point where trees become less effective at sequestering carbon.

There is a growing body of science showing that timber harvest at or near CMAI maximizes the carbon sequestration potential of any given acre of forestland.

A 2016 study published in Ecosphere by Gray et al. concluded that although large trees accumulated carbon at a faster rate than small trees on an individual basis, their contribution to carbon accumulation rates was smaller on an area basis, and their importance relative to small trees declined in older stands compared to younger stands. That study also concluded that old-growth and large trees are important carbon stocks, but they play a minor role in additional carbon accumulation.[16]

Similar to the concepts validated by Gray et al., the USDA recently published a Technical Report on the future of America's forests and rangelands.[17]

Key points of the Report include:

- The projected decrease in young forests and increase in older forests will result in overall decreases in growth rates and carbon sequestration. *Id.* at 6-36.
- The amount of carbon sequestered by forests is projected to decline between 2020 and 2070 under all scenarios, with the forest ecosystem projected to be a net source of carbon in 2070. *Id.* at 6-36.

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[16] Andrew Gray, et al., *Carbon Stocks and Accumulation Rates in Pacific Northwest Forests: role of stand age, plant community, and productivity*, 7 Ecosphere 1, 1-19 (2016), https://esajournals.onlinelibrary.wiley.com/doi/pdf/10.1002/ecs2.1224 (last visited September 18, 2024).
[17] U.S. Dep't of Agric., Forest Serv., *Future of America's Forest and Rangelands: Forest Service 2020 Resources Planning Act Assessment* (July 2023), https://www.fs.usda.gov/sites/default/files/fs_media/fs_document/2020-RPA-Assessment.pdf (last visited Sept. 17, 2024) (Technical Report).

- Without active management, significant disturbance, and land use change, forests approach a steady state in terms of carbon stock change over time. *Id.* at 6-27.
- Annual carbon sequestration is projected to decrease, indicating carbon saturation of U.S. forests, due in part to forest aging and senescence. *Id.* at 6-27.

A recently published report by the Environmental Protection Agency echoed these conclusions regarding the adverse impacts to carbon sequestration due to forest "aging." The report concluded that, due to an aging forest land base, increases in the frequency and severity of disturbances in forests in some regions, among other drivers of change, forest carbon density is increasing at a slower rate resulting in an overall decline in the sink strength of forest land remaining forest land in the United States.[18]

These and other research papers and assessments were identified and discussed in our comments to the December NOI, where we urged the Forest Service to consider the latest scientific studies in their carbon/climate change analysis.

Based on these technical reports and assessments, it is clear that "aging forests" are <u>*hampering*</u> forest's ability to maximize carbon sequestration and mitigate climate change. The management implications of the Adaptive Strategy will restrict the Forest Service's ability to conduct timber harvest at CMAI thereby inhibiting the capability of NFS lands to mitigate climate change by maximizing carbon sequestration. Ironically, the Strategy attempts to expand the number of "aging forests" on the NFS, which will have a profound adverse impact on climate change.

The DEIS provided only a cursory analysis of the proposed action's effects on carbon and omitted entirely any effects analysis of climate change in general. The DEIS acknowledged the importance of "carbon uptake" but provided no analysis of the proposed Amendment's effects on carbon uptake. Had the Forest Service conducted such an analysis based on the best available data, including the studies and data referenced above, the proposed Amendment's potential to significantly affect carbon uptake/sequestration would have been revealed. Nor did the Forest Service seek to quantify the effects of reduced carbon sequestration and increased greenhouse gas levels using the social cost of carbon or any other framework or explain why it could not. The Forest Service's cursory review fails to meet NEPA's hard look standard.

<u>*Cumulative Effects*</u>

"Every EIS must consider the cumulative impacts of the actions evaluated." *Selkirk Conservation All. v. Forsgren,* 336 F.3d 944, 958 (9th Cir. 2003). Cumulative impacts represent the "incremental impact of the action . . . added to other past, present, and *reasonably foreseeable* future actions" undertaken by any person or agency. 40 C.F.R. § 1508.7 (emphasis added). "To 'consider' cumulative effects, some quantified or detailed information is required . . . . General statements about 'possible' effects and 'some risk' do not constitute a 'hard look' absent a justification regarding why more definitive information could not be provided.

[18] U.S. Env't Prot. Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2022* (2024), https://www.epa.gov/system/files/documents/2024-04/us-ghg-inventory-2024-main-text_04-18-2024.pdf (last visited Sept. 17, 2024).

Neighbors of Cuddy Mountain v. U.S. Forest Serv., 137 F.3d 1372, 1380 (9th Cir. 1998). Moreover, "[i]t is not appropriate to defer consideration of cumulative impacts to a future date when meaningful consideration can be given now." *Kern v. U.S. Bureau of Land Mgmt.*, 284 F.3d 1062, 1075 (9th Cir. 2002).

The Forest Service's patent failure to consider these plan revision and amendment processes in its cumulative effects analysis violates NEPA. Here, the DEIS failed to conduct any cumulative effects analysis on several reasonably foreseeable future actions, including the NWFP Amendment[19] (where a draft EIS is imminent), the Blue Mountains Forest Plan revision,[20] the Tongass Forest Plan revision,[21] the Lolo Forest Plan revision,[22] and other forest plan revision or amendment efforts. These actions unquestionably fall under the scope of "reasonably foreseeable" future actions and need to be included in the cumulative effects analysis. *See* 36 C.F.R. § 220.3 (defining reasonably foreseeable future actions as "those Federal or non-Federal activities not yet undertaken, for which there are existing decisions, funding, or identified proposals").

The Forest Service's failure to consider the NWFP Amendment in its cumulative effects analysis is particularly alarming. The Secretary of Agriculture appointed a 21-member federal advisory committee to provide consensus recommendations on the amendment, which affect 19 Forest Plans. The NWFP Amendment, once finalized, will provide direction on the management of old-growth and mature forests in the Pacific Northwest, and those future actions should have been considered in the Forest Service's analysis for cumulative effects regarding this proposed Amendment.

Range of Alternatives

Section 102(2)(H) of NEPA requires that the Forest Service "study, develop, and describe appropriate alternatives to recommended courses of action in any proposal which involves unresolved conflicts concerning alternative uses of available resources." 42 U.S.C. § 4332(2)(H). Regulations pursuant to this section requires agencies to rigorously explore and objectively evaluate all reasonable alternatives and to briefly discuss the reasons for eliminating any alternatives that were not developed in detail. 40 C.F.R. §1502.14.

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[19] The Forest Service announced that the Draft EIS for the NWFP Amendment will be released in October 2024. *See* Press Release, U.S. Dep't of Agric., Forest Serv., *Update on the Release of the Draft Environmental Impact Statement for the Amendment to the Northwest Forest Plan* (Aug. 27, 2024), https://www.fs.usda.gov/detail/r6/news-events/?cid=FSEPRD1202159 (last visited Sept. 17, 2024).

[20] The Forest Service provided an opportunity to provide feedback on the Draft Assessment, Potential Species of Conservation Concern, Lands that May Have Wilderness Character draft inventory, and Wild and Scenic Rivers draft inventory from March 25 to May 26, 2024. *See* U.S. Dep't of Agric., Forest Serv., *Blue Mountains Forest Plan Revision*, https://www.fs.usda.gov/detail/umatilla/home/?cid=fseprd1188541 (last visited Sept. 17, 2024).

[21] The Tongass National Forest issued its Assessment in July 2024. U.S. Dep't of Agric., Tongass Nat'l; Forest, *Tongass National Forest Plan Revision Assessment - Working Version of the Table of Contents and Literature Cited for all Assessment Sections* (July 2024), https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fseprd1197322.pdf (last visited Sept. 17, 2024).

[22] The Lolo National Forest issued its scoping letter on January 31, 2024. U.S. Dep't of Agric., Forest Serv., Lolo Nat'l Forest, *Proposed Action Scoping Letter* (Jan. 31, 2024), https://usfs-public.app.box.com/s/j7h0ti0rl0933lj1cb5df6ro0nq42ylg (last visited Sept. 17, 2025).

It is notable that all three action alternatives considered are limited in scope. Each of these alternatives proposes similar restrictive standards and guidelines but to different degrees of intensity. Absent are alternatives that consider addressing the purpose and need from different angles or perspectives. This limited scope of alternatives does not satisfy NEPA regulations regarding rigorous exploration of reasonable alternatives.

The Forest Service should have analyzed an alternative that eliminated inclusion of those National Forests that are currently governed by LMPs containing explicit protective standards and guidelines for old-growth protection and old-growth recruitment. For example, as mentioned above, the NWFP Amendment's finalization is imminent (end of 2025), but will occur after the proposed Amendment is adopted. The consequence of these dueling amendment processes is that the environmental baseline (i.e., the status quo which serves as the basis for analyzing environmental consequences) for the NWFP Amendment would change *from* the 1994 NWFP, as amended in 2006 for Survey and Manage, *to* the 1994 NWFP, as amended in 2006 for Survey and Manage ***and*** as amended by this proposed Amendment. The change in environmental baseline during the development of the NWFP Amendment is disruptive and problematic: nineteen forest plans in the Pacific Northwest will operate under this proposed Amendment for a year before the Northwest Forest Plan Amendment is finalized. The transition between this proposed Amendment and the NWFP Amendment will cause unnecessary disruptions/delay in forest management projects that would benefit old-growth stands. For that reason, the Forest Service should have considered an alternative that excluded the forest plans implicated under the expected NWFP Amendment.

Additionally, the Forest Service failed to consider an alternative that responded directly to the Threat Assessment. Such an alternative would propose new standards to replace existing LMP standards that restrict active forest management designed to reduce threats from wildfire or insect and disease. As we stated prior, active forest management to address these threats is currently restricted by existing standards that prohibit such management. An alternative that considered and addressed those standards, rather than creating new ones, should have been considered.

The Forest Service's failure to consider a reasonable range of alternatives violates NEPA.

ESA

Failure to Consult under Section 7 of the ESA

The Forest Service has failed to consult with the U.S. Fish and Wildlife Service (FWS) and/or the National Marine Fisheries Service (NMFS) under Section 7 of the ESA. To comply with the ESA, the Forest Service was required, at a minimum, to prepare, a biological assessment, given that listed species or critical habitat may be present over the 193 million acres of national forest lands that are impacted by the proposed Amendment.

ESA Section 7 requires that federal agencies, "in consultation and with the assistance of the Secretary [of the Interior], insure that any action authorized funded, or carried out by such agency . . . is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat." 16 U.S.C. § 1536(a)(2). To fulfill the consultation requirement, agencies must request information from the Department of the Interior about whether listed species or critical habitat may be present in the area of a proposed action. *Id.* § 1536(c). If listed species or critical habitat may be present, the agency must conduct a biological assessment. *Id.* If, based on the biological assessment, the agency concludes that the action is likely to adversely affect listed species or critical habitat, it must undergo formal consultation with the FWS and NMFS, which includes preparation of a Biological Opinion. *See* 50 C.F.R. § 402.14.

Here, the Forest Service failed to follow the ESA's consultation requirements. The Forest Service determined that Section 7 consultation "*was not warranted* for the old-growth amendment at this time." DEIS at S-11 (emphasis added). The Forest Service inappropriately concluded that "reasonable certainty of effects to species does not exist because of the national scale and programmatic nature of the old-growth amendment." *Id*. However, the Forest Service never made its ESA-mandated threshold request to the Secretary of the Interior of whether listed species or critical habitat "may be present" in the proposed action area. Given that the proposed Amendment encompasses 128 LMPs and hundreds of millions of acres, it is indisputable that listed species and critical habitat are present and implicated by the proposed Amendment. The Forest Service simply ignored its obligations to prepare a biological assessment to determine whether formal consultation is necessary. Nor did the Forest Service attempt to request a concurrence letter from the FWS or NMFS.

The Forest Service's contention that the national scope of the proposed Amendment relieves the agency of its ESA obligations has no legal support. There is no authority under the ESA or relevant case law to support the Forest Service's desire to circumvent its ESA obligations simply because the proposed action has a broad geographic scope. In fact, FWS and NFFS's Consultation Handbook acknowledges that consultation is required for forest plan amendments, like the proposed Amendment. *See* Consultation Handbook at 5-7; *id.* at xxii (acknowledging that certain types of national or regional agency actions can have a streamlined consultation process but they are not exempted).[23] The Forest Service's rationale that Section 7 consultation is not required because effects are unknown is also contradicted by the DEIS itself, which includes an entire section that evaluates effects on endangered species. The analysis itself is deficient because, among other reasons, it fails to address the harm to wildlife caused by increased fuels loads that result from constraining timber harvest and other active management in additional areas. The analysis clearly underscores the need for an effects analysis under Section 7.

The Forest Service claims that it "commits" to Section 7 consultation for any future old-growth conservation actions "where impacts to listed species would occur." The ESA does not allow for a wait and see approach. Rather, it prohibits "Federal agencies from 'steamrolling' activity in order to secure completion of the [proposed action] regardless of their impact on endangered species." *N. Slope Borough v. Andrus*, 486 F.Supp.332, 356 (D.D.C.), *order vacated in part sub*

[23] U.S. Fish and Wildlife Serv. and Nat'l Marine Fisheries Serv., *Endangered Species, Consultation Handbook, Procedures for Conducting Consultation and Conference Activities Under Section 7 of the Endangered Species Act* (Mar. 1998), https://www.fws.gov/sites/default/files/documents/endangered-species-consultation-handbook.pdf. (last visited Sept. 17, 2024).

nom. Nat'l Wildlife Fed'n v. Andrus (D.C. Cir. July 8, 1980), and *aff'd in part, rev'd in part,* 642 F.2d 589 (D.C. Cir. 1980); *see* 16 U.S.C. § 1536(d).

The proposed Amendment would select national management directives from among alternatives, and thus plainly foreclose alternative management regimes. In sum, the Forest Service has failed to comply with the ESA. While formal consultation and a Biological Opinion are clearly required, the Forest Service has failed to even prepare a biological assessment to determine whether formal consultation with the FWS or NMFS is necessary or seek a concurrence letter finding that formal consultation is not necessary. *See, e.g.*, *Friends of Clearwater v. Petrick*, 588 F.Supp.3d 1071, 1085 (D. Idaho Mar. 2, 2022) ("The plain language of the statute and regulation thus set out a simple two-step process for an action agency to comply with section 7(c)(1): receive an adequate list and prepare biological assessments for any species on that list.").

<u>Significant Regulatory Action Subject to OMB Review</u>

EO 12866, as amended by EO 14094,[24] requires federal agencies to assess the potential costs and benefits of "significant" rules and submit this assessment, along with each rule, to OMB's Office of Information and Regulatory Affairs for review.[25] EO 14094 defines "significant regulatory action" as any regulatory action that is likely to result in a rule that may, among other things, "*have an annual effect on the economy of $200 million or more*"; or may "adversely affect *in a material way* the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, territorial, or tribal governments or communities." 88 Fed. Reg. 21,879, 21,879 (Apr. 6, 2023) (emphases added).[26] The Forest Service is required to consider the costs and benefits of the proposed Amendment, which is a significant regulatory action that is expected to have large economic effects, and to design the proposed Amendment in a cost-effective manner to ensure that the benefits of its action justify the costs.

The Forest Service has not completed any meaningful analysis of the significant economic impacts the proposed Amendment would have on the local and national economies dependent on timber harvest. The proposed Amendment expressly revises Standard 3 (NOGA-FW-STD-03), which has been "completely reworded" so that active forest management in old-growth forests "shall not be for the purpose of timber production as defined in 36 CFR 219.19." DEIS at 49. Though the DEIS cites and incorporates the agency's "SocioEcon and Cultural Impacts Analysis Report" (SocioEcon and Cultural Report, DEIS at 1), the DEIS and the Report couches the proposed Amendment's economic impacts primarily in terms of recreation and sustainability, *not* in terms of the real economic losses—direct and indirect, immediate and long-term—from the loss of timber harvest and wood products production.[27]

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[24] Proclamation No. 14094, *Modernizing Regulatory Review*, 88 Fed. Reg. 21,879 (Apr. 6, 2023) (EO 14094).
[25] *See* Cong. Rsch. Serv., *Cost-Benefit Analysis in Federal Agency Rulemaking* (Mar. 8, 2022), https://crsreports.congress.gov/product/pdf/IF/IF12058 (last visited Sept. 17, 2024).
[26] Section 1(b) of EO 14094, which amends section 3(f) of EO 12866.
[27] U.S. Dep't of Agric., Forest Serv., *DRAFT Social, Economic and Cultural Impacts Analysis Report for the Draft EIS for Amendments to LMPs to Address Old-Growth Forests Across the NFS* (June 2024), https://usfs-

The Forest Service expressly states that the proposed Amendment, "as currently proposed, would prohibit vegetation management within old-growth forest conditions when the purpose is to grow, tend, harvest, or regenerate trees for economic reasons."[28] But the DEIS concludes, without support, that "the timber industry is unlikely to be impacted by the amendment, although regional impacts may occur," and "no effects are expected on traditional timber industry jobs in logging, wood product manufacturing, and pulp production." DEIS at S-14.

The Forest Service's conclusions are internally inconsistent and patently false, given that the forest products industry will be affected by the proposed Amendment. As outlined above and contrary to the Forest Service's assertions, the proposed Amendment will effectively modify timber suitability and alter PSQs on an undisclosed amount of NFS acres. The direct effects to the forest products industry as a result of these changes can be assessed by considering the impacts to the industry following past amendments with similar components. The NWFP, which amended 19 LMPs, also drastically modified timber suitability and PSQs and serves as a reasonable comparison for effects on the timber industry.

The NWFP 10-Year Monitoring Report[29] on socioeconomics analyzed and summarized the immediate effects of the authorization and implementation of that Plan. It concluded that "Federal timber supplies dropped over the course of the 1990s, and federal agencies did not produce anticipated PSQ volumes. Thirty thousand direct timber industry jobs were lost between 1990 and 2000 in the Plan area. About 19,000 of these jobs were lost between 1990 and 1994, and the main cause was reduced timber supplies across ownerships." It went on to state that "**Roughly 11,400 of the lost jobs can be attributed to cutbacks in <u>federal harvests</u>**." Finally, it concluded that "40 percent of the communities within 5 miles of FS- or BLM-managed lands had decreases in socioeconomic well being between 1990 and 2000." NWFP 10-Year Monitoring Report at 13. These effects to the forest products industry and the rural communities where they are primarily located should have been analyzed in the DEIS as the proposed Amendment's impacts to those resources will be similar to those impacts imposed by the NWFP 30 years ago.

A 2010 report by Paul F. Ehinger & Associates summarized mill closures and job losses in five states from 1990 to 2010.[30] Closures in three of those states, Washington, Oregon, and California, were located in the footprint of the NWFP. A total of 327 mills in those states closed during this time period, resulting in the loss of 29,131 jobs. These closures and job losses were at least partially a function of the NWFP Amendment that significantly reduced PSQs through the establishment of millions of acres of reserves where timber production was prohibited.

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public.app.box.com/v/PinyonPublic/file/1566823060212 (last visited Sept. 17, 2024) (SocioEcon and Cultural Report).

[28] U.S. Dep't of Agric., Forest Serv., *National Old-Growth Amendment* https://leg.mt.gov/content/Committees/Interim/2023-2024/Environmental-Quality-Council/EQC_Meetings/2024-June-17/Old-Growth-Amendment-USFS.pdf (last visited Sept. 17, 2024).

[29] Susan Charnley, et al., *Northwest Forest Plan, The First 10 Years (1994-2003), Socioeconomic Monitoring Results, Volume I: Key Findings* (Apr. 2006), https://www.fs.usda.gov/pnw/pubs/pnw_gtr649.pdf (last visited Sept. 17, 2024).

[30] Paul F. Ehinger and Assocs., *Summary Description of Mill Closure Data From 1990 – 2010*, (Dec. 15, 2010) https://amforest.org/wp-content/uploads/2016/01/Mill_Closures.pdf (last visited Sept. 17, 2024).

Comparable outcomes resulting from the proposed Amendment are likely, given the similar restrictive nature of both amendments. Denying this reality is deeply offensive to the tens of thousands of workers, families, and businesses in the West and beyond that rely on federal land management for their livelihoods and purpose.

The Forest Service is required to give *substantive* consideration of the social and economic sustainability of the proposed Amendment, including analytical requirements, which the agency has not done here. 36 C.F.R. § 219.8(b). Nor has the Forest Service submitted the proposed Amendment for analysis by the OMB.

EO 12866 requires agencies to conduct a regulatory analysis for regulatory actions that are significant, and a benefit-cost analysis is the primary analytical tool used for that analysis.[31] EO 12866 requires that agencies "shall assess both the costs and the benefits of the intended regulation and, recognizing that some costs and benefits are difficult to quantify, propose or adopt a regulation *only upon a reasoned determination that the benefits of the intended regulation justify its costs*." 58 Fed. Reg. 51,735, 51,736 (Oct. 4, 1993) (Section 1(b)(6)) (emphasis added). Further, EO 14094 directs that "[r]egulatory analysis, as practicable and appropriate, *shall recognize distributive impacts and equity*, to the extent permitted by law." 88 Fed. Reg. 21,879, 21,879 (Apr. 6, 2023) (emphasis added).

Not only is the DEIS devoid of any discussion of the real economic impacts the proposed Amendment will have to the timber industry and the local and national economics it supports, it makes no mention of satisfying the requirements of EO 12866 or OMB review. Further, the SocioEcon and Cultural Impacts Analysis Report makes only one mention of EO 12866, SocioEcon and Cultural Report at 77, completely omitting EO 12866's requirements, makes no mention of EO 14094, and provides no responses to the requirements of either EOs, the significance monetary threshold, or meaningful analysis of the potential economic impacts of the proposed Amendment. Had the Forest Service properly accounted for those impacts, the results would meet that threshold and require OMB review.

Conclusion

The forest products sector, including AFRC and its members, are partners of the Forest Service who can help advance its mission to improve the health and productivity of NFS lands. We are also integral to mitigating the most immediate threats to our national forests and public health: wildfires, insects and disease infestations, and toxic smoke polluting our air and impacting our most vulnerable populations. We spend a significant amount of time and energy each year advocating on behalf of the Forest Service to provide the agency with adequate funding and the necessary tools to help it navigate a labyrinth of regulations and standards that stand in the way of meeting its mission and addressing these threats. We make every effort to remove barriers that inhibit the Forest Service's ability to effectively manage NFS lands. We work closely with local units to assist and support them in their efforts to implement treatments that align with these goals. Unfortunately, this proposed Amendment runs counter to each of these efforts by

[31] *See* Off. of Mgmt. and Budget, *Circular No. A-4, Regulatory Analysis* (Nov. 9, 2023) https://www.whitehouse.gov/wp-content/uploads/2023/11/CircularA-4.pdf (last visited Sept. 17, 2024) (providing the most recent guidance to agencies on the development of regulatory analysis required under EO 12866).

creating new barriers and additional layers of complexity to an already failing management paradigm. As such we are unable to find a path forward through the proposed action alternatives that we can wholly support.

Ultimately, we urge the Forest Service to select Alternative 1, the no-action alternative. The Forest Service should reconsider its current approach; meaningfully address the legal, policy, public engagement, and scientific concerns outlined above; and determine if the current process and alternatives are the best and only way forward to achieve its goals. However, we suspect that such a decision is unlikely at this point. If the Forest Service does select one of the action alternatives, we strongly urge the Forest Service to consider the immediate impacts to projects currently in the NEPA planning process. It would be prudent for the Forest Service to include explicit language in the final decision that allows those projects to proceed unaffected by the impending Amendment. A widespread "reset" of hundreds of projects, most of which are designed to reduce the risk of high severity wildfire, would be disastrous to the forest sector infrastructure and workforce, the Forest Service's other partners, the health and resiliency of the NFS, and America's rural, forested communities.

Sincerely,

Travis Joseph
President/CEO

Alabama Forestry Association
Alaska Forest Association
American Loggers Council
American Walnut Manufacturers Association
Associated California Loggers
Association of Consulting Foresters
Associated Logging Contractors of Idaho
Associated Oregon Loggers
California Farm Bureau
California Forestry Association
Congressional Sportsmen's Foundation
Douglas Timber Operators
Federal Forest Resource Coalition
Forest Landowners Association
Forest Resources Association
Great Lakes Timber Professionals Association
Harney County, Oregon
Indiana Hardwood Lumberman's Association
Intermountain Forest Association/Black Hills Forest Resource Association

Minnesota Forest Industries
Missouri Forest Products Association
Montana Logging Association
Montana Wood Products Association
Mountain States Legal Foundation
North Carolina Forestry Association
Oregon Forest Industries Council
Skamania County, Washington
United Brotherhood of Carpenters
Washington Contract Loggers Association
Washington Forest Protection Association

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ATTACHMENT A

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policy

A Restoration Framework for Federal Forests in the Pacific Northwest

Jerry F. Franklin and K. Norman Johnson

We outline elements of a forest restoration strategy designed to produce ecological and economic benefits on federal forests in Oregon and Washington, along with some of their policy and management implications. Implementation of this restoration strategy has begun on 11 projects (at scales from hundreds to thousands of acres) on federal lands. On Moist Forest sites (MF), the strategy calls for reserving older forest stands, thinning plantations to accelerate development of structural complexity, and implementing variable retention harvests in younger forests to help provide diverse early seral ecosystems. On Dry Forest (DF) sites, the strategy calls for silvicultural treatments that retain and release older trees, reduce stand densities, shift composition toward fire- and drought-tolerant tree species, and incorporate spatial heterogeneity at multiple spatial scales. Immediate goals of this restoration framework include increased ecological integrity and resilience in DFs, increased diversity and complexity of successional stages in MFs, and provision of wood products to local communities. Over the long run, we believe this program can provide an acceptable pathway to sustained yield on federal forestlands in the Pacific Northwest.

Keywords: Dry Forest, forest restoration, Moist Forest, northern spotted owl, old-growth, retention harvest

In the last few years, we have reported to members of the US Congress and the US Department of the Interior Secretary of Interior on the potential of developing management strategies in the Pacific Northwest (PNW) that integrate old-growth protection with other ecological and economic benefits on federal lands.[1] As with much of the western United States, extensive forestlands in the PNW are controlled by the federal government (Figure 1), and their use and management has long fueled conflicts between different groups and agencies. Recent successes with the thinning of plantations in western Oregon and Washington and fuel reduction projects in the wildland-urban interface by the USDA Forest Service in eastern parts of those states have helped to build public trust (Thomas et al. 2007, Toman et al. 2011) and we seek to build on those successes.

Ecological restoration on public lands, as suggested here, represents more than an academic exercise—it has become a sociopolitical reality. In fact, comprehensive ecological restoration is becoming the foundation of federal land management across the nation (e.g., Bosworth 2006). In 2009, the USDA Secretary of Agriculture announced a restoration vision for the national forests (Vilsack 2009), ultimately reinforced in the recently adopted US Forest Service planning rule (USDA 2012). Furthermore, activities to sustain habitat and restore ecosystem health are emphasized in the new northern spotted owl (NSO; *Strix occidentalis caurina*) recovery plan, which describes the restoration of ecosystem structures and processes as being good for NSO (USDI Fish and Wildlife Service 2011). In early 2012, the Secretary of Interior proposed expansion of ecological forestry projects in western Oregon to provide sustainable timber and healthier habitat (US Bureau of Land Management [BLM] 2012). These new projects will cover more than 5,000 ac and explore compatibility between forest restoration and protection of NSO.

But can restoration needs of federal forests in the PNW be fulfilled while also meeting other societal needs? Ecological restoration is grounded in principles of ecosystem science, including ecosystem dynamics, disturbance ecology, and landscape ecology. However, restoration activities will have to provide economic returns if they are to be widely implemented, with such benefits typically coming from commercial timber harvest. Indeed, shrinking federal budgets will require that restoration activities be at least partially self-supporting, if large-scale restoration is going to occur. Furthermore, significant skepticism about the effectiveness of

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AFRC Comments
Attachment A - Pg. 1

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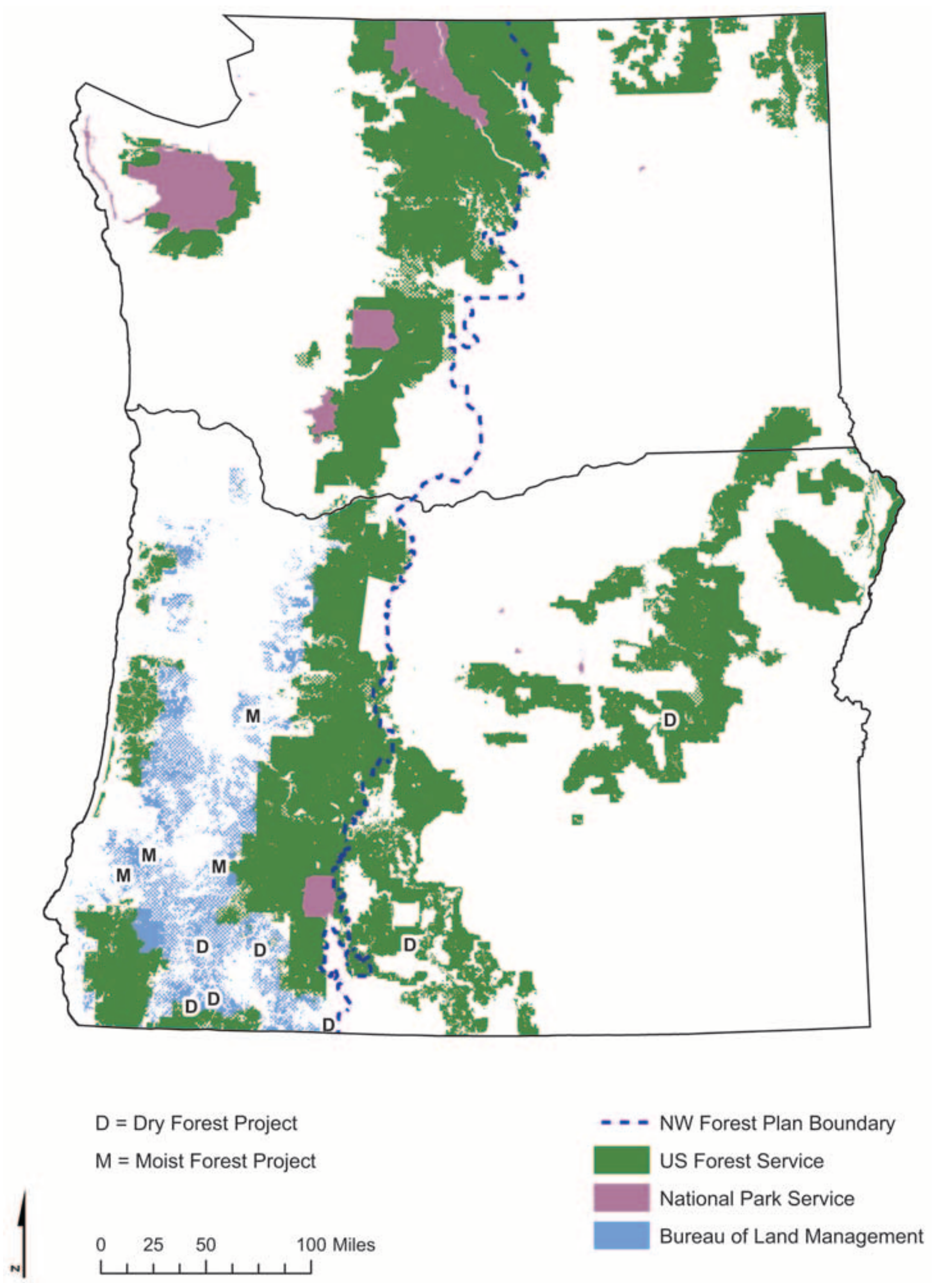

Figure 1. Distribution of federal forestlands in the PNW showing locations of projects demonstrating the restoration principles discussed in this article. (D. Johnson, Applegate Forestry, provided this figure.)

ecosystem restoration must be overcome, even though the general concept enjoys wide public support (Shindler and Mallon 2009).

A Strategic Restoration Framework

We begin with the following definition provided by the US Forest Service (USDA 2012, p. 21272) in its new planning rule:

> [Restoration is] the process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed. Ecological restoration focuses on reestablishing the composition, structure, pattern, and ecological processes necessary to facilitate terrestrial and aquatic ecosystems sustainability, resilience, and health under current and future conditions.

In applying this definition we emphasize several elements. First, restoration should focus on entire ecosystems rather than individual attributes, such as fuels. Programs with singular resource objectives generally marginalize other important values (e.g., Gunderson et al. 1995), resulting in less resilient ecosystems and communities. Focusing broadly on restoring ecosystems serves a wider range of natural resource and stakeholder interests. Second, restoration should center on restoring resilience and functionality in the context of desired future conditions, even while learning from the past. Attempting to return landscapes to a given historical state is unlikely to create either resilience under current and future conditions or socially desirable outcomes (Hobbs et al. 2011). Third, restoration efforts should prioritize the most degraded environments. By "degraded" we mean, e.g., ecosystems where human activities have increased the risk of catastrophic disturbances or created extensive landscapes deficient in important successional stages, such as early seral and old-growth ecosystems. Finally, any comprehensive restoration effort must recognize differences among ecosystems and set treatment goals accordingly—a one-size-fits-all approach will almost certainly fail. Hence, we divide PNW federal forestlands into "moist forests" (MF) and "dry forests" (DF) because these contrasting environments require fundamentally different policies and practices, including approaches to old-growth conservation.

Defining MFs and DFs

The DF and MF classification of federally controlled forests with which we begin is a more appropriate ecological stratification than the traditional categorization of PNW forests as "westside" and "eastside." Rather than using geography, we used scientifically defined plant associations to assign forest sites to their respective DF and MF categories (Table 1), with both conditions occurring on both sides of the Cascade Range. These plant associations reflect distinctive compositions, growth conditions, and historical disturbance regimes (e.g., Atzet et al. 1992), such as broad gradients in fire behavior in PNW forests that reflect variability in both site and landscape conditions. Another advantage to plant associations is that they are readily identifiable in the field by trained resource professionals.

MF and DF sites have contrasting historic disturbance regimes. Historically, MFs generally experienced large infrequent (intervals of one to several centuries) wildfires, which included extensive areas where fire severity resulted in stand-replacement conditions (Agee 1993). DF sites experienced predominantly low- and mixed-severity fire behaviors at frequent (e.g., 5–35 year) intervals (Agee 1993, Perry et al. 2011). Some plant associations currently straddle the boundary between MF and DF stratifica-

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Table 1. Assignment of plant association series and groups to MF and DF categories. Moist grand and white fir associations are intermediate and may be appropriately considered as either MF or DF, depending on circumstances.

MF	
	Western hemlock (*Tsuga heterophylla*) series
	Sitka spruce (*Picea sitchensis*) series
	Western redcedar (*Thuja plicata*) series
	Pacific silver fir (*Abies amabilis*) series
	Mountain hemlock (*Tsuga mertensiana*) series
	Subalpine fir-Engelmann spruce (*Abies lasiocarpa-Picea englemanni*) series
	Tanoak (*Lithocarpus densiflorus*) series
	Moist grand fir (*Abies grandis*) Plant Association Group
	Moist white fir (*Abies concolor*) Plant Association Group
DF	
	Ponderosa pine (*Pinus ponderosa*) series
	Oregon white oak (*Quercus garryana*) series
	Douglas-fir (*Pseudotsuga menziesii*) series
	Jeffrey pine (*Pinus jeffreyi*) series
	Dry grand fir Plant Association Group
	Dry white fir Plant Association Group

tion, but climate change is expected to increasingly shift these associations toward DF status with projected increases in wildfire frequency (e.g., Dello and Mote 2010, Spies et al. 2010).

Characteristics and Current State of MFs

MF ecosystems undergo many centuries of stand development and change after major disturbances, such as severe wildfire or windstorm, before achieving the massiveness and structural complexity of old-growth forests (Franklin et al. 2002). Ecosystem development is relatively well understood, with distinctive early seral, young, mature, and old stages (Franklin et al. 2002; Figure 2); intermediate disturbances can alter developmental patterns (Franklin and Spies 1991, Spies 2009).

Composition, structure, and function of existing unmanaged old-growth MFs generally are relatively unaffected by human activities, except at stand edges (Forest Ecosystem Management Assessment Team 1993). Management activities in these existing old-growth MFs, such as thinning, are not needed to sustain conditions in these forests and can actually cause old-growth MFs to diverge widely from natural forests in structure and function or become destabilized (Franklin et al. 2002). Wildfire suppression is typically consistent with efforts to retain such forests—i.e., it is not known to result in significant changes in MF ecosystems (Agee 1993).

Restoration may be needed in MF landscapes in which old-growth stands are embedded, however. Many MF landscapes are currently dominated by dense young plantations, which are low in biodiversity and deficient in the early (preforest) and late (mature and old-growth) successional stages, which are richest in biodiversity. Late-successional MFs provide habitat for thousands of species including the NSO and other habitat specialists (Forest Ecosystem Management Assessment Team 1993); past timber harvests have greatly reduced their extent and continuity (e.g., Wimberly 2002, Spies et al. 2007). Continued decline in NSO populations across much of its range have heightened the importance of retaining the remaining late-successional forests (Forsman et al. 2011).

Early successional or seral MF sites are highly diverse, trophic- and function-rich ecosystems that occur after a severe disturbance but before the reestablishment of a closed forest canopy (Greenberg et al. 2011, Swanson et al. 2011). Theoretically, disturbances of either natural (e.g., wildfire) or human (e.g., timber harvest) origin are capable of generating this stage. Large natural disturbances often produce high-quality early seral ecosystems provided they are not intensively salvaged and replanted (Swanson et al. 2011), but such disturbances are poorly distributed in time and space. For example, less than 1% of suitable NSO habitat (complex forest) was transformed by wildfire into early successional habitat between 1996 and 2006 in MF-dominated provinces of the Northwest Forest Plan (NWFP; USDI Fish and Wildlife Service 2011). Areas devoted to intensive timber production generally provide little high-quality early seral habitat for several reasons. First, few or no structures from the preharvest stand (e.g., live trees, snags, and logs) are retained on intensively managed sites but are abundant after severe natural disturbances (Swanson et al. 2011). Additionally, intensive site preparation and reforestation efforts limit both the diversity and the duration of early seral organisms, which may also be actively eliminated by use of herbicides or other treatments (Swanson et al. 2011). Consequently, many MF landscapes currently lack sufficient representation of high-quality early seral ecosystems because of harvest, reforestation, and fire suppression policies on both private and public lands (Spies et al. 2007, Swanson et al. 2011). Functional early seral habitat can be created using regeneration harvest prescriptions that retain biological legacies and use less intensive approaches to reestablishment of closed forest canopies, as discussed later.

Characteristics and Current State of DFs

Historical forest conditions on DF sites have been extensively summarized (e.g., Noss et al. 2006, Courtney et al. 2008, and Johnson et al. 2008). Low tree densities and dominance by larger, older trees of fire- and drought-resistant species, such as ponderosa pine (*Pinus ponderosa*) and western larch (*Larix occidentalis*), characterized many DF sites (Munger 1917, Youngblood et al. 2004, Spies et al. 2006, Kolb et al. 2007, Johnson et al. 2008; Figure 3). Spatial heterogeneity, including fine-scale low-contrast structural patchworks, was also characteristic (Franklin and Van Pelt 2004, Larson and Churchill 2012) (Figure 3). Denser, more even-structured stands, consisting of mixtures of Douglas-fir (*Pseudotsuga menziesii*), grand fir (*Abies grandis*), western larch, and ponderosa pine, occurred and even dominated some DF landscapes as a result of more severe fires and insect epidemics (e.g., Hessburg et al. 2005, 2007).

Composition and structure of existing DF landscapes have been dramatically altered by decades of fire suppression, grazing by domestic livestock, timber harvesting, and plantation establishment (Noss et al. 2006) resulting in (1) many fewer old trees of fire-resistant species, (2) denser forests with multiple canopy layers, (3) more densely forested landscapes with continuous high fuel levels, and, consequently, (4) more stands and landscapes highly susceptible to stand-replacement wildfire and insect epidemics (e.g., Hessberg et al. 2005, Noss et al. 2006). Outbreaks of western spruce budworm (*Choristoneura occidentalis*) and other defoliators are currently widespread in mature stands of grand fir and Douglas-fir and have been for over 30 years. In southwestern Oregon, DF sites that have not been previously harvested are largely occupied by dense maturing Douglas-fir stands, which appear to be the first generation of closed conifer forests on many of these sites. Historically, these DF landscapes were occupied by diverse communities including open grasslands, shrub fields, oak savannas, and mixed hardwood and conifer woodlands (McKinley and Frank 1996).

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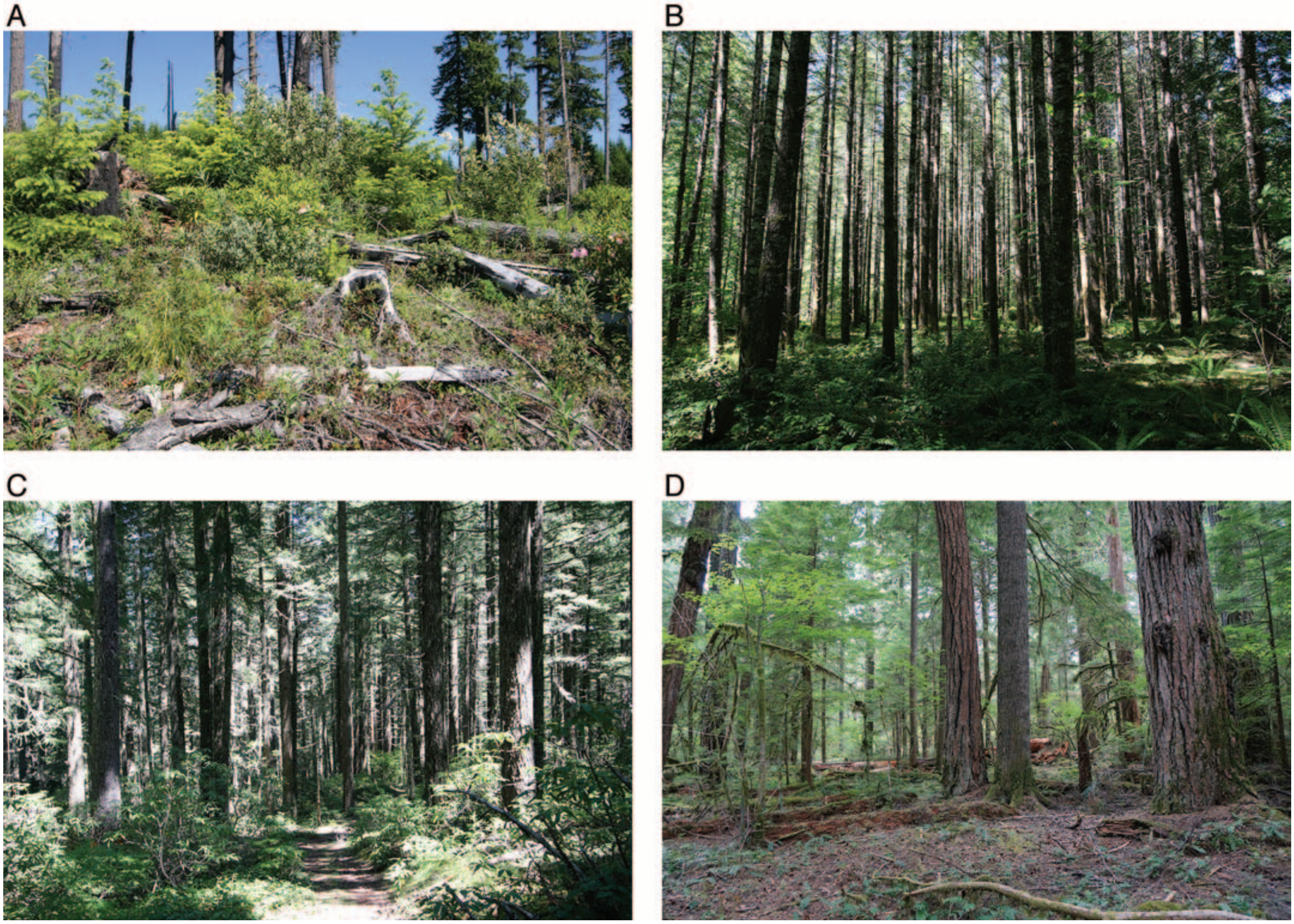

Figure 2. Major stages in MF development after a stand-replacement event. (A) Early seral or preforest ecosystem dominated by diversity of plant life forms. (B) Young forest ecosystem dominated by Douglas-fir with high stem densities and a closed forest canopy. (C) Mature forest ecosystem dominated by Douglas-fir, which is undergoing reestablishment of the understory community, including regeneration of shade-tolerant tree associates. (D) Old forest ecosystem dominated by mixture of tree species, including Douglas-fir and western hemlock, with a diverse and spatially variable understory of cryptogams, ferns, herbs, shrubs, and small trees.

Ecological Forestry as a Basis for Restoration Prescriptions

Our silvicultural proposals are based on "ecological forestry" concepts, which incorporate principles of natural forest development, including the role of natural disturbances in the initiation, development, and maintenance of stands and landscape mosaics (Seymour and Hunter 1999, North and Keeton 2008, Bunnell and Dunsworth 2009, Long 2009). Key elements of ecological forestry include (Lindenmayer and Franklin 2002, Franklin et al. 2007) (1) retaining structural and compositional elements of the preharvest stand during regeneration harvests (Franklin et al. 1997, Gustafsson et al. 2012); (2) using natural stand development principles and processes in manipulating established stands to restore or maintain desired structure and composition; (3) using return intervals for silvicultural activities consistent with recovery of desired structures and processes; and (4) planning management activities at landscape scales, using knowledge of spatial pattern, and ecological function in natural landscapes.

Protection of Older Stands and Trees

Elements of ecological forestry differ in their application, even though they share a common theme. For example, management of old trees and stands would vary as a function of forest type. On MF sites, older forest stands on federal lands are retained under our restoration strategy because of their ecological and social significance, whether they are located inside or outside of current reserves. In addition, older trees in any treated younger MF stands are also retained. On DF sites, older trees are retained under our restoration strategy, regardless of their size. On these sites, the focus is on individual old trees rather than stands because active management is often necessary to restore DF stands to more resilient conditions, including enhancement of the survival of old trees.

In the PNW, the occurrence of older trees and forests currently is far below the historic range of variability, despite their ecological importance (Spies 2009). Decades of legal battles over older stands and trees are clear evidence of societal interest in them; these conflicts have perpetuated stakeholder distrust of foresters and diverted attention from restoration (Thomas et al. 2007, Spies et al. 2009). Although it seems straightforward, classifying trees or stands as old is not a simple task. The age at which forests are deemed "older" is a social decision, influenced but not defined by scientific input, with age a commonly used surrogate in determining which forests are going to be

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Figure 3. Dry Forest dominated by ponderosa pine illustrating the fine-scale mosaic that includes openings and patches dominated by tree reproduction and by mature and old trees; such conditions were historically characteristic of many, but not all, DF landscapes (Yakima Indian Reservation, Washington).

Table 2. Some distinguishing characteristics of old conifers of ecological significance.

Heartwood accumulations and development of thick fire-resistant bark (Van Pelt 2008)
Abundant microhabitats important for maintaining biodiversity (Michel and Winter 2009)
Highly individualistic canopies including large branches, epicormic branch systems, and multiple tops (Van Pelt 2008, Van Pelt and Sillett 2008)
Presence of cavities, pockets of decayed wood, and brooms (Van Pelt 2008)

Table 3. Elements of MF restoration strategy.

Retain existing older stands and individual older trees found within younger stands proposed for management, using a selected threshold age
Accelerate development of structural complexity in younger stands, using diverse silvicultural approaches (Bailey and Tappeiner 1998, Garman et al. 2003, Carey 2003, Wilson and Puettmann 2007)
Implement variable retention regeneration harvests (Franklin et al. 1997, Beese et al. 2003, Franklin et al. 2007, Gustafsson et al. 2012) in some younger MFs, retaining such structures as individual trees, snags, and logs and intact forest patches
Accommodate development of diverse early seral ecosystems following harvest, by using less intense approaches to site preparation and tree regeneration
Embed preceding objectives in a silvicultural system that includes creation and management of multiaged, mixed-species stands on long rotations (e.g., 100–160 yr)

preserved from timber harvest. Age limits can also vary based on ecological thresholds, management objectives, and ease of implementation. For example, in a prior analysis we have used 80, 120, and 160 years to identify "older" in MFs (Johnson and Franklin 2009), an age range that goes from retaining all late-successional forests (80), to retaining most mature and all old-growth forests (120) or (at a threshold age of 160) retaining the oldest mature and all old-growth forests.

Given the importance of age, the initial selection of individual trees for retention in treated DFs is based on age rather than size—i.e., we use an age limit rather than a diameter limit.[2] Diameter limits can result in undesirable outcomes in DF restoration, such as by allowing removal of small older trees important to stand complexity and function. Diameter limits also can prohibit removal of large young trees that provide ladder and crown fuels and competition, thereby increasing the potential for wildfire or drought to kill old trees (McDowell et al. 2003, Johnson et al. 2008). We also do incorporate retention of younger, larger-diameter trees for wildlife and other purposes in our prescriptions, especially when they offer no threat to older trees.

Our focus on older trees rather than simply larger ones is because older trees have distinctive ecological characteristics and functions. Older trees are not simply larger versions of young trees. Trees acquire distinctive physiological and structural features from the aging process and responses to physical and biotic damage (e.g., wind, disease, parasites, and insects; Table 2). Such characteristic features of old trees (often including their larger size) make them structural cornerstones in forests, contributing to ecosystem services, such as wildlife habitat, resistance to fire and drought, and genetic reservoirs, and require centuries to replace.

MF Restoration Strategy

Our MF strategy focuses on increasing the underrepresented late-successional forests and early seral ecosystems (Table 3). Demonstration projects using these MF regeneration harvest principles are underway on the Roseburg and Coos Bay Districts of the BLM and at least two more projects are being planned (Figure 1; Wheeler 2012). As mentioned earlier, older forest stands on MF sites on federal lands will be retained (both inside and outside of current reserves) to protect their ecological and social significance. The MF strategy also includes the thinning of younger forests to accelerate development of structural complexity characteristic of older forest stands.

The most potentially controversial element of our MF restoration strategy is resumption of regeneration harvesting in younger stands using variable retention prescriptions (Figure 4). One specific objective of these harvests is to provide for continued creation of diverse early seral ecosystems in MF landscapes, as a part of a silvicultural system that includes management of mixed-age, mixed-species forests over long (e.g., 100–160 years) rotations. Very few regeneration harvests are currently planned in federal MFs in the PNW, outside of the projects described in this article, primarily because past proposed harvests in mature and old-growth stands have been litigated consistently. Existing timber harvests are currently confined to thinning younger stands (Baker et al. 2006, Thomas et al. 2007).

We expect the resumption of regeneration harvests on federal lands to be controversial partly because stakeholders usually equate it with the unpopular practice of clearcutting (Bliss 2000). However, we propose using variable retention harvesting and not clearcutting; these are very different approaches. Unlike conventional clearcuts, variable retention harvests incorporate significant elements of the preharvest stand

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A

B

Figure 4. Ground and aerial views of variable retention regeneration harvest units. (A) Retention harvest unit with approximately 15% of the preharvest forest left in undisturbed patches or "aggregates," which include a diversity of structures (e.g., live trees, snags, and down logs). (B) Retention harvest unit with approximately 15% of the preharvest forest left in undisturbed patches of varying size, including some associated with protection of riparian and stream habitat. (Photo courtesy of Washington State Department of Natural Resources.)

through the next rotation, including undisturbed forest patches and individual live and dead trees, to enrich the biodiversity, ecological processes, and structural diversity of the postharvest stand (Franklin et al. 1997, Gustafsson et al. 2012, Lindenmayer et al. 2012; Figure 4). Our current proposal for MF regeneration harvest calls for retention of approximately 30% of the preharvest stand as patches, plus some additional retention (typically of green trees that are intended to become snags and logs) on harvested portions of the units. With these biological legacies and the significant open areas created by the harvesting, variable retention harvests provide optimal conditions for (1) development of diverse early seral ecosystems needed by significant elements of regional biodiversity (Swanson et al. 2011), (2) regenerating new cohorts of desirable shade-intolerant tree species, and (3) providing substantial flows of wood products. We view younger, previously harvested stands as the obvious candidates for regeneration harvests, given current levels of older forests are far below historic levels and policy direction calls for their retention as NSO habitat (USDI Fish and Wildlife Service 2011).

DF Restoration Strategy

Elements of this DF restoration strategy, including stand-level treatments and retention of dense forest habitat patches at the landscape level, have been or are currently being incorporated into projects on federal lands (e.g., Ager et al. 2007, Gaines et al. 2010, Brown 2012). Projects (Figure 1) using our DF principles are underway on BLM lands in southwestern Oregon, where the NSO is featured (Reilly 2012), the Malheur National Forest in central Oregon (Brown 2012), and the Fremont-Winema National Forest in south-central Oregon. DF restoration has a number of important stand- and landscape-level elements (Table 4; also see North et al. 2009 and Larson and Churchill 2012). Many DFs need silvicultural treatments to restore more resistant and resilient conditions, although details of prescriptions will vary with specific management objectives, plant associations, stand conditions, and landscape contexts.

The retention and nurturing of older trees and other significant structural elements of the DF stand is the starting point for this restoration strategy. Although many DFs include older trees, almost all such forests are highly modified structurally and compositionally by past management, which has greatly reduced older tree populations and increased stand densities. Currently, both remaining old trees and the forests in which they are embedded are at risk from intense wildfires, epidemics of defoliating insects, and competition, the latter resulting in accelerated mortality due to bark beetles (Noss et al. 2006, Courtney et al. 2008, Franklin et al. 2008). Selection of the threshold age for older trees is particularly important for DFs, because it is applied to all DF stands. In our work we usually use 150 years as the threshold age for older trees

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Table 4. Elements of the DF restoration prescriptions.

Retain and improve survivability of older conifers by reducing adjacent fuels and competing vegetation—old trees can respond positively (e.g., McDowell et al. 2003)
Retain and protect other important structures such as large hardwoods, snags, and logs; some protective cover may be needed for cavity-bearing structures that are currently being used (e.g., North et al. 2009)
Reduce overall stand densities by thinning so as to (1) reduce basal areas to desired levels, (2) increase mean stand diameter, (3) shift composition toward fire- and drought-tolerant species, and (4) provide candidates for replacement old trees
Restore spatial heterogeneity by varying the treatment of the stand, such as by leaving untreated patches, creating openings, and providing for widely spaced single trees and tree clumps (Larson and Churchill 2012)
Establish new tree cohorts of shade-intolerant species in openings
Treat activity fuels and begin restoring historic levels of ground fuels and understory vegetation using prescribed fire
Plan and implement activities at landscape levels, incorporating spatial heterogeneity (e.g., provision for denser forest patches) and restoration needs in nonforest ecosystems (e.g., meadows and riparian habitats).

because (1) trees in DFs generally begin exhibiting some old-growth characteristics by this age and (2) significant Euro-American influences were underway by 1860, e.g., introduction of large domestic livestock herds (Franklin et al. 2008, Robbins 2009).

Other threshold ages for older trees could be considered in DFs, such as 100 and 200 years, but these introduce other problems. When 100 years is used as the threshold, many trees lacking old-growth attributes are retained, making it difficult to reduce stand densities to the desired levels. Additionally, this age threshold limits the removal of higher-valued trees and thus affects economic viability of treatments. Using 200 years, many trees that have old-growth cohort attributes will likely be removed, affecting the ecological value of the treatment. However, this age threshold would also allow harvest of more high-value trees, at least initially.

Retaining some denser forest areas in an untreated or lightly treated condition is a challenging landscape-level planning component of our DF restoration strategy. Most DF landscapes include species and processes that require denser forest as habitat, such as preferred nesting, roosting, and foraging habitat for NSO (USDI Fish and Wildlife Service 2011). Another more widely distributed example in PNW DFs is the northern goshawk (*Accipitor gentilis*; Crocker-Bedford 1990). Maintaining approximately one-third of a DF landscape in denser patches of multilayered forest has been proposed for the NSO (Courtney et al. 2008). In general, landscape amounts and distributions will be a function of topographic and vegetative factors along with wildlife goals. Untreated patches in the hundreds of acres could be preferentially located in less fire-prone areas, such as steep north-facing slopes, riparian habitats, and sites protected by natural barriers, such as lakes and lava flows. The longevity of the dense forest patches should be increased by restoring DF conditions in the surrounding landscape matrix (Agar et al. 2007, Gains et al. 2010). Losses of denser forest patches are inevitable, but—because the surrounding restored matrix still is populated with older, larger trees—suitable dense replacement habitat can be regrown within a few decades.

Ecological Forestry and Adaptive Management

Credible adaptive management will be essential to implementing our proposed restoration approach on federal forests in the PNW, because it includes significant new elements and affects the entire region. This is challenging because successful adaptive management has been limited in the PNW (Stankey et al. 2003, Bormann et al. 2007). Key elements include comprehensive regional analysis and planning, integrated monitoring and research activities, and systematic assessments of ecological and social outcomes by independent parties. Two elements requiring particular attention are (1) interactions between DF restoration and NSO populations and (2) effectiveness in creation of diverse early seral ecosystems using variable retention regeneration harvests.

Regional targets for total amount and spatial distribution of early seral ecosystems need to be scientifically assessed for the MFs on federal lands in the PNW. Determinations of natural range of variability of such habitat, such as has been done in the Oregon Coast Ranges (Wimberly 2002, Spies et al. 2007), is a good starting point. Additional focused research on early seral ecosystems is needed to (1) expand current knowledge of biodiversity and functions in early seral ecosystems of both natural and human origin and (2) explore different approaches (e.g., silvicultural prescriptions) for creating diverse early seral ecosystems.

Finally, road networks and plantation establishment after intensive harvesting have significantly affected both aquatic and forest ecosystems on both DF and MF landscapes (e.g., Franklin and Forman 1987, Forest Ecosystem Management Assessment Team 1993). Restoring aquatic and semiaquatic ecosystems is a high-priority restoration concern throughout federal forests, but one that we cannot adequately address in this short article. Reducing the impacts of permanent roads on aquatic ecosystems is an important objective, but it must be weighed against needed access for restoration projects and long-term management.

Harvest Potential

We have estimated (Johnson and Franklin 2009) that our restoration strategy could increase timber harvest from the federal forests of the PNW over the next 15 years, primarily by resuming regeneration harvests in MFs and expanding the extent of restoration treatments (i.e., partial cutting) in DFs.

Our MF strategy adds regeneration harvests in younger stands to current thinning. The economic viability of such sales in normal markets is unquestionable, because regeneration harvests remove larger volumes per acre and include larger trees than are produced in the currently thriving thinning programs. However, a critically important undetermined variable is the MF land base available for regeneration harvests for several reasons, including some related to the strategy itself. For example, initial estimates using unmanaged stands as models suggest that our proposed silvicultural system might provide one-half of the per acre yields expected under intensive timber production (Johnson and Franklin 2012). On the other hand, the significantly greater wildlife and environmental benefits from the variable retention approach may result in greater social acceptability of this approach and, consequently, significantly broaden the land base on which it could be applied.

Our DF strategy calls for shifting from fuel treatments, a current focus of DF federal actions, to broad-scale ecosystem restoration. Stand-level harvest implications are difficult to clarify. Basically, we call for creating a more heterogeneous spatial pattern than in current practice, while conserving old trees and removing diameter limits on harvest. However, some DF stands clearly are economically marginal with viability depending on market conditions and mill proximity (e.g., Adams and Latta 2005,

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Johnson and Franklin 2009). Mill closures east of the Cascades have accentuated this problem, making comprehensive restoration dependent on new infrastructure investments. Accurate assessments of feasibility and timber yields from DF restoration await empirical data from field trials, such as the projects in Oregon using our restoration strategy (e.g., Brown 2012).

Integrating Restoration Strategies with Existing and Emerging Forest Policies

How well do our proposals for conserving old-growth and restoring MFs and DFs interface with existing PNW federal policies? Where are they consistent with existing policies and where are adjustments needed? Three important current policies are (1) the NWFP, which was adopted in 1994 for all federal forests within the NSO range; (2) interim management guides developed in the mid-1990s for eastside national forests beyond the NSO range (USDA Forest Service 1995); and (3) new policies proposed in the NSO Recovery Plan (USDI Fish and Wildlife Service 2011) and proposed critical habitat for the NSO (USDI Fish and Wildlife Service 2012).

Moist Forests

Retaining older forests on MF sites is generally consistent with existing and emerging policy. Much late-successional forest (more than 80 years) was protected in the NWFP as late-successional reserves (LSR) and riparian reserves (Thomas et al. 2007), and most of the remaining older forests on MF sites was recently recommended for retention in the NSO Recovery Plan (USDI Fish and Wildlife Service 2012). Commercial thinning in plantations to increase structural complexity is generally consistent with the NWFP (USDA Forest Service and US BLM 1994) and the NSO Recovery Plan and draft critical habitat rules allow for these actions (USDI Fish and Wildlife Service 2011, 2012), although recent findings on the negative impact of such thinning on some prey species of the NSO may create new limitations on harvest activities (Manning et al. 2012).

However, there are numerous policy issues that surround implementation of the regeneration harvest component of our restoration strategy on MF sites. Three provisions from the planning regulations implementing the National Forest Management Act (NFMA) are especially important:

1. The revised NFMA planning rule calls for national forestland to be identified as not suitable for timber production if "There is no reasonable assurance that such lands can be adequately restocked within 5 years after final regeneration harvest" (USDA 2012, p. 21266).[3] The definition of "adequate restocking" adopted in the *Forest Service Handbook and Regional Direction* would need to accept the concept of relating adequacy of stocking to prescription goals, such as creation of diverse early seral ecosystems, to allow the restoration strategy described here.
2. The planning rule incorporates a sustained yield requirement: "The quantity of timber that may be sold from the national forest is limited to an amount equal to or less than that which can be removed from such forest annually in perpetuity on a sustained yield basis" (USDA 2012, p. 21267). The plan may depart from this limit under certain conditions and after allowing public comment, but calculation of the long-term sustained yield remains a foundational element in national forest planning. Regeneration harvests are one major component of long-term sustained yield. Thus, it appears that this sustained yield provision will require the national forests to develop a long-term strategy that includes regeneration harvests on MFs. We do not know whether our proposed approach to regeneration harvest will be considered in this strategy.
3. The planning rule stipulates that "The regeneration harvest of even-aged stands of trees is limited to stands that generally have reached the culmination of mean annual increment of growth" (USDA 2012, p. 21267), but exceptions are allowed where the primary purpose of the harvest is something other than timber production. These exceptions are important because some stands, which otherwise would be candidates for a regeneration harvest, have not reached culmination.

Implementation of the regeneration harvest component on MF sites will also be affected by the recent NSO Recovery Plan (USDI Fish and Wildlife Service 2011) and proposed critical habitat for the NSO (USDI Fish and Wildlife Service 2012). Active management using ecological forestry principles is endorsed in both documents but there is uncertainty about the type, timing, and location of allowed activities. In a Presidential Memorandum (Obama 2012) released with proposed critical habitat, the Secretary of Interior is directed to ". . . develop clear direction, as part of the final rule, for evaluating logging activity in areas of critical habitat, in accordance with the scientific principles of active forest management and to the extent permitted by law." This direction will be critical to determining the extent to which regeneration harvests will be allowed within critical habitat.

Dry Forests

Interfacing our proposal for restoration of DFs with existing policy is complex, because candidate DFs are located both inside and outside the NWFP area. Within the NWFP areas, LSRs included DF landscapes in eastern and southern portions of the NSO range. The NWFP allowed for harvest in DF LSRs to restore and maintain natural ecological conditions (Forest Ecosystem Management Assessment Team 1993), although such activity rarely has been undertaken in the past (Thomas et al. 2007). Hence, our DF restoration strategy is consistent with the NWFP. DF restoration is explicitly encouraged in the NSO Recovery Plan (USDI Fish and Wildlife Service 2011), in part because potential for large wildfires and outbreaks of western spruce budworm greatly increase risks to large contiguous blocks of multilayered DFs (e.g., Courtney et al. 2008, Dello and Mote 2010). Still, it is not clear how this stated intent will be implemented and some owl biologists and environmentalists currently oppose any modification of suitable NSO habitat; litigation of this aspect of the NSO Recovery Plan is likely.

Outside the NWFP area, our proposals for restoration of DF are largely consistent with existing policy. We do substitute retention of older trees for the current interim upper diameter limit of 21 inches (see Brown 2012). However, increasingly, national forests have been granted exceptions to the "21 inch" policy to remove large, young white firs that have invaded historic ponderosa pine–dominated stands.

Still, as with MF, several policy issues remain regarding implementation of our DF restoration strategy:

1. We call for accelerated rates of treatment on a much broader DF land base than is currently proposed under fuel treatment programs. Simulations of fuel treatment effects show that thinning as little as 1%

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of the forest per year can significantly alter fire behavior (Finney et al. 2007). Consequently, goals of thinning 20–30% of DFs over the next 20 years reflect budget and personnel shortages and a singular focus on fire. Unfortunately, fuel treatments alone leave most DFs and included old trees vulnerable to fire, drought, and insects, hence, our call for both an altered and an accelerated program.

2. Our strategy calls for a network of dense patches in treated landscapes, tailored to the situation and wildlife species of interest, a feature often not recognized in DF project implementation. However, there is a framework for such a network in the new NSO Recovery Plan and proposed critical habitat designation. Because many DF stands provide suitable habitat for NSO, it is essential to comprehensively plan the amount and spatial distribution of reserved dense forest patches and, conversely, identify areas for restoration treatment.
3. Although commercial treatments are central to our DF strategy, comprehensive restoration of DF landscapes will require investments from either timber sale revenues or appropriated funds (Adams and Latta 2005, Johnson et al. 2008). Such investments are problematic in a time of shrinking federal budgets.
4. Maintenance of restored DF conditions after initial mechanical treatments could be done with prescribed fire, possibly eliminating the potential for future timber production. We envision the continued use of harvesting to maintain desired conditions in many DF stands. Resolution of this question—controlled burns or harvest or both—is also related to addressing the sustained yield clause of the NFMA planning rule.

Conclusions and Implications

Our experiences thus far with projects implementing our restoration strategies, including extensive interactions with stakeholder groups, have been very useful in refining our strategy. Agency personnel have proved to be very capable of developing silvicultural prescriptions based on ecological forestry principles and implementing the resulting projects. We view our restoration strategy as a credible alternative to the extreme choices with which stakeholders are currently being presented of either managing federal lands for intensive wood production, on the one hand, or effectively preserving all of it for owls, on the other. This does not mean that we do not anticipate other challenges will arise that need to be addressed—several key issues must still be resolved, and we make the following recommendations to address these issues.

First, the lack of public trust in agency proposals probably has been the largest single obstruction in moving active management forward on federal forestlands. The general absence of credible third-party assessments has contributed significantly to this problem. We view such third-party review and public reporting as essential for successfully undertaking a major new innovative management program on federal lands.

Second, given the high potential for catastrophic resource losses in federal DFs, we advocate a comprehensive 20-year program for restoring one-half to two-thirds of PNW DF landscapes outside of wilderness and roadless areas through a combination of commercial and precommercial treatments. This will require a significant increase in the amount of commercial thinning undertaken (Johnson and Franklin 2009). The need to increase the pace of restoration was recently acknowledged by the US Forest Service (USDA Forest Service 2012).

Finally, resolving the MF land base on federal lands that will ultimately be available for reinstituting regeneration harvests is highly problematic both legally and socially. There are even questions about whether previously harvested stands will be available for such harvests. Some of them have been identified as NSO critical habitat; others provide habitat for other species requiring special treatment (Johnson and Franklin 2012). Three conclusions emerge: (1) our MF strategy provides a pathway to a long-term sustained timber yield from MFs that does not currently exist, (2) reversing the trend of the shrinking land base for timber production is a key element in determining sustainable timber harvests, and (3) developing public understanding and acceptance of the ecological need for creating diverse early seral ecosystems in MF will require significant effort.

Endnotes

1. This article is largely based on two more comprehensive reports (Johnson and Franklin 2009, 2012).
2. Age limits can be criticized as being more difficult to apply than diameter limits. However, effective visual guides to tree age based on external characteristics of trees have been developed (Van Pelt 2008) and used (e.g., Brown 2012). Furthermore, questions typically arise regarding only the subsample of trees that appear near the threshold age. Two caveats are relevant in the use of age as the first screen in selecting trees for retention: (1) stakeholders and agency personnel must agree on some allowance for errors in age estimation and (2) as noted, size is important for many wildlife species, such as cavity nesters, and will be considered in developing silvicultural prescriptions.
3. National forests operate under the 1982 planning rule until they develop new forest plans (USDA 1982). The wording on these provisions is slightly different in that rule, but the intent is similar.

Literature Cited

Adams, D.M., and G.S. Latta. 2005. Costs and regional impacts of restoration thinning programs on the national forests in eastern Oregon. *Can. J. For. Res.* 35(6):1319–1330.

Agee, J.K. 1993. *Fire ecology of Pacific Northwest forests.* Island Press, Washington, DC. 493 p.

Ager, A., B. Finey, B. Kerns, and H. Maffei. 2007. Modeling wildfire risk to northern spotted owl (*Strix occidentalis caurina*) habitat in Central Oregon, USA. *For. Ecol. Manage.* 246: 45–56.

Atzet, T., D.L. Wheeler, B. Smith, J. Franklin, G. Riegel, and D. Thornburgh. 1992. Vegetation. P. 92–113 in *Reforestation practices in southwestern Oregon and northern California*, Hobbs, S.D., S.D. Tesch, P.W. Owston, R.E. Stewart, J.C. Tappeiner II, and G.E. Wells (eds.). Oregon State Univ. Forest Research Laboratory, Corvallis, OR.

Bailey, J.D., and J.C. Tappeiner. 1998. Effects of thinning on structural development in 40-to 100-year-old Douglas-fir stands in western Oregon. *For. Ecol. Manage.* 108:99–113.

Baker, D., G. Ferguson, C. Palmer, and T. Tolle. 2006. *The Northwest Forest Plan—The first ten years (1994–2003). Implementation monitoring: Summary of regional interagency monitoring results.* USDA For. Serv., Pac. Northw. Res. Stn., Portland, OR. 18 p.

Beese, W., B.G. Dunsworth, K. Zielke, and B. Bancroft. 2003. Maintaining attributes of old-growth forests in coastal B.C. through variable retention. *For. Chron.* 79:570–578.

Bliss, J. 2000. Public perceptions of clearcutting. *J. For.* 98(12):4–9.

Bormann, B.T., R.W. Haynes, and J.R. Martin. 2007. Adaptive management of forest ecosystems: Did some rubber hit the road. *Bioscience* 57(2):186–191.

Bosworth, D. 2006. Investing in the future: Ecological restoration and the US Forest Service. *J. For.* 105(4):208–211.

Bunnell, F.L., and G.B. Dunsworth. 2009. *Forestry and biodiversity: Learning how to sustain biodiversity in managed forests.* UBC Press, Vancouver, Canada. 349 p.

Brown, S.J. 2012. The Soda Bear Project and the Blue Mountain Forest Partners: US Forest Ser-

Downloaded from https://academic.oup.com/jof/article/110/8/429/4599612 by guest on 11 September 2024

vice collaboration. *J. For.* DOI: 10.5849/jof.12-078.

CAREY, A.B. 2003. Biocomplexity and restoration of biodiversity in temperate coniferous forest: Inducing spatial heterogeneity with variable density thinning. *Forestry* 76:127–136.

COURTNEY, S.P., A.B. CAREY, M.L. CODY, ET AL. 2008. *Scientific review of the draft northern spotted owl recovery plan.* Sustainable Ecosystems Institute, Portland, OR. 157 p.

CROCKER-BEDFORD, D.C. 1990. Goshawk reproduction and forest management. *Wildl. Soc. Bull.* 18:262–269.

DELLO, K.D., AND P.W. MOTE (EDS.). 2010. *Oregon climate assessment report.* Oregon Climate Change Research Institute, Corvallis, OR. 414 p.

FINNEY, M., R. SELI, C. MCHUGH, A. AGER, B. BAHRO, AND J. AGEE. 2007. Simulation of long-term landscape-level fuel treatment effects on large wildfires. *Int. J. Wildl. Fire.* 16: 712–727.

FOREST ECOSYSTEM MANAGEMENT ASSESSMENT TEAM. 1993. *Forest ecosystem management: An ecological, economic, and social assessment.* USDA For. Serv. Reg. 6, Portland, OR.

FORSMAN, E.D., R.G. ANTHONY, K.M. DUGGER, ET AL. 2011. *Population demography of northern spotted owls: 1985–2008.* Studies in Avian Biology, No. 40, Cooper Ornithological Society, University of California Press, Berkeley, CA. 106 p.

FRANKLIN, J.F., AND R.T. FORMAN. 1987. Creating landscape patterns by forest cutting: Ecological consequences and principles. *Landsc. Ecol.* 1(1):5–18.

FRANKLIN, J.F., AND T.A. SPIES. 1991. Ecological definitions of old-growth Douglas-fir forests. P. 61–69 in *Wildlife and vegetation of unmanaged Douglas-fir forests*, Ruggiero, L.F., K.B. Aubry, A.B. Carey, and M.H. Huff (eds.). USDA For. Serv. Gen. Tech Rep. PNW-GTR-285. 533 p.

FRANKLIN, J.F., D.R. BERG, D.A. THORNBURGH, AND J.C. TAPPEINER. 1997. Alternative silvicultural approaches to timber harvesting: Variable retention harvest systems. P. 111–139 in *Creating a forestry for the 21st century*, Kohm, K.A., and J.F. Franklin (eds.). Island Press, Washington, DC.

FRANKLIN, J.F., T.A. SPIES, R. VAN PELT, ET AL. 2002. Disturbances and structural development of natural forest ecosystem with silvicultural implications: Using Douglas-fir forests as an example. *For. Ecol. Manage*. 155:399–423.

FRANKLIN, J.F., AND R. VAN PELT. 2004. Spatial aspects of structural complexity in old-growth forests. *J. For.* 102(3):22–27.

FRANKLIN, J.F., R.J. MITCHELL, AND B.J. PALIK. 2007. *Natural disturbance and stand development principles for ecological forestry.* USDA For. Serv. Gen. Tech. Rep. NRS-19. 44 p.

FRANKLIN, J.F., M.A. HEMSTROM, R. VAN PELT, J.B. BUCHANAN, AND S. HULL. 2008. *The case for active management of dry forest types in eastern Washington: Perpetuating and creating old forest structures and functions.* Washington Department of Natural Resources, Olympia, WA. 97 p.

GAINES, W.L., R.J. HARROD, J. DICKINSON, A.L. LYONS, AND K. HALPUKA. 2010. Integration of northern spotted owl habitat and fuels treatments in the eastern Cascades, Washington, USA. *For. Ecol. Manage.* 260:2045–2052.

GARMAN, S.L., J.H. CISSEL, AND J.H. MAYO. 2003. *Accelerating development of late-successional conditions in young managed Douglas-fir stands: A simulation study.* USDA For. Serv. Gen. Tech. Rep. PNW-GTR-557. 57 p.

GREENBERG, C.H., B.S. COLLINS, AND F.R. THOMPSON III (EDS.). 2011. *Sustaining young forest communities: Ecology and management of early successional habitats in the central hardwood region of the USA*. Springer, New York. 310 p.

GUNDERSON, L.H., C.S. HOLLING, AND S.S. LIGHT. 1995. *Barriers and bridges to the renewal of ecosystems and institutions.* Columbia University Press, New York. 593 p.

GUSTAFSSON, L., S.C. BAKER, J. BAUHUS, ET AL. 2012. Retention forestry to maintain multifunctional forests: A world perspective. *BioScience* 62:633–645.

HESSBURG, P., J. AGEE, AND J.F. FRANKLIN. 2005. Dry forests and wildland fire of the inland Northwest USA: Contrasting the landscape ecology of the presettlement and modern era. *For. Ecol. Manage*. 211:117–139.

HESSBURG, P.F., K.M. JAMES, AND R.B. SALTER. 2007. Re-examining fire severity relations in pre-management era mixed conifer forests: Inferences from landscape patterns of forest structure. *Landsc. Ecol.* 22(1):5–24.

HOBBS, R.J., L.M. HALLETT, P.R. EHRLICH, AND H.J. MOONEY. 2011. Intervention ecology: Applying ecological science in the twenty-first century. *Bioscience* 61:442–450.

JOHNSON, K.N., J.F. FRANKLIN, AND D.L. JOHNSON. 2008. *A plan for the Klamath Tribes' management of the Klamath Reservation Forest.* Rep. to the Klamath Tribes. Available online at www.klamathtribes.org/information/background/documents/Klamath_Plan_Final_May_2008.pdf; last accessed Apr. 21, 2011.

JOHNSON, K.N., AND J.F. FRANKLIN. 2009. *Restoration of the federal forests of the Pacific Northwest.* Available online at www.cof.orst.edu/cof/fs/PDFs/JohnsonRestoration_Aug15_2009.pdf; last accessed Apr. 20, 2012.

JOHNSON, K.N., AND J.F. FRANKLIN. 2012. *Southwest Oregon secretarial pilot projects on BLM lands: Our experience so far and broader considerations for long-term plans.* Available online at www.cof.orst.edu/cof/fs/PDFs/BLM_report_feb15_Johnson.pdf; last accessed Apr. 20, 2012.

KOLB, T.E., J.K. AGEE, P.Z. FULE, N.G. MCDOWELL, K. PEARSON, A. SALA, AND R.H. WARING. 2007. Perpetuating old ponderosa pine. *For. Ecol. Manage.* 249:141–157.

LARSON, A.J., AND D. CHURCHILL. 2012. Tree spatial patterns in fire-frequent forests of western North America, including mechanisms of pattern formation and implications for designing fuel reduction and restoration treatments. *For. Ecol. Manage*. 267:74–92.

LINDENMAYER, D.B., AND J.F. FRANKLIN. 2002. *Conserving forest biodiversity.* Island Press, Washington, DC. 351 p.

LINDENMAYER, D.B., J.F. FRANKLIN, ET AL. 2012. A major shift to the retention approach for forestry can help resolve some global forest sustainability issues. *Conserv. Lett.* DOI: 10.1111/j.1755-263X. 2012.00257.

LONG, J.N. 2009. Emulating natural disturbance regimes as a basis for forest management: A North American view. *For. Ecol. Manage.* 257: 1868–1873.

MANNING, T., J.C. HAGAR, AND B.C. MCCOMB. 2012. Thinning of young Douglas-fir forests decreases density of northern flying squirrels in the Oregon Cascades. *For. Ecol. Manage*. 264: 115–124.

MCDOWELL, N., J.R. BROOKS, S.A. FITZGERALD, AND B.J. BOND. 2003. Carbon isotope discrimination and growth response of old *Pinus ponderosa* trees to stand density reductions. *Plan, Cell Environ*. 26:631–644.

MCKINLEY, G., AND D. FRANK. 1996. *Stories on the land: An environmental history of the Applegate and Illinois Valleys.* USDI Bureau of Land Management, Medford District Office, Medford, OR. 247 p.

MICHEL, A.K., AND S. WINTER. 2009. Tree microhabitat structures as indicators of biodiversity in Douglas-fir forests of different stand ages and management histories in the Pacific Northwest, USA. *For. Ecol. Manage.* 257: 1453–1464.

MUNGER, T.T. 1917. *Western yellow pine in Oregon.* USDA Bull. 418, Washington, DC. 48 p.

NORTH, M.P., AND W.S. KEETON. 2008. Emulating natural disturbance regimes: an emerging approach for sustainable forest management. P. 341–372 in *Patterns and processes in forest landscapes—Multiple use and sustainable management*, Lafortezza, R., J. Chen, G. Sanesi, and T.R. Crow (eds.). Springer, The Netherlands.

NORTH, M., P. STINE, K. O'HARA, ET AL. 2009. *An ecosystem management strategy for Sierran mixed-conifer forests.* USDA For. Serv. Gen. Tech. Rep. PSW-GTR-220, Pac. Southw. Res. Stn., Albany, CA. 49 p.

NOSS, R., J. FRANKLIN, W. BAKER, AND T. SCHOENNAGEL. 2006. Managing fire-prone forests in the western United States. *Front. Ecol. Environ*. 4(9):481–487.

OBAMA, B. 2012. *Proposed revised habitat for the spotted owl: Minimizing regulatory burdens.* Mem. for the Secretary of the Interior, The White House, Washington, DC. Available online at www.whitehouse.gov/the-press-office/2012/02/28/presidential-memorandum-proposed-revised-habitat-spotted-owl-minimizing-; last accessed May 2, 2012.

PERRY, D.A., P. HESSBURG, C. SKINNER, T.A. SPIES, S.L. STEPHENS, A.H. TAYLOR, J.F. FRANKLIN, B. MCCOMB, AND G. RIEGEL. 2011. The ecology of mixed severity fire regimes in Washington, Oregon, and northern California. *For. Ecol. Manage.* 262:703–717.

REILLY, E. 2012. The Pilot Joe Project—Dry forest restoration in southwestern Oregon. *J. For.* DOI: 10.5849/jof.12-081.

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AFRC Comments
Attachment A - Pg. 10

Robbins, W. 2009. *Landscapes of promise: The Oregon story, 1800–1940.* University of Washington Press, Seattle, WA. 416 p.
Seymour, R., and M. Hunter. 1999. Principles of ecological forestry. P. 22–64 in *Managing biodiversity in forested ecosystems*, Hunter, M. (ed.). Cambridge University Press, Cambridge, UK.
Shindler, B., and A.L. Mallon. 2009. *Public acceptance of disturbance-based forest management: A study of the Blue River landscape strategy in the Central Cascades Adaptive Management Area.* USDA For. Serv. Res. Pap. PNW-RP-581, Pac. Northw. Res. Stn., Portland, OR. 42 p.
Spies, T.A. 2009. Science of old growth, or a journey into wonderland. P. 31–43 in *Old growth in a new world: A Pacific Northwest icon reexamined.* Spies, T.A., and S.L. Duncan (eds.). Island Press, Washington, DC. 326 p.
Spies, T., M. Hemstrom, A. Youngblood, and S. Hummel. 2006. Conserving old growth forest diversity in disturbance-prone landscapes. *Conserv. Biol.* 20(2):356–362.
Spies, T.A., K. Johnson, K. Burnett, J.L. Ohmann, B.C. McComb, G.H. Reeves, P. Bettinger, J.D. Kline, and B. Garber-Yonts. 2007. Cumulative ecological and socioeconomic effects of forest policies in coastal Oregon. *Ecol. Applic.* 88(1):5–17.
Spies, T.A., S.L. Duncan, K.N. Johnson, F.J. Swanson, and D. Lach. 2009. Conserving old growth in a new world. P. 313–326 in *Old growth in a new world: A Pacific Northwest icon reexamined*, Spies, T.A., and S.L. Duncan (eds.). Island Press, Washington, DC. 326 p.
Spies, T.A., T.W. Giesen, F.J. Swanson, J.F. Franklin, D. Lach, and K.N. Johnson. 2010. Climate change adaption strategies for federal forests of the Pacific Northwest, USA: Ecological policy and socio-economic perspectives. *Landsc. Ecol.* 25:1185–1199.
Stankey, G.H., B.T. Bormann, C. Ryan, B. Shindler, V. Sturtevant, R.N. Clark, and C. Philpot. 2003. Adaptive management and the Northwest Forest Plan: Rhetoric and reality. *J. For.* 101:40–46.
Swanson, M., J.F. Franklin, R.L. Beschta, C.M. Crisafulli, D.A. DellaSala, R.L. Hutto, D.B. Lindemayer, and F.J. Swanson. 2011. The forgotten stage of forest succession: Early-successional ecosystems on forest sites. *Front. Ecol. Environ.* 9:117–125.
Thomas, J.W., J.F. Franklin, J. Gordon, and K.N. Johnson. 2007. The Northwest Forest Plan: Origins, components, implementation experience, and suggestions for change. *Conserv. Biol.* 20:277–287.
Toman, E., M. Stidham, B. Shindler, and S. McCaffrey. 2011. Reducing fuels in the wildland–urban interface: Community perceptions of agency fuels treatments. *Int. J. Wildl. Fire* 20(3):340–349.
US Bureau of Land Management (BLM). 2012. *Secretary Salazar proposes expansion of ecological forestry in western Oregon to provide sustainable timber, healthier habitat.* Available online at www.blm.gov/or/news/files/2]22-12_Oregon_Forestry_Release.pdf; last accessed Mar. 21, 2012.
USDA. 1982. 36 CFR Part 219. National forest system land and resource management planning, *Fed. Regist.* 47:43037–43061.
USDA. 2012. 36 CFR Part 219. National forest system land management planning. *Fed. Regist.* 77(68):21162–21276.
USDA Forest Service. 1995. *Interim management direction establishing riparian, ecosystem, and wildlife standards for timber sales (revised).* Regional forester's forest plan amendment no. 2. Available online at www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5314617.pdf; last accessed Apr. 20, 2012.
USDA Forest Service. 2012. *Increasing the pace of restoration and job creation on our national forests.* Available online at www.fs.fed.us/publications/restoration/restoration.pdf.; last accessed May 3, 2012.
USDA Forest Service, and US Bureau of Land Management (BLM). 1994. *Record of decision for amendments for Forest Service and Bureau of Land Management planning documents within the range of the northern spotted owl.* USDA For. Serv. Region, Portland, OR. 74 p. (plus Attachment A: Standards and guidelines.)
USDI Fish and Wildlife Service. 2011. *Revised recovery plan for the northern spotted owl (Strix occidentalis caurina).* USDI Fish and Wildlife Service, Portland, OR. 258 p.
USDI Fish and Wildlife Service. 2012. Endangered and threatened wildlife and plants; revised critical habitat for the Northern Spotted Owl. *Fed. Regist.* 77(46):14062–14165.
Van Pelt, R. 2008. *Identifying old trees and forests in eastern Washington.* Washington State Department of Natural Resources, Olympia, WA. 166 p.
Van Pelt, R., and S.C. Sillett. 2008. Crown development of coastal *Pseudotsuga menziesii*, including a conceptual model for tall conifers. *Ecol. Monogr.* 78:283–311.
Vilsack, T. 2009. *Vision for the forest service: Remarks as prepared for delivery Seattle, Washington—August 14, 2009.* Available online at www.fs.fed.us/video/tidwell/vilsack.pdf; last accessed Apr. 21, 2011.
Wheeler, A. 2012. Roseburg District secretarial pilot project: My experience. *J. For.* DOI: 10.5849/jof.12-076.
Wilson, D.S., and K.J. Puettmann. 2007. Density management and biodiversity in young Douglas-fir forests: Challenges of managing across scales. *For. Ecol. Manage.* 246:123–134.
Wimberly, M. 2002. Spatial simulation of historical landscape patterns in coastal forests of the Pacific Northwest. *Can. J. For. Res.* 32:1316–1328.
Youngblood, A., T. Max, and K. Coe. 2004. Stand structure in east-side old-growth ponderosa pine forests of Oregon and northern California. *For. Ecol. Manage.* 99(213):191–217.

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Case Study

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Roseburg District Pilot Project

Abe Wheeler

For the past 20 years, the US Department of the Interior (USDI) Bureau of Land Management (BLM) Oregon and California Railroad (O&C) lands of western Oregon have been the focus of intense debate. The O&C Lands Act of 1937 and the Endangered Species Act of 1973 have driven discussions regarding these lands since the northern spotted owl's listing in 1990. In an attempt to balance seemingly opposed interests, the Northwest Forest Plan was developed in 1994. Litigation within the courts has prevented a full implementation of the Northwest Forest Plan. For example, much of the plan's predicted sustained yield volume was supposed to have come from regeneration harvest in "old-growth" forests. The recent status quo has been a thinning-only approach,

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AFRC Comments
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ATTACHMENT B

Sustainable Harvest Levels and Short-Term Timber Sales for Options Considered in the Report of the Forest Ecosystem Management Assessment Team: Methods, Results, and Interpretations

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1993

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Project Organization

Norm Johnson coordinated assessment of sustainable timber harvest levels and short-term sales with the assistance of numerous Forest Service and Bureau of Land Management (BLM) employees. Sarah Crim led the Pacific Northwest Region's effort to assess sustainable harvest levels with the help of Alan Ager, Bill Connelly, Jim Merzenich, and Forest Service analysts throughout the Region. Klaus Barber led the Pacific Southwest Region's effort with the help of Ken Wright and numerous Forest Service analysts. Mike Howell and Chris Cadwell led the BLM effort with the assistance of numerous other BLM analysts.

Sarah Crim led the timber sales assessment for the Forest Service with the help of John Nunan, Tom Ortman, Molly Egan, the timber staff of the Pacific Northwest Regional Office, and timber staffs on the National Forests. Randy Gould and Nancy Anderson led the timber sales effort for BLM with the assistance of many BLM personnel. Steve Armitage led BLM's analysis of inoperable lands.

Debbie Cummings, Oregon State University, helped with the analysis of the probable sales quantities.

Mauragrace Healey, Writer/Editor with the Interagency SEIS Team, edited this document and Chris Hamilton, Information Resource Manager, BLM Coos Bay District, prepared tables and figures. The authors wish to thank them for their patience.

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Sustainable Harvest Levels and Short-Term Timber Sales for Options Considered in the Report of the Forest Ecosystem Management Assessment Team: Methods, Results, and Interpretations

Objectives

Following the April 2, 1993, Forest Conference in Portland, Oregon, President Clinton created three interagency working groups including the Forest Ecosystem Management Assessment Team (FEMAT). The authorizing letter to FEMAT stated in part, "You should address a range of alternatives in a way that allows us to distinguish the different costs and benefits of various approaches (including marginal cost/benefit assessments), and in doing so, at least the following should be considered: timber sales, short and long term; production of other commodities; effects on public uses and values, including scenic quality, recreation, subsistence, and tourism..." (see Appendix A for the complete memo).

In July 1993, the assessment team released its report, "Forest Ecosystem Management: An Ecological, Economic, and Social Assessment" (USDA 1993, referred to in this paper as the "FEMAT Report"). In the section titled "Outlook for Federal Timber Harvests" in the FEMAT Report (USDA 1993:VI-4), it states, "Johnson, K.N., S. Crim, K. Barber, and M. Howell in an analysis written for this report, includes further details on the assumptions, techniques, and results." The purpose of this paper is to document that analysis.

Specifically, this paper has three objectives. First, it will present the methods used to estimate "timber sales, short and long term" for the different options considered in the FEMAT Report. Second, it will give the results for the different options considered in the report by administrative unit. Third, it will interpret some of the more important results including the marginal cost/benefit assessments of the different policies and discuss unresolved issues.

Estimating the Probable Sale Quantity

The FEMAT Report examines 10 options which vary in the amount and distribution of reserves, rules for management of reserves, rules for management of lands outside reserves, and other considerations (see Table 1 for a description of the options). In addition, a number of variations on these options were examined in the course of developing the report, especially different interpretations of the Scientific Analysis Team (SAT) Report (Thomas et al. 1993). All 10 options plus their variations will be discussed here from the standpoint of the timber harvest that might result.

General Methodology

In calculating sustainable harvest levels for each of the FEMAT options, we first established how each of the various components of the options would be simulated. We then enlisted the assistance of Forest Service and BLM personnel in projecting the sustainable harvest levels for each of the options. We projected the sustainable harvest level for each National Forest and BLM Sustained Yield Unit in the owl region. Table 2 lists these units along with the abbreviations we use to identify these areas. We asked the field units to conform to the following direction in calculating harvest levels.

1. Start with the existing Forest Plans (Forest Service, Pacific Northwest Region, also referred to as Region 6) or proposed Forest and District Plans (Forest Service, Pacific Southwest Region, also referred to as Region 5, and BLM) as the base. Overlay the new allocations and management rules for each option on top of these plans and retain the most restrictive of these unless otherwise specified.

2. Assume a nondeclining yield mandate where planned harvest levels in future decades cannot be less than the previous decade harvest.

3. Project the likely level of sustainable harvest under each option.

We called this estimate of the likely level of sustainable harvest the "probable sale quantity" (PSQ) to distinguish it from the allowable sale quantity (ASQ) of previous assessments and Forest and District Plans. Allowable sale quantities are ceilings or upper limits on harvest levels. In this effort, we attempted to portray the likely sales levels under each option as opposed to an upper limit.

The harvest levels were estimated by Forest Service and BLM personnel using a variety of approaches including generally available harvest scheduling models such as FORPLAN (Johnson et al. 1986) and TRIM-PLUS© (REI 1988), simulators developed specifically for the task, and data base manipulation techniques. Field personnel for the Forest Service in Region 6 and for the BLM did not provide PSQ estimates for all of the options. Table 3 summarizes which PSQ estimates were derived from modeling efforts and which were built from information obtained from the results found under other options.

We found that the definitions of the options changed from week to week. Given the time constraints, we did not have the opportunity to reissue modeling direction and resimulate options as rules changed. We therefore developed adjustment factors to apply to the PSQ estimates obtained from the field units. Appendix B contains the details of both the modeling approaches used in Regions 5, 6, and the BLM, as well as information on what adjustment factors were applied in each of the options. The details on how the adjustment factors were developed are presented below in the sections on riparian reserves and green tree retention (GTR) standards.

Table 4 summarizes the way in which late-successional and riparian reserves were modeled for PSQ estimation along with how green tree retention standards and Adaptive Management Areas were handled in each of the options. In Table 4, we use the term timber suitable base rather than "matrix" lands. When we estimate probable sale quantities, we refer to the lands on which timber harvest can regularly be scheduled as the "timber suitable base". The classification scheme we use to define this land area is different from the one employed in the FEMAT Report to arrive at the matrix lands. Both the timber suitable lands and the matrix lands are located outside of four kinds of withdrawals: (1) Congressional withdrawals, (2) administrative withdrawals, (3) late-successional reserves, and (4) riparian reserves. The matrix lands also exclude Adaptive Management Areas. Thus, matrix acres include all federal lands outside the four types of withdrawals listed above and Adaptive Management Areas, whether they are productive forest, nonproductive forest or nonforest. The timber suited acres, on the other hand, include only the physically and economically suited timber land outside of the first four withdrawals including those lands that meet this definition within the Adaptive Management Areas. Thus the timber base used in our calculations is a subset of the acres located in the matrix lands as defined in the FEMAT report.

Late-Successional Reserves

As noted in Table 4, we did not include any potential thinning, harvest, or salvage volume from any of the late-successional reserves in calculating PSQ estimates. We determined in a separate calculation potential volume that might be acquired from thinning and salvage activities in the reserves. The results of this separate calculation is presented in a subsequent section of this report.

Riparian Reserves

The FEMAT Report calls for some type of special treatment for riparian areas under each of the options. Option 7 contains the riparian guidelines present in the existing or proposed agency plans, and the remainder of the options have riparian reserve scenario 1, 2 or 3 (see Table 5). Each of these three riparian strategies contain direction on determining buffer widths and identifying unstable ground. The methods followed in estimating these two factors are presented below. In addition, we calculated a set of adjustments for post-analysis changes to the number of intermittent streams, for converting from horizontal to slope distance and for removing inoperable lands from the timber suitable base. The details of these adjustments are also given below.

Estimating Buffers

The width of the buffers in these three riparian reserve scenarios can be based on a number of criteria including fixed distances from the streams and "height of site-potential trees". The criterion which produces the greater distance is the one to be followed. The direction for determining minimum widths for riparian reserves is shown in Table 5. Since the "height of site-potential trees" gave the maximum distance in most instances, we chose to model the width of riparian buffers based on this criterion.

• Determining the Height of Site-Potential Trees

The height of a site-potential tree was first defined in the glossary of the SAT Report (Thomas et al. 1993) as, "a tree that has attained the maximum height possible for a given site", and later defined in the glossary of the FEMAT Report as, "a tree that has attained the average maximum height given site conditions where it occurs." In the FEMAT Report, a site-potential tree is further defined in the aquatic chapter as, "the average maximum height of the tallest dominant trees (200 years or more) on a given site" (USDA 1993:II-37). To estimate the height of a site-potential tree, we collected information on the tallest Douglas-fir trees found on plots in old-growth forests as a proxy for the "average maximum" height attainable on sites throughout the owl region. Using BLM plot information from stands over 200 years old in riparian areas, we estimated this height for the sites commonly found in the owl region. The heights varied from 250 feet on high site land along the coast, to 170 feet on the west side of the Cascade Range, to 110 feet on the east side. Further analysis of plots on the Siuslaw, Willamette, and Olympic National Forests showed heights within about 10 percent of the original estimates (Table 6).

We then determined the average McArdle site (the most general measure of site potential) for each administrative unit and assigned the associated BLM site-potential tree height (Table 7). In Region 6, all west side National Forests were site IV (170 feet) except for the Siuslaw (site II, 250 feet) and the Olympic (site III/IV, 190 feet). All east side Forests were site V (140 feet). In Region 5, Dunning site index was used and similar analysis led to site-potential tree heights between 165 and 200 feet for the four National Forests. On lands administered by the BLM, the heights varied by Sustained Yield Unit between site class II in Coos Bay District; site class III in Salem, Eugene and Roseburg Districts; and site class IV in Medford and Lakeview Districts.

• Estimating the Extent of Riparian Reserves

The amount of area located in riparian reserves is a function of the width of the buffers and the number of miles of stream in each stream class. The procedure for determining buffer widths based on the site-potential tree heights was discussed previously. The number of miles of stream by stream class was derived by the Aquatic/Watershed Group (see FEMAT Report, Appendix V-G, Table V-G-4) and is displayed in Table 7 of this paper.

Given the site-potential tree height and the number of miles of stream by stream class (see Table 7), the acres located in the buffers were determined by the Forest Service at the National Forest level, and by the BLM at the State Office level, using Geographic Information System (GIS) analysis and/or use of the buffer factors shown below.

Site Class	Stream Class					
	Fish bearing	Permanent, non fish bearing		Intermittent		
	Riparian Reserves	Riparian Reserves		Riparian Reserves		
	1, 2, 3	1, 2	3	1	2	3
II	124.8	52.8	26.4*	52.4	25.4	8.4*
III	104.3	45.3	22.7*	46.1	23.2	7.7*
IV	83.4	38.4	19.2*	39.4	20.2	6.7*
V	75.1	33.5	15.7*	32.5	15.3	5.1*

*approximated.

These factors were derived by applying a buffering algorithm to the sample quads described in Appendix V-G of the FEMAT Report. Each of the sample quads were sent through the buffering algorithm to determine the number of acres located in the buffers per mile of stream for each unique combination of site class and stream class. In this way, the overlap between buffers was netted out of the factors (A. Ager pers. comm.).

Multiplying the buffer factors shown above times the miles of stream gives one measure of the acres in riparian reserves (horizontal measure). As seen in Table 7, the percent of administrative unit in riparian reserves varies from 4 to 74 percent for riparian scenario 1, from 3 to 59 percent for riparian scenario 2, and from 2 to 38 percent for riparian scenario 3.

• Updating Stream Mile Information

The number of miles of stream by stream class was updated several times by the Aquatic/Watershed Group. The last update, which is reflected in Table 7, occurred after Forest analysts in Region 6 had completed their probable sale quantity analyses. As a result, we adjusted the estimates calculated for six of the National Forests to reflect this new information. Table 8 contains the factors used to bring the PSQ estimates into compliance with the last set of information on stream mileage.

• Converting from Horizontal Distance to Slope Distance

The FEMAT Report (USDA 1993:V-34 — 35) calls for the use of slope distance instead of horizontal distance in the measurement of buffer widths. Estimates of acreage withdrawals for harvest analysis, based on the different buffer widths, were based on horizontal distance. To adjust to slope distance, in Region 6 we obtained estimates of likely average slope percents by stream class for each National Forest (F. Swanson pers. comm.). We then calculated the proportion of slope distance to horizontal distance for each stream class on each administrative unit, and finally, we calculated an average percent adjustment for the different riparian reserve strategies weighted by the relative acreage in each stream class. Region 5 used an average slope to horizontal proportion of about 0.9. Adjustments for lands administered by the BLM were then approximated by using the equivalent factors for the nearest National Forests. The factors used in deriving adjustments to the PSQ estimates for each option are shown in Table 8.

Estimating Additional Unsuitable Lands

The late-successional and riparian reserves should protect much of the unstable ground considered suitable for timber production in the Forest and District Plans. Still, FEMAT's Aquatic/Watershed Group felt that some additional unstable lands would be found outside the reserve system, especially in riparian reserve strategies 2 and 3 which provide less protection to headwall areas than riparian reserve strategy 1. They therefore requested an additional withdrawal which was applied to all options using riparian reserve strategy 2 or 3 (Table 8).

Estimating Inoperable Acres

The extensive riparian network prescribed under some options may create a pattern of reserves that could render some of the land between the reserves, otherwise classified as suitable for timber production, to actually be inoperable. In addition, acres might be inoperable because of the inability to build roads in the area due to interim riparian rules against road building across riparian areas. Therefore, a study was undertaken to develop an estimate of inoperable acres under both riparian reserve systems 1 and 2.

The sample quads used to estimate stream density on National Forests and BLM Districts were employed to estimate land inoperable due to the riparian reserves and rules. Land that met either of two criteria were classified as inoperable:

1. Areas less than 300-feet wide. If an area was less than 300-feet across, it would be difficult to fell the timber without falling it into the surrounding stream buffers. Therefore, areas less than 300-feet across were classified as inoperable. (Note: if a road went across the area, the idea was tested by assuming that a portion of it could be made accessible by pulling adjacent trees to the road. This changed the results very little, however, so it was not considered in most quads.)

2. The area was more than 2 miles from the nearest road. If the area was more than 2 miles from a road, it was assumed to be beyond an economically feasible logging distance.

Almost no land suitable for timber production is more than 2 miles from a road in the federal land within the owl region. Therefore, the estimates of inoperable land reported here (Table 8) reflect only areas less than 300 feet-wide.

Timber Suitable Base

Two sets of additional management rules for the timber suitable acres were examined on lands administered by both the Forest Service and BLM. They were levels of green tree retention and special rules for Adaptive Management Areas under Option 9. The procedures followed for these two types of management guidelines are presented below. In addition, National Forests in Region 5 were required to examine 180-year rotations on their suitable lands under Option 9. The results of this analysis are shown in the section on additional policy analysis.

Calculating Green Tree Retention

The different options have five basic strategies for green tree retention:

1. Retention based on provisions of Forest and District Plans (Options 7 and 8).

   Modeling strategy: used Forest and District Plan yield tables.

2. Retention based on provisions of Forest and District Plan augmented by additional green trees and snags for woodpeckers on the eastern fringe of the owl range and the Klamath Province as specified in the SAT Report (Options 4 and 5).

Modeling strategy: used Forest and District Plans yield tables adjusted for additional requirements on the Winema, Deschutes, Okanogan, Wenatchee, Rogue River, and Siskiyou National Forests.

3. Retention of six large trees per acre (Options 1, 2, 3, 6, and 10)

   Modeling strategy: Defined six large trees as six trees with an average diameter between the quadratic mean diameter of the stand and that of the largest tree. In Region 6, six trees meeting this definition in mature stands averaged 20 percent of the volume on the west side of the Cascade Range, 15 percent on the east side in Washington, and 9 percent on the east side in Oregon. An adjustment to the first decade harvest for Region 6 National Forests was made to bring green tree retention on even-aged harvest units up to this level (Table 8). Region 5 National Forests already achieved these levels in their proposed Forest Plans. The BLM Districts achieved them with only slight modification in their proposed plans.

4. Retention of four large trees per acre plus 10 percent of the matrix left in well-distributed patches of late-successional forest (Option 3).

   Modeling strategy: Not modeled directly because Option 3 was calculated as a weighted average of Options 2 and 6.

5. Forest and District Plan provisions in the Oregon Coastal Province and Olympic and Mt. Baker-Snoqualmie National Forests; 15 percent of volume in cutting units elsewhere with at least half in distributed patches of late-successional forest (Option 9).

   Modeling strategy: An adjustment was made in first decade harvest on administrative units, as needed, to bring green tree retention on even-aged harvest units up to the specified level (Table 8).

Modeling PSQ for Adaptive Management Areas

From a PSQ standpoint, the Adaptive Management Areas in Option 9 were modeled in a similar manner to the rest of the forests in the owl region. Late-successional and riparian reserves were maintained according to the rules of Option 9, and Forest and District Plan standards and guidelines were utilized to augment the green tree retention requirements of Option 9. With the qualifications listed below, we generally modeled the Adaptive Management Areas of Option 9 as contributing approximately the same harvest per suitable acre as if they were part of the suitable timber base with no special additional prescriptions. This approach is consistent with the overall strategy for the areas mentioned in the FEMAT Report, that Adaptive Management Areas should demonstrate innovative approaches to implementation of Option 9 as opposed to having separate objectives of their own.

One special adjustment was included that set minimum rotation requirements for the Forest Service portion of a number of Adaptive Management Areas to represent, in some small way, the probable lengthening of rotation that might occur on many of the Adaptive Management Areas:

Adaptive Management Area	Simulation rules
Olympic NF	At least 100-year rotation
Finney	No scheduled PSQ
Snoqualmie Pass	No scheduled PSQ
Cispus	At least 100-year rotation
Blue River	
Forest Service	At least 100-year rotation
BLM	No special requirements
Applegate	
Forest Service	At least 150-year rotation
BLM	No special requirements
Hayfork	No special requirements (180-year rotation in force)
Goosenest	No special requirements (180-year rotation in force)
Little River	No special requirements
North Coast	No special requirements

Other Adjustments

During the FEMAT process, the California BLM Ukiah District provided information that indicated their ASQ level prior to the FEMAT options would be about 2.3 million board feet (16' basis) or about 1.9 million board feet (32' basis). Since most of the FEMAT options were resulting in PSQ levels considerably less than the pre-FEMAT level, no explicit PSQ modeling was conducted for the California BLM Ukiah District. While data tables for the Districts in Oregon are complete, only a portion of the tabulated data were available for the Ukiah District.

Results

Evolution of Sale Quantity Estimates under Different Northern Spotted Owl Protection Plans

In 1990, the Interagency Scientific Committee released its report on the northern spotted owl (Thomas et al. 1990). Called the "Thomas Report", its Conservation Strategy called for a system of large reserves scattered over the region of the northern spotted owl along with controls (the 50-11-40 rule) on the matrix land between the reserves. Soon thereafter, an interagency committee made an estimate of the harvest level possible under that strategy (USDA 1990, also known as the "Hamilton Report") which suggested that an allowable sale quantity of 2.37 billion board feet could be attained from federal land within the owl region when the proposal was overlaid on proposed Forest Plans in Regions 5 and 6 and approved District Plans for BLM (Table 9). The Forest Service would provide 2.0 billion of that total.

In 1992, the Forest Service released their Final Environmental Impact Statement on Management for the Northern Spotted Owl. Alternative B in that report called for implementation of the Conservation Strategy in the Thomas Report and gave a new estimate of the allowable sale quantity that might result for lands administered by the Forest Service within the owl region: 1.66 billion board feet---a decline of 17 percent from the previous estimate in the Hamilton Report.

Two primary reasons can be given for this reduction:

1. A more sophisticated analysis of the 50-11-40 rule. This rule required each federal agency to have at least half of each quarter township in stands over 11" dbh, and with a canopy closure of at least 40 percent. Initial assumptions were that this rule would have little effect on potential harvest levels; later assessment proved this assumption wrong in some cases.

2. Experience with implementing the Forest Plans, including the Forest Service Chief's ecosystem policy, resulted in lower estimates of likely harvest levels attainable on the reduced land base available for timber harvest under the Conservation Strategy.

In preparation of the FEMAT Report, a simulation was made of the sustainable harvest level given in the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992). This analysis suggested a harvest level of 1.23 for the Forest Service and a total harvest of 1.56 for all federal land within the owl region (Table 9)---a decline of almost 40 percent for the Forest Service and a decline of almost 35 percent for all federal land from the original estimate in the Hamilton Report. Thus, the federal agency's estimate of the harvest level on federal forests within the owl region that is compatible with a high level of protection of the northern spotted owl has declined 35 percent over 3 years. A number of reasons explain this decline:

1. A different land base was used. While the recovery plan was based on the Thomas Report, it added 250,000 acres of "designated conservation areas" (reserves). The Wenatchee National Forest was especially impacted by these additional reserves.

2. Region 5 updated its proposed Forest Plans and BLM issued new draft District Plans that gave significantly greater protection to late-successional species and stream habitat.

3. Forest Service and BLM analysts were asked to provide sale levels they felt were likely to be achieved (which we call the probable sale quantity) rather than the maximum or upper limit levels (called the allowable sale quantity) of the previous studies.

4. Further experience with implementing the Forest Plans, including the Chief's ecosystem policy, resulted in lower estimates of likely harvest levels attainable on the reduced land base available for timber harvest under the Thomas Report. Some Forest analysts came to believe that per acre yield assumed in the Forest Plans could not be achieved under the Thomas Report given those stands available for harvest and the operational difficulties of actually laying the sales out on the ground.

The 10 Options

Probable sale levels for the first decade under the rules for each option are summarized in Table 10 along with recent harvest levels. Each of these options start with existing Forest Plans (Forest Service, Region 6) or proposed plans (Forest Service, Region 5 and BLM) as the base. The new allocations and management rules for each option are then overlaid on these plans and the more restrictive set of management rules are retained, with two exceptions. In Option 9, Forest Plan restrictions for late-successional species outside of the late-successional reserve system are released. Also in Option 9, a lower level of green tree retention is prescribed than that now practiced or proposed by some Forests.

It should be noted that all PSQ estimates for BLM are reported in 32 foot logs. To convert them to 16 foot logs---BLM's usual way of reporting---divide the BLM numbers by 0.825.

The PSQ estimates in this report reflect updated analysis that corrected some minor problems in the estimates reported in the FEMAT Report. Most of these corrections are to Option 9 which drops from the PSQ shown in the FEMAT Report of 1.084 billion board feet (USDA 1993, Table II-5 on page II-48) to a PSQ shown in Table 10 of this paper of 1.05 billion board feet. A footnote to Table II-5 in the FEMAT Report states, "Probable sale levels should be within 10 percent of final results..." The results of our revisions to PSQ generally fall within this 10 percent margin.

One exception is the PSQ estimate for Option 1. This PSQ has fallen significantly because we developed a more realistic estimate for National Forests in Region 6.

Option 7, which has the highest harvest level, simulates the agencies' existing or proposed plans overlaid with the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992) as that plan is interpreted by the agencies. The remaining options contain various additional levels of protection for streamside habitat, marbled murrelet habitat, habitat for other species, and ecologically significant old-growth forest. The additional protection measures impact harvest levels by precluding areas from harvest, distributing the harvest, extending the rotations, and requiring more stringent green tree retention standards.

We estimated a probable sale quantity for lands administered by the Forest Service and BLM within the owl region of 1.64 billion board feet per year based on the Forest and District Plans plus their interpretation of the northern spotted owl recovery plan (Option 7), and 1.05 billion for the Clinton Administration's proposed plan (Option 9) (Table 10). Region 6 portions of these two estimates are 0.99 billion board feet (Option 7) and 0.63 billion (Option 9). The difference between the Option 7 and Option 9 estimates can be ascribed largely to protection of habitat for other late-successional species (especially the marbled murrelet) and to protection of watersheds and riparian systems (especially habitat for potentially threatened fish stocks).

Adding 10 percent to the probable sale quantity for "other wood" often harvested along with the sound sawtimber of the probable sale quantity gives an average timber sales level for Option 9 for the first decade of 1.15 billion board feet per year. This projected level is approximately 25 percent of 1980-89 harvest levels from federal land in the owl region (a 75 percent reduction) and 48 percent of the 1990-1992 harvest levels from these forests (a 52 percent reduction) (Table 10). Other options give higher or lower harvest levels.

Over time we would expect the sustainable harvest level to rise as the effect of intensive management in the timber suitable lands takes hold and a better balance of age classes occurs. In Option 9, the sustainable harvest level for the first decade for National Forests in Region 6, as an example, assumes just over 50 cubic feet per year from the suitable timber land while these sites should be capable of considerably higher growth rates in the long term. We would expect green tree retention and other objectives to reduce potential growth somewhat, but we still feel that the sustainable level over time could increase.

To estimate PSQ for federal land in the owl region under each option, we first made PSQ calculations by administrative unit and then aggregated them. We feel most confident in the state and regional totals reported in Table 10, but have included the administrative unit results because of significant interest in them. They should, however, be viewed with caution--more accurate them. They should, however, be viewed with caution--more accurate administrative unit estimates of PSQ await plan revisions.

Detailed information on the PSQ for each option is given by administrative unit in five tables:

1. The acres suitable for timber production used in calculation of the PSQ (Table 11)
2. Probable sale quantity in board feet (Table 12)
3. Probable sale quantity in cubic feet (Table 13)
4. The annual board feet of PSQ per suitable acre (Table 14)
5. The annual cubic feet of PSQ per suitable acre (Table 15)

In addition, Table 11 shows some summary information about the amount of land area and forested area on each administrative unit. Comparing the information to the suitable acre table enables a number of observations. We see that approximately 23 percent of the forested land on these administrative units is considered suitable for timber production in Option 9. This percent varies from 5 to 6 percent on the Mt. Baker-Snoqualmie and Siuslaw National Forests to 51 percent on the Upper Willamette Sustained Yield Unit of BLM. In Option 9, the coastal administrative units generally have a smaller proportion of their forest available for timber production than do the Cascade units (5 to 11 percent).

As discussed earlier, the FEMAT Report does not report land suitable for timber production. Rather, it reports "matrix" land in each option. Matrix information by administrative unit for an option can be compared to suitable land for the option to develop a relationship between the two numbers (Table 16). For the three options analyzed here, Options 4, 7 and 9, suitable acres, on average, varied from 65-75 percent of matrix acres.

• Allocation of Late-Successional Forest

The FEMAT effort classified the forest into different seral stages. Four of the seral stages could be called late-successional forest in their entirety: (1) medium conifer, single story, (2) medium conifer, multistory, (3) large conifer, single story, and (4) large conifer, multistory. These four stages together comprise over 8 million acres--- over 45 percent of the forested lands administered by the Forest Service and BLM. One seral stage, small conifer, contains some stands considered to be late-successional forest. Other seral stages for forested lands included seedlings and saplings, brush and grass (mostly recent cutover), sparse conifers and hardwoods.

By linking the ratio of suitable land base/matrix for an option to the GIS estimate of the matrix acres, it is possible to approximate suitable acres by seral stage for each administrative unit (Tables 16, 17a-17f). Summary results across all administrative units for some seral stages in Option 9 are:

Category	----------------FS/BLM forested--------		
	Total	Timber suitable (before adjustment)	% suitable
	thousands of acres		
Seedlings/saplings	3477	879	25
Small conifer	5200	968	19
Med. conifer single-story	2603	438	17
Med. conifer multistory	1157	345	30
Large conifer single-story	1305	171	13
Large conifer multistory	2961	382	13
Total (med/lrg conifer)	8026	1336	17

Thus, in Option 9, approximately 17 percent of the medium/large coniferous forest on lands administered by the Forest Service and BLM is on land considered suitable for timber production.

This seral stage analysis should be viewed as a first, crude approximation to the amount of different seral stages in the suitable timber base. Because these results are based on the assumption of a constant relationship between suitable acres and matrix acres for an administrative unit across all seral stages, they should be viewed with caution. Also, agency analysis of their age classes could yield a somewhat different allocation of suitable acres among seral stages because of different rules for allocating stands among the stages.

•• Adaptive Management Areas

Adaptive Management Areas contain approximately 19 percent of the land suitable for timber production in Option 9 (Table 18). They contribute somewhat less than 19 percent of the harvest---perhaps 15 percent---because of the special modeling rules used for them in the analysis.

•• Allocation of Roadless Areas

Over 3 million acres of roadless areas still exist in the National Forests of the owl region. Approximately 10 percent of these acres are in the timber suitable land base for Option 9 and the acres contribute approximately 70 million board feet (6 percent) of the PSQ in that option (Table 19).

Additional Policy Analysis

Interpreting Murrelet Protection Guidelines for Option 9

In the development of the PSQ for Option 9, we assumed that the late-successional reserve system for the option would suffice for marbled murrelet protection. Option 9 turned out to require that LS/OG1 and LS/OG2 areas be reserved within the near zone of the marbled murrelet (referred to as marbled murrelet zone 1 in the FEMAT Report), even if they were outside the unified reserves established in Option 9. We have reported these updated figures in the PSQ estimates for Option 9 for the National Forests. The effects on four National Forests are as follows:

Forest	Suitable timber land		PSQ	
	Without OG1/OG2 reserved (before adjustments)	With OG1/OG2 reserved	Without OG1/OG2 reserved (before adjustments)	With OG1/OG2 reserved
	thousands of acres		millions of board feet	
MBS	65	57	13.7	11.8
OLY	73	64	15.7	13.0
SIS	143	103	44.6	31.4
SIU	31	30	25.9	25.8
Total	312	254	99.9	82.0

In at least one place (page IV-24), the FEMAT Report could be interpreted to suggest all "owl additions" should also be reserved. We did not do that in this analysis. Also, reserving these lands might reduce the PSQ another 5-10 million board feet on these four coastal National Forests.

With all the LS/OG1 and LS/OG2 areas reserved, the BLM's timber base would lose about 11,000 acres of mostly young timber scattered throughout western Oregon. At 300 board feet per acre, that would reduce harvest 3 million board feet per year from the levels reported in this paper. Reservation of all owl additions would have only a slight additional impact.

Long Rotations in Region 5

The FEMAT Report calls for use, in Option 9, of "180-year harvest rotations for conifer and mixed evergreen forests" on federal land in California. The objective for this control is not given in the report. At least part of the goal here, though, appears to compensate for the lack of a "50-11-40" rule in the option.

Numerous approaches could be taken to implementing this direction. First, the user must select the harvest control. At least three possibilities exist: (1) use area control (cut 1/180 of the area per year), (2) set the minimum rotation for future stands at 180 years, and (3) set the minimum rotation for existing stands at 180 years. These three types of harvest controls can be used alone or in any combination.

If area control is chosen (with or without the rotation minimums), then three more decisions are needed: (1) determination of the land base in regulation (such as the timber suitable base, all forest outside of late-successional reserves and Wilderness, all forest), (2) the geographic extent of regulation (such as the entire forest regulated as a unit or each major watershed regulated separately), and (3) the harvest priority (such as cut first the stand with the highest return or cut the average stand).

Without the 180-year rotation requirement, Region 5 under Option 9 will produce approximately 257 million board feet per year. With the requirement, Region 5 will provide from 20 to 212 million board feet per year, depending on the decisions made relative to the variables in the calculation discussed above (Table 20).

We have chosen in Option 9 to represent an approach for Region 5 that applies area control, watershed by watershed, using all forest in the watershed outside of late-successional reserves and Wilderness as the regulation base, and allowing the stand with the highest return to be cut first. We used area control because there is some concern over rates of disturbance. We used watershed as the regulation unit because the FEMAT Report calls for watersheds as the basic planning unit in the future. We used all forest outside of late-successional reserves and Wilderness as the regulation base because that is similar to the types of land included in the 50-11-40 rule calculation. Finally, we allowed the highest valued stand to be selected first because that is allowed on other administrative units.

Thus, the Region 5 PSQ under Option 9 is reported as 184 million board feet per year. For comparison, applying the 50-11-40 rule to Region 5 in Option 9 might yield a PSQ of about 190 million board feet. It should be noted that the PSQ for California in the FEMAT Report was estimated at 152 million board feet which came from an initial estimate of an area control approach calculated on a forest-wide basis that included only land suitable for timber production (estimated at 159 million board feet here).

Green Tree Retention in Region 5

The FEMAT Report calls for green tree retention in Option 9 of 15 percent of sale unit volume for the National Forests of California (USDA 1993:III-23). These National Forests were considering green tree retention levels of 23-48 percent in their proposed Forest Plans (Table 9). In Option 9, we reduced the green tree standards for these forests to the 15 percent level.

The FEMAT Report calls for Forest Plan standards and guidelines to apply where they are more restrictive than those in Option 9 (USDA 1993:III-23) although it is difficult to tell by the wording whether that rule applies in this case. Applying the green tree requirement in the proposed Forest Plans in Region 5 would lower the PSQ there by about 10 percent. Thus, the PSQ would decline from 184 million board feet per year to about 166 million board feet per year.

Variations on the SAT Report

The SAT Report (Thomas et al. 1993) proposed a strategy for the protection of habitat for late-successional species and threatened fish stocks on federal land in the owl region. It called for implementation of the Thomas Report's Conservation Strategy (or the northern spotted owl recovery plan), protection of all mature forest within the range of the marbled murrelet, and implementation of riparian reserve system 1.

To understand the SAT Report's implication regarding risk to species and timber harvest, we examined two types of murrelet protection: (1) protection of all mature habitat within the range (called "SAT"), and (2) protection of LS/OG1, LS/OG2, and owl additions identified in a report by Johnson et al. (1991) (called "revised SAT"). We also examined two types of fish habitat protection: (1) riparian reserve 1 (called "SAT") and (2) riparian reserve 1 protection for permanent streams, and half the protection for intermittent streams (called "half SAT"). Table 21 gives the results of the four simulations. We summarize their timber harvest results for the owl region as follows:

Murrelet protection	Fish habitat protection	PSQ (MMBF/YR)	% greater than SAT
SAT	SAT	743	---
SAT	half SAT	826	11
Revised SAT	SAT	848	14
Revised SAT	half SAT	931	25

Thus, moving to revised SAT for murrelet or fish protection raises the PSQ by about 11 to 14 percent, and moving to both at once approximately doubles these results. As can be seen in Table 21, the impact by administrative unit varies considerably: the coastal forests receive the biggest boosts in PSQ from the change. The scenario with revised murrelet protection and half SAT fish protection formed the basis for Option 5.

Key Watersheds

An important question remains as to whether further timber sales will be allowed in Key Watersheds. All these watersheds must have a watershed assessment done before sales can proceed and we do not know what this assessment will show or how the information will be used. The Tier 1 Key Watersheds, which cover over 90 percent of the Key Watershed acreage, contain potentially threatened fish stocks. Certainly, any harvest here will proceed very cautiously.

Therefore, we evaluated the contribution of Tier 1 Key Watersheds for selected options:

Option	------------------PSQ------------------		%
	With Key Watersheds	Without Key Watersheds	chng
6	811	645	21
9	1050	849	19

While Options 6 and 9 have a somewhat comparable acreage in late-successional reserves, Option 9 experiences a lower impact on harvest from removing Key Watersheds because one objective of the option was to overlap reserves and Key Watersheds. See Table 22 for comparisons by administrative unit for Option 9.

The 50-11-40 Rule

We have two analyses that allow estimation of the effect of the 50-11-40 rule: (1) Option 7 (Forest and District Plans plus the northern spotted owl recovery plan) was analyzed with and without the 50-11-40 rule; and (2) Option 10 is simply Option 6 without the 50-11-40 rule.

	With 50-11-40	Without 50-11-40	% reduction
Option 7	1561	1956	25
Options 6/10	811	958	18

As the extent of withdrawals in the matrix increases (as is seen in a corresponding increase in the riparian reserve system from Option 7 to Options 6 and 10), the impact of the 50-11-40 rule diminishes. See Table 23 for comparisons by administrative unit.

Potential Sources of Error in PSQ Estimates

As pointed out in the FEMAT Report, some of the management rules and procedures for the different options make it difficult to fully determine the actual sale level that will result. While we will concentrate on Option 9, most of the discussion here also applies to the other options.

Estimates of Stream Miles and Interim Buffer Widths

The riparian reserve levels were a function of both the specified buffer widths and amount of streams and wetlands on the administrative units. For a number of reasons, the estimates made here of these two variables may be in error:

1. Estimates of stream miles for the different administrative units came from a relatively small sample of quads (approximately two per National Forest or BLM District) (see Chapter V of the FEMAT Report for more information).
2. The amount of intermittent streams that will be found on federal lands remains an issue.
3. No estimate of wetland buffers were included in the PSQ calculations.
4. The guidelines for buffers call for buffering all 100-year flood plains, inner gorges and riparian vegetation. This was not directly addressed.
5. Site-potential tree heights came from a relatively small sample.
6. An average site-potential tree height was assigned to each administrative unit after determining the average site of the administrative unit. No recognition was made that the site along streams might be higher than this average or that the site might vary over the forest.

Interpreting Northern Spotted Owl Protection Guidelines

The northern spotted owl recovery plan (USDI 1992) calls for a number of types of reserves including managed pair areas, reserved pair areas, and 100-acre buffers around each nest site. These reserves were not always retained in Options 2, 3, 6, 8, 9, and 10. It remains to be seen whether they will be needed.

Additional Buffers for Sensitive Vertebrates and Invertebrates

Like many of the options, Option 9 calls for designation of "activity centers" or other special buffers for marbled murrelets and other species, as they are found, within which timber harvest will be prohibited or restricted. We allowed for the impact of only those sites that had been located at the time of the analysis. We expect many more sites will be found, especially for the murrelet, with a resulting impact on timber harvest levels.

Inoperable Acres

It was difficult for us to fully capture the impact of the extensive riparian network in Option 9 on the area available for timber production. Much of the timber production area will be in fairly small pieces and slivers between the riparian corridors---at least until watershed analysis is completed. While we did conduct an inoperable land assessment, and a reduction for inoperable acres was factored into the probable sale quantity, we remain concerned about whether we have recognized the full extent of this problem.

The Effect of Green Tree Retention on Future Stand Growth

Many of the options call for green tree retention beyond that prescribed in the underlying Forest Plans of Region 6 and, to a lessor degree, of BLM's District Plans. We built into our analysis the effects on volume harvested per acre from these policies. Recent studies (Birch and Johnson 1992) though, suggest that leaving green trees in coastal forests can also reduce future stand growth. We did not build such reductions into the PSQ for the next decade, although it might be argued that future growth reductions will ripple back to the present and reduce near-term harvest levels under a nondeclining yield harvest policy. We did not consider the potential effect of reductions in future growth on PSQ for the next decade, in part because the short time available for this analysis precluded reconstruction of underlying yield tables. In addition, the PSQ for most of the administrative units starts significantly below the long-term potential growth for the forests. Thus, somewhat reducing this long-term growth rate will not necessarily translate into an equivalent reduction in PSQ now.

Still, reducing future stand growth could have some effect on PSQ for the next decade especially in those options that call for leaving six large trees per acre (Options 2, 6, 8, and 10). Option 9, on the other hand, calls for leaving 15 percent of the volume in harvest units, approximately equally distributed between clumps and scattered trees. Leaving 7.5 percent of the volume in scattered trees works out to leaving about 2.5 large trees per acre. Interpreting the work of Birch and Johnson, the growth effects of such a policy might reduce the PSQ of the next decade by up to 5 percent. This 5 percent reduction---should it be needed---would be in addition to the reduction in immediate inventory which we built into the analysis.

Unresolved Issues in the Calculation of PSQ

Including the Key Watershed Harvest in the PSQ

A watershed assessment must be completed before more timber sales can occur in Tier 1 Key Watersheds. In the meantime, other parts of the forest could be the source of the Tier 1 Key Watershed's share of the harvest. Without some thought, these Key Watersheds may function somewhat like the roadless areas of the 1980s: present in the timber base but unavailable, with a resulting overemphasis on timber harvest from other lands. To avoid this problem, we urge the Forest Service and BLM to consider keeping the probable sale contributions from these watersheds separate (noninterchangeable) from the rest of the probable sale level, such that the portion of the probable sale level ascribed to these areas must actually come from these areas.

Including the Adaptive Management Areas in the PSQ

We must await the completion of Adaptive Management Areas plans to get a firm idea of their associated sale levels. Until then, there will be a natural tendency to stay away from these areas even though they are assumed to contribute timber harvest just slightly below that of comparable acres elsewhere in the suitable timber base. Going elsewhere for the Adaptive Management Area volume could create problems. As with Tier 1 Key Watersheds, therefore, we urge that the Forest Service and BLM consider keeping the probable sale contributions from these areas separate (noninterchangeable) from the rest of the probable sale level such that the portion of the probable sale level ascribed to these areas must actually come from these areas.

Increasing the Level of Protection of Habitats

A number of mitigation steps are outlined in the FEMAT Report to increase the level of protection given to the habitat of different species, if that is desired. Increasing habitat protection to an 80 percent likelihood of achieving stable, well-distributed populations, as an example, for species that do not attain that level of protection under Option 9 (such as anadromous fish stocks) could have a significant impact on the probable sale quantity.

Reflecting Historic Patterns of Forest Structure and Disturbance

Theories about how to achieve sustainable forest ecosystems are rapidly evolving. Much of the thinking centers around the objective of reflecting historic (pre-European) patterns of forest structure and disturbance as the surest guide to sustainable forests, and we would expect Forest and District Plan revisions to consider this guide. In their work, FEMAT did not directly address this issue in terms of matrix management. Rather FEMAT, in many options such as Option 9, used the matrix management approach of the Forest and District Plans slightly augmented by green tree retention requirements. Altering rotation length and other practices in the matrix to enable federal forests to reflect historic patterns of forest structure and disturbance could significantly affect timber harvest levels.

Maintaining Consistency with the Ecosystem Policy of the Federal Agencies

Many National Forests in Region 6 have already begun implementation of the Forest Service Chief's new ecosystem policy. Green tree retention under this policy is often higher than the 15 percent called for under Option 9. Therefore, implementation of Option 9 could require a rollback of these practices on some forests---always a hard thing to achieve---or the probable sale levels estimated here could prove inaccurate. The BLM Districts may experience similar phenomena as they implement the ecosystem policy of their agency.

Dependence on the Harvest of Late-Successional Forest

Most of the harvest in Option 9 (and many other options) over the next decade will come from late-successional forest (over 80 years old). Close to 50 percent will come from forest over 200 years old. Thus late-successional forest will remain the bulwark of the harvest in the next decade under Option 9. On the four National Forests in the Cascade Range that will provide much of the Forest Service's contribution to harvest under Option 9 (Gifford Pinchot, Mt. Hood, Willamette, and Umpqua), little other approach is possible given the age class distribution of the inventory (Table 24). While Option 9 may reserve sizeable amount of late-successional forest on federal land, it does not escape the historic dependence on late-successional forest and old growth as the source of harvest volume (see the sale analysis below for details). How publicly acceptable this policy will be remains to be seen.

Achieving Stability in Planned Sale Levels

According to the FEMAT's authorizing letter (Appendix A), one of the principles the President said should guide the FEMAT effort was that "the plan should produce a predictable and sustainable level of timber sales..." The goal of a predictable level of timber sales will be difficult, perhaps impossible, to achieve under Option 9 or most of the other options presented in the FEMAT Report.

In the past the federal lands in the owl region had a primary objective of offering a similar level of timber sales from year to year. That goal was often achieved even if harvest on federal lands was sometimes erratic due to fluctuations in the wood products market.

Until recently, a fundamental assumption was that a sustained yield of timber would sustain the underlying forest processes. Now that assumption is being questioned. The major goal of forest management has shifted to sustaining the underlying ecological processes of the forest, which, in the FEMAT Report, are largely measured through the protection of habitat for late-successional species and fish.

The laws governing management of federal forest lands require protection of threatened species and their habitats, not production of commodities. Overall, uncertainty will cloud the preparation of timber sales prepared under the direction of the FEMAT Report for the foreseeable future. Planning processes for which we have no blueprint will be required that measure and control cumulative environmental effects. Extensive project surveys will be needed for a multitude of species before timber sales can go forward; as species are located, significant sale modification or abandonment may be necessary. In sum, it will be difficult in the future to achieve predictable supplies of timber from federal lands in the owl region.

The Reserves as Potential Sources of Timber Volume

We analyzed the potential volume from thinning and catastrophic salvage in late-successional reserves separate from the probable sale levels discussed above.

From Thinning

Many of the options in the FEMAT Report allow thinning in young stands within late-successional reserves. Some restrict this thinning to small managed stands (less than approximately 12" dbh or about 50 years old) where such action will accelerate the development of late-successional forest. One (Option 9) allows thinning in managed or natural stands up to 80 years old where such action will assist, or be neutral to, development of late-successional forest.

Little volume could be produced from thinning managed stands in reserves in the first decade under most options---the stands are too young (generally less than 30 years old) to contribute much volume except in a few places like the Oregon Coast. For example, such action on lands administered by the BLM would produce less than 5 million board feet per year. Next decade, though, such harvest could begin to contribute more volume.

On the other hand, more volume might be produced by allowing the thinning of natural stands in reserves up to 80 years old. For example, such action on lands administered by the BLM could produce up to 25 million board feet per year under many of the options.

In total, though, thinning in reserves has only very limited ability to produce timber volume in this decade. This conclusion is partly explained by the age class structure of the federal lands. Considering the four National Forests in the Cascade Range that will provide much of the timber harvest in most options, we see that most of the forests are either less than 40 years old or greater than 80 (Table 24). Looking at the distribution of standing volume on these Forests, the situation is even clearer: over 90 percent of the volume is in stands over 80 years old. This pattern is also shown, to a lessor degree, on lands administered by the BLM.

The conclusion is reenforced by the limited proportion of these young stands that would be available within late-successional reserves in options such as option 9. Most of these stands are in Congressional withdrawals, administrative withdrawals, or riparian reserves.

From Catastrophic Salvage

The standards and guidelines for many of the options allow salvage within late-successional reserves after a catastrophic event such as fire or windthrow. To assess the potential harvest associated with such policies, we did an analysis of potential timber yield that might be gained from fire salvage on lands administered by the Forest Service in Region 6 under the options.

We first estimated fire frequency from Forest Service records that spanned 21 years (1970-1991). Fire frequencies varied from a low of 0.008 percent per year (Siuslaw National Forest) to a high of 0.5 percent per year (Siskiyou National Forest) (Table 25). The average historical fire frequency equated to about a 770 year rotation. Conversations with ecologists (T. Spies pers. comm.) led us to believe that the expected future fire frequency would yield a shorter average rotation. Therefore, we also considered about half the calculated rotation of 350 years.

We next estimated the yield that might accrue from salvaging stands burned at these historic rates. Because most of the volume in the owl region is in mature stands (the 8 million acres of medium and large conifer described above), we concentrated on their salvage. We estimated the volume per acre in these stands by administrative unit with an overall regional average of about 6200 cubic feet per acre.

However, most of the options, including Option 9, follow the salvage rule in the northern spotted owl recovery plan that requires leaving enough dead trees to achieve natural levels of snags and coarse woody debris once late-successional characteristics again occur (80-100 years). Following these rules, it appears likely that salvage of only relatively small trees (those under 20" dbh) from large, heavily-impacted areas will be permitted. Therefore, we estimated the proportion of the volume less than 20" dbh in the mature forest of each National Forest (Table 25) which averaged about 25 percent of the volume in mature stands less than 20" dbh.

Finally, we estimated the acres of mature forest that might be available for salvage within late-successional reserves. For Option 9, the Forest Service Region 6 acreage in mature forest in reserves totals 1.3 million acres after netting out administrative and congressional withdrawals (Table 25). These reserves overlap with riparian reserves.

Multiplying the historic fire frequency times the mature acres in reserves times the volume that might be available for harvest yields the potential salvage yield from mature stands in the owl region. We did this calculation both for a fire frequency that would yield a 770 year rotation (1X) and the one that would yield a 350 year rotation (2X). Average annual volumes under these assumptions would be from 2.2 to 4.4 million cubic feet per year or 12.1 to 24.2 million board feet per year. Expanding these estimates to cover the entire region might double this estimate.

Other volume would potentially be available from wind storms (especially in the Siuslaw and Olympic National Forests). Also, salvage volume could potentially be available in the small conifer stands. While these stands have much lower average volumes than the medium and large conifer stands, they also would have a higher percentage of the volume under 20" dbh.

On the other side of the issue, not all fire-damaged areas in reserves will be salvaged. Option 9 does not allow salvage in areas less than 10 acres. Realistically, salvage of all available areas will probably not occur. Finally, there are considerable safety issues involved in falling small dead trees under large dead trees.

Short-Term Timber Sales

It takes many months or years to prepare timber sales. Sale planning and design by an interdisciplinary team, completion of protocols for the location of threatened and endangered species (such as the northern spotted owl and marbled murrelet), and National Environmental Policy Act (NEPA) compliance all take significant amounts of time. Given the time required to prepare new sales, the impacts of various options on the short-term federal timber supply is, for the most part, a function of how the options affect the existing and near-term timber sale program. In assessing the consequences of the options relative to the timber sale program, we concentrated our efforts on determining where the individual sales were located with respect to the variety of terrestrial and aquatic reserve systems present in the options, Key Watersheds, Adaptive Management Areas, and other problematic allocations. We then determined how much sale volume was located inside and outside of these various allocations for each of the different sale categories.

Methodology

We first asked Forest Service and BLM field personnel to stratify existing sales and those nearing completion into four categories:

1. Sales sold and awarded (category 1). These are sales that have been bought by the purchaser and a formal contract has been written. These sales are currently being harvested and are often referred to as "volume under contract".

2. Sales prepared but not sold that have been enjoined by the decisions of Judge Dwyer (category 2). By and large, these sales would have been the basis of the Forest Service's fiscal year 1992 timber sale program if Judge Dwyer had lifted the injunction on sales in northern spotted owl habitat.

3. Sales prepared but not yet sold that are not enjoined by the decisions of Judge Dwyer (categories 3 and 4). Category 3 sales would be sold by September 30, 1993, and category 4 sales by December 31, 1993. They are lumped together for this analysis.

4. Sales sold and not awarded (category 5). These sales have been bought by a purchaser but have not been formerly awarded with the issuance of a contract.

Each National Forest and BLM unit was then asked to locate individual timber sales on a 1/2-inch to the mile base map and identify each sale as belonging to one of the five categories. In addition, the field units supplied the following information for each timber sale: sale name, predominant harvest method, sale volume, consultation requirements for spotted owls and murrelets, stand age, harvest acres, remaining system road construction and riparian volume. For the latter, the field units were instructed to use the buffer widths used in the probable sale quantity analysis.

Map overlays were created for the late-successional reserve systems present in the various options. Specifically, overlays of LS/OG1, LS/OG2, and owl additions were developed along with ones for the designated conservation areas (DCAs) and "Option 9" reserves. Overlays were also constructed depicting boundaries for spotted owl critical habitat units (CHUs), marbled murrelet near zone, RARE roadless areas, Adaptive Management Areas, and Key Watersheds. The Key Watersheds were further identified as being either Tier 1 or Tier 2. Forest Service Regional Office staff used the overlays in conjunction with the timber sale base maps to make ocular estimates of the percent of each timber sale located within each of these areas.

The information gained from this overlay process along with the information provided by the field units was used to develop a PARADOX data base for Forest Service sales and a LOTUS spreadsheet for BLM sales. A series of queries were then performed on the data bases, the results of which are presented below.

Comparison of Options

The FEMAT options are, in essence, a set of land allocations and standards and guidelines for the federal forests of the owl region. In evaluating the impact of these options on the Forest Service timber sale program, we looked at three categories of land allocations: (1) allocations exempting timber harvest, (2) allocations requiring further analyses prior to permitting harvest, and (3) allocations where the short-term management direction is uncertain. We chose to examine these two latter categories because the amount of time needed to conduct required inventories, analyses and assessments or the time required to further clarify direction may preclude timber sales from going forward in the near term. The preemptive allocations we examined were terrestrial and aquatic reserves systems, the "further analyses" allocations were Key Watersheds, and the "clarify direction" allocations were Adaptive Management Areas. Some type of terrestrial or aquatic reserve system is part of all options, Key Watersheds are identified in all but Option 7, and Adaptive Management Areas are only found in Option 9. We sorted the timber sales to determine which were inside and which were outside of these various option components. Table 25 displays how much of the existing and near-term timber sale program is impacted.

Options 2, 4, 5, 6, 9, and 10 contain 47-62 percent of the categories 1 and 5 sale volume, 47-61 percent of the category 2 sale volume, and 22-34 percent of the categories 3 and 4 sale volume in murrelet, late-successional or riparian reserves. Option 1 has the most timber in some type of reserve: 96 percent of the sale volume in categories 1 and 5, 98 percent of the sale volume in category 2, and 70 percent of the sale volume in categories 3 and 4. Option 7 has the least amount in reserves: 27 percent of the sale volume in categories 1 and 5, 18 percent in category 2, and 6 percent in categories 3 and 4. Figure 1 displays the sale volume remaining outside reserve systems under each option as a percentage of the total sale volume present in each category. Option 1 has the least amount of sale volume remaining outside the reserves: 4 percent of the sale volume in categories 1 and 5, 2 percent in category 2, and 30 percent in categories 3 and 4. Option 7 has the most sale volume remaining outside of reserves: 73-94 percent of the sale volume across all categories remains outside reserves. The remaining options have from 39-78 percent of all sale volume located outside the reserve systems. Of these remaining options, Option 5 has the most sales volume present outside of the reserves and Option 2 has the least amount.

Timber sales which were not in some type of reserve were further sorted according to Key Watershed and Adaptive Management Area boundaries. When those timber sales that fell outside of reserves yet inside Key Watersheds or Adaptive Management Areas are considered unavailable in the near term along with the timber sales inside reserves, Options 2, 4, 5, 6, 9 and 10 have 60-72 percent of the sale volume in categories 1, 2 and 5, and 40-51 percent of the sale volume in categories 3 and 4 unavailable for harvest. By restricting sales from Key Watersheds and Adaptive Management Areas under these options, 10-18 percent more sale volume is made unavailable when compared to restricting sales in only the reserve systems. Option 1 still has the largest impact on the sale program; however, adding Key Watershed restrictions on top of the Option 1 reserve system results in the least additional unavailable sale volume. Adding the Key Watersheds in this instance resulted in 0-1 percent more volume being unavailable. The size of the reserve system for Option 1 basically makes the impact of other allocations marginal to nonexistent. Since Option 7 does not contain Key Watersheds, the amount of sale volume unavailable does not change. This option continues to have the least impact on the timber sale program.

Figure 2 displays the resulting volume available under each option assuming all timber sales located in reserves systems, Key Watersheds, and Adaptive Management Areas cannot be harvested in the near term. Option 7 has the most volume available and Option 1 has the least. The remaining options are fairly well clustered together.

The preceding discussion centered on effects of the terrestrial and aquatic reserves when considered jointly. We also looked at the relative impact of each type of reserve when taken separately. Specifically, we examined the impact of alternative murrelet policies, alternative late-successional reserve systems, and alternative riparian scenarios. The results are presented below.

Alternative Marbled Murrelet Policies

The options embody one of two murrelet strategies: (1) set aside LS/OG1 and LS/OG2 areas in the murrelet near zone or (2) set aside LS/OG2 in the murrelet near zone. Because the murrelet is a threatened species, we felt all murrelet habitat might prove to be exempt from harvesting in the near term. We therefore chose to examine potential impacts of additional murrelet strategies. The results of this work are shown in Table 27.

The murrelet strategies we considered include policies excluding all sales within the murrelet near zone, policies excluding sales within LS/OG1 and LS/OG2 areas in the murrelet near zone, and those preempting sales located in LS/OG2 areas in the murrelet near zone. For each of these strategies we then examined the impact on available sale volume of excluding sales needing consultation on the murrelet. When the policy of excluding sales needing consultation is added to the strategy for the murrelet near zone, for example, an additional 103 million board feet across all sale categories becomes unavailable. This is due to the consultation requirements for sales within the murrelet far zone (also referred to in the FEMAT Report as marbled murrelet zone 2).

The murrelet strategies impact the sale volume quite differently. Looking at Table 27, we see the strategy referred to as "LS/OG2 within the murrelet near zone" is the least restrictive across all sale categories and the "murrelet near zone with consultation" is the most restrictive in terms of sale volume. It is also interesting to note that the effect of adding consultation as a criterion for removal of sales has the most impact on the "LS/OG2 within murrelet near zone" strategy. This is due to the presence of those sales within the near zone needing consultation which are not located in LS/OG2 areas.

Regardless of option, all sales that fall within the murrelet near zone and all sales needing consultation might be preempted from harvest in the near term. We chose to evaluate what this type of policy would mean to available sale volume if it was enacted in conjunction with each of the options. The results of this assessment are shown in Table 28.

Adding the "murrelet near zone plus consultation" strategy to each of the options results in the removal of an additional 8 to 318 million board feet from the available volume in category 2, and an additional 5 to 65 million board feet from the available volume in categories 3 and 4. The largest additional removals occur under Option 7 where designated conservation areas are the only reserves.

Late-Successional Reserves

The range of options considered in this study include different late-successional reserve systems. Timber sales were examined to see whether they were located in each of these reserve systems. A comparison was then made to see how much of each sale category fell within and outside of each of the reserve systems. The results are shown in Table 29.

For all sale categories, the late-successional reserve system built on designated conservation areas (DCAs) removes the least amount of sale volume from availability, and the late-successional reserve system referred to as "LS/OG1, LS/OG2, LS/OG3 and Owl Additions" removes the most sale volume. Under the "DCA" strategy, 27 percent of the sale volume in category 1, 18 percent of the sale volume in category 2, 6 percent of the sale volume in categories 3 and 4, and 38 percent of the sale volume in category 5 is in the reserves. In contrast, the "LS/OG1, LS/OG2, LS/OG3 and Owl Additions" system removes 95 percent of the sale volume in category 1, 97 percent of the sale volume in category 2, 63 percent of the sale volume in categories 3 and 4, and 100 percent of the sales volume in category 5 from the total available sale volume.

We also examined how well the alternative late-successional reserve systems overlapped with sales located in spotted owl critical habitat designated by the USDI Fish and Wildlife Service. Table 30 displays the total volume inside each of the reserve systems and the total amount of that volume that is also located in critical habitat unit. For category 2 sales, 294.4 million board feet of the sale volume is located in critical habitat. Of that 294.4 million board feet, 121.8 is inside DCAs, 160.1 is inside DCAs and LS/OG1 areas, 110.3 is inside LS/OG1 and Owl Addition areas, 166.0 is inside LS/OG1, LS/OG2 and Owl Additions, 243.3 is inside LS/OG1, LS/OG2, LS/OG3 and Owl Additions, and 140 million board feet is inside "Option 9" reserves. While the "LS/OG1, LS/OG2, LS/OG3 and Owl Additions" reserve system captures most of the sales located in critical habitat, none of the reserve systems capture all of it, and there appears to be no clear trend in terms of "DCA" based reserves overlapping these areas more than "LS/OG" based systems or vice versa.

Riparian Reserves

The riparian reserve scenarios have not yet been located on the ground. The field units examined each sale and determined how much of the volume fell within riparian scenario 1 and riparian scenario 2. Personnel at the field units felt that the estimates they developed have a 10-20 percent margin of error associated with them.

We looked at the relationship of the riparian reserves to total sale volume for each of the sale categories. The results shown in Table 31 suggest that, for the most part, riparian scenario 1 removes 25-35 percent of the total sale volume from the available base and riparian scenario 2 removes 15-30 percent. The relationship between riparian scenario 1 and riparian scenario 2 also appears to be fairly constant across categories. Under riparian scenario 1, about 3-6 percent more sale volume is set aside than under riparian scenario 2.

Age Class Distribution and Harvest Methods

Each of the sales were tagged according to their predominant stand age and harvest method. We grouped the ages into three categories: (1) less than 80 years, (2) 80 to 200 years, and (3) 200 years and older, and we grouped the harvest methods into two classes: (1) even-aged regeneration harvest and (2) other harvest methods. The silvicultural treatments in the latter group range from partial cuts to hazard tree removals. Table 32 displays by sale category the amount of sale volume and harvest acres coming from each of the age and harvest method groupings.

There are two noteworthy trends displayed in Table 32. The amount of sale volume coming from stands 200 years and older shifts dramatically between sale categories. For sale categories 1, 2 and 5, 49-50 percent of the total sale volume is from stands 200 years and older. In contrast, only 10 percent of the sale volume in categories 3 and 4 is from stands greater than 200-years old. The other trend is in harvest method. While even-aged regeneration harvest is the predominant method for category 1 sales, the predominant method for categories 3 and 4 sales is some other form of harvest.

Another aspect of the age class distribution that we examined was the overlap between the allocations in the options and stands 200 years and older. Table 33 shows: (1) the amount of volume available under each option assuming all volume within the various option components is unavailable in the near term, (2) the amount of this volume classified as 200 years and older, and (3) the total amount of sale volume in each sale category classified as 200 years and older.

Examining category 2 sales in Table 33 reveals that of the total sale volume (1199.2 million board feet), 49 percent or 591.3 million board feet is classified as 200 years and older. Of that 591.3 million board feet, 31-84 percent is available for harvest under Options 2 through 10. Option 1, which has 20.1 million board feet available for harvest, excludes from harvest 100 percent of the stands greater than 200-years old. Option 7, on the other hand, protects the least amount of the sale volume 200 years and older. Of the 591.3 million board feet of category 2 sale volume classified as 200 years and older, 495.0 million board feet or 84 percent of this volume is located outside the reserves in Option 7.

With the exception of Option 1, Option 2 has the least amount of sales 200 years and older lying outside of reserves and Key Watersheds. Of the 591.3 million board feet of category 2 sale volume classified as 200 years and older, 185.1 million board feet or 31 percent falls outside the reserves and Key Watersheds in Option 2. The remaining 69 percent lies within one of the option's components. Figure 3 displays these percentages for each of the options and sale categories.

Screening Individual Options

Forest Service

This section looks at how the various allocations within an option are distributed in relation to each other. In order to see whether the components of an option overlap or are mutually exclusive we classified each of the sales categories for an option according to four or five hierarchical criteria. First, the sales were classified as to whether they were within the option's murrelet reserves. Given this determination, sales were further classified as to whether they were inside or outside the late-successional reserve system of the option. Then the sales were further classified as to whether they were inside or outside Key Watersheds or Adaptive Management Areas. Finally, the sales were sorted to determine which were inside roadless areas. Table 34 presents the results of this sorting process for Option 9.

The volume in the intersection of each sale category and sale classification in Table 34 is further classified in terms of total volume and riparian reserve volume. The riparian reserve volume represents the amount of total sale volume located in Option 9 riparian reserves. For example, the total volume in category 1 sales is 1808.1 million board feet. Total sale volume located in riparian reserves is 394.3 million board feet. Total volume net of riparian reserves is 1413.8 million board feet (1808.1 — 394.3).
Table 34 shows the amount of sale volume located in each allocation and whether the allocations overlap. From this information we can determine the marginal impact on sale volume of precluding harvest in the different land allocations. A word of caution is in order, however. As the following example will illustrate, the marginal cost of precluding harvests from the different land allocations is a function of the order in which the allocations are considered. There is, for example, 471.6 million board feet of category 2 sale volume located in the terrestrial reserves and 349.2 million board feet of category 2 volume located in Key Watersheds. Of the 349.2 million board feet located in Key Watersheds, 57 percent or 197.9 million board feet falls within the terrestrial reserve system and 150.1 million board feet fall outside the reserves. If terrestrial reserves are first made unavailable for harvest, then the cost of this decision could be viewed as a loss of 471.6 million board feet of sale volume. If harvest is then precluded from Key Watersheds, the incremental cost in terms of sale volume for that decision would be 150.1 million board feet, the amount of sale volume located in Key Watersheds but outside of reserves.

If we reverse the order and first preclude harvest from the Key Watersheds and then the reserves, the marginal costs of these decisions will be different. The costs in terms of lost sale volume for precluding harvest from Key Watersheds would, in this instance, be 349.2 million board feet, the full amount of category 2 sale volume located in Key Watersheds. Adding the reserves on top of the Key Watersheds would then result in an additional 273.7 million board feet of sale volume being ascribed to the reserves rather than 471.6 million board feet. How the lost sale volume is distributed back to the individual allocations is a function of which allocations get considered first. It's truly a case of "first in gets hardest hit".

The overlap between the Adaptive Management Areas and terrestrial reserves is less than that found for the Key Watersheds and terrestrial reserves. There is 168.3 million board feet of category 1 volume, 163.6 million board feet of category 2 volume, and 52.5 million board feet of categories 3 and 4 sale volume located in Adaptive Management Areas. Of the total Adaptive Management Area volume, 19 percent of the category 1, 11 percent of the category 2, and 26 percent of the categories 3 and 4 sale volume occurs inside terrestrial reserve systems. The remainder occurs outside the reserves. There is greater overlap between roadless area designations and terrestrial reserves: 147.4 million board feet of category 1 sale volume is located in roadless areas; as is 108.9 million board feet of category 2 volume, 19.5 million board feet of categories 3 and 4 volume, and 17.4 million board feet of category 5 sale volume. Of this volume, 46 percent of the category 1, 53 percent of the category 2, 11 percent of the categories 3 and 4, and 100 percent of the category 5 fall within the terrestrial reserves. The remainder is located outside the reserves.

By sorting down through the sales shown in Table 34, we can determine how much of the sale volume falls inside and outside of each of the Option 9 allocations. A quick scan reveals that approximately 32 percent of category 1, 28 percent of category 2, 46 percent of categories 3 and 4, and 24 percent of category 5 sale volume is located outside of Option 9 allocations and roadless areas. The remainder of the sale volume falls within one or more of the reserve systems, Key Watersheds, Adaptive Management Areas, or roadless areas.

It is quite clear from Table 34 that the allocations do not perfectly overlap. If only the terrestrial reserves exclude harvesting in the near term, then of the 1199.2 million board feet of category 2 sales, 727.6 million board feet would be available for harvest. If the aquatic reserves are also unavailable then the amount of sale volume drops to 572.3 million board feet. If, in addition, Key Watersheds and Adaptive Management Areas are restricted areas in the next year or two due to requirements for further analysis, then the pool of available sale volume falls to 355.6 million board feet. Finally, if roadless areas are determined to be off limits, then the category 2 sale volume available is 340.9, 28 percent of the total volume in category 2 sales.

Bureau of Land Management

The information contained in Table 35 shows the distribution of sale volume using similar categories to those used by the Forest Service. The major difference is found under category 2. The volume shown under category 2 consists of sold sales which are enjoined. Of this volume, 70 million board feet is comprised of sold and awarded timber sales, the remainder is sold and unawarded. In addition, BLM does not have any designated roadless areas so those land allocation classes have been eliminated.

The volume shown under category 5 consists of Section 318 sales. The vast majority of these sales have just completed the consultation process. The actual volume which will be available for award is approximately half of that shown. This is due to the fact that in order to avoid "jeopardy calls" for the northern spotted owl and adverse modification of its critical habitat, the affected sale actions were changed prior to the finalization of the biological opinions. The affected sales will have to be modified in order to reflect these changes prior to their award.

Sale Information Update

In July 1993, the Forest Service updated and corrected the sale data that formed the foundation for this work. Table 36 shows the results of this update. Comparing Table 36 to the original data in Table 26, we see the largest change occurred in the total category 1 sale volume. In the original data there was 1808.1 million board feet of volume available in category 1 sales. This has now dropped to 1457.0 million board feet. This reduction is due to the harvesting that occurred April through July 1993. Sale data changes monthly as category 1 sales are harvested, categories 3 and 4 sales are sold and new sales are planned. It is not unexpected to find these differences since each data base takes a "snapshot" of the sale situation at different points in time. There is nothing, however, in the updated information to suggest the relationships we discovered and the magnitude of impact on the near-term sale program are significantly different than those found with the original data.

Summary

Drawing on timber sales that have already been prepared to provide volume in the near term may prove difficult under most options because of their location in terrestrial and aquatic reserve systems, Key Watersheds, Adaptive Management Areas, roadless areas, and critical habitat for the northern spotted owl as designated by the USDI Fish and Wildlife Service. Option 7 has the least impact on the pool of available sales. Of the 1.7 billion board feet of categories 2, 3 and 4 sales, Option 7 has approximately 1.4 billion sales outside of its "DCA" based terrestrial reserve system. It is questionable, however, whether all this volume is available given the recent rulings on the murrelet and the potential listing of threatened fish stocks. When Option 7 is adjusted to reflect current murrelet requirements, the amount of available volume drops to under 1 billion board feet. Option 1 has the most impact on the timber sale program. Only 130 million board feet remain available if harvesting is excluded from its terrestrial and aquatic reserves and the Key Watersheds. The remainder of the options are clustered between these two options with anywhere from 500 to 700 million board feet remaining available for harvesting.

The element of time is critical when putting together a short-term timber program. The sale volumes reported above could easily be delayed for some time while sales are redesigned to come into compliance with the rules of each option. The rules that determine where roads can and cannot be placed relative to riparian reserves are an example of why sales might need to be redesigned and, as a result, delayed from being offered.

The agencies may be able to prepare some additional sales in fiscal year 1994 beyond those listed here. Recent sale preparation has focused on sales in less controversial areas. More of these sales might be ready before the end of fiscal year 1994. It must be pointed out though, that the majority of the categories 3 and 4 sales considered above will be sold before the end of this fiscal year.

Thus, the new sales will replace, to some degree, the depletion of these sales. Beyond fiscal year 1994, the picture improves somewhat assuming the agencies are given clear rules for project design and an efficient process for dealing with sales in spotted owl habitat. One dark cloud on the horizon, however, is the continued reduction in force that is rapidly depleting the ranks of timber sale preparers. Unless this reduction is slowed and (in some cases) reversed, the person power may not exist to prepare a future sales program of any size.

Table and Figure Abbreviations

ACEC	Area of Critical Environmental Concern
ALS	Alsea Sustained Yield Unit
AMA	Adaptive Management Area
BF	Board feet
BLM	Bureau of Land Management (USDI)
CF	Cubic feet
CHU	Critical habitat unit
CLA	Clackamas Sustained Yield Unit
COL	Columbia Sustained Yield Unit
COOS	Coos Bay District
DCA	Designated conservation area
DES	Deschutes National Forest
DOU	Douglas Sustained Yield Unit
EUG	Eugene District
FEIS	Final Environmental Impact Statement
FEMAT	Forest Ecosystem Management Assessment Team
GIP	Gifford Pinchot National Forest
HCA	Habitat Conservation Area
ISC	Interagency Scientific Committee
JAC	Jackson Sustained Yield Unit
JOS	Josephine Sustained Yield Unit
KLA	Klamath District
KLA	Klamath Sustained Yield Unit
LS/OG	Late-successional/old-growth (area)
LAK	Lakeview District
MED	Medford District
MBS	Mt. Baker-Snoqualmie National Forest
MMBF	Million board feet
MMCF	Million cubic feet
MTH	Mt. Hood National Forest
NF	National Forest
OKA	Okanogan National Forest
PSQ	Probably sale quantity
ROR	Rogue River National Forest
ROS	Roseburg District
SAL	Salem District
SAN	Santiam Sustained Yield Unit
SAT	Scientific Analysis Team (Report)
SCT	South Coast Sustained Yield Unit
SHA/TRN	Shasta-Trinity National Forest
SIS	Siskiyou National Forest
SIU	Siuslaw National Forest
SIU	Siuslaw Sustained Yield Unit
SOU	South Umpqua Sustained Yield Unit
SXR	Six Rivers National Forest
UKI	Ukiah District
UMP	Umpqua National Forest
UPW	Upper Willamette Sustained Yield Unit
WEN	Wenatchee National Forest
WIL	Willamette National Forest
WIN	Winema National Forest

Table 1. Summarized description of the options for forest ecosystem management. (See explanatory notes for origin of the late-successional reserves and managed late-successional areas.) (This table was developed from Table III-2 of the FEMAT Report.)

Option	Late-Successional Reserves	Managed Late-Successional Areas	Riparian Reserve strategy	Matrix
Option 1	LS/OG1s; plus LS/OG2s; plus LS/OG3s; plus owl additions; plus occupied marbled murrelet sites; plus buffers for other species associated with old-growth forests. No timber harvest.	Buffers for other species associated with old-growth forests.	Riparian 1	50-11-40 rule plus retention of six large green trees, two large logs, and two snags per acre. Timber harvest rotations of 180-years plus 10 percent of the matrix in stands over 180-years.
Option 2	LS/OG1s; plus LS/OG2s; plus owl additions; plus occupied marbled murrelet sites. Timber harvest only in younger forest stands and limited salvage.		Riparian 2	50-11-40 rule plus retention of six large green trees, two large logs, and two snags per acre.
Option 3	LS/OG1s; plus LS/OG2s within marbled murrelet zone 1; plus owl additions in the western portion of the northern spotted owl range; plus buffers for other species associated with old-growth forests. Timber harvest only in younger forest stands and limited salvage.	LS/OG2s outside marbled murrelet zone 1 plus owl additions -- approximately 50% to be retained with other 50% to be managed on 250-350 year rotations or through uneven-age management in the eastern portion of the owl's range. Six green trees retained in cutting units. Managed pair areas for the eastern portion of the northern spotted owl range. Number and management to be based on the provisions of the Final Draft Recovery Plan (USDI 1992). Buffers for other species associated with old-growth forests.	Riparian 2	50-11-40 rule plus retention of four large green trees, 2-12 logs per acre plus snag levels to support cavity excavators, plus protection of 10 percent of the matrix to be left in well-distributed patches of late-successional (or oldest available) forests.

Table 1. (continued)

Option	Late-Successional Reserves	Managed Late-Successional Areas	Riparian Reserve strategy	Matrix
Option 4	LS/OG1s; plus LS/OG2s in marbled murrelet zone 1; plus designated conservation areas; plus reserved pair areas; plus residual habitat areas; plus occupied marbled murrelet sites; plus buffers for other species associated with old-growth forests. Management based on treatments of younger forest stands and limited salvage adapted from provisions of the Final Draft Recovery Plan (USDI 1992).	Managed pair areas -- number and management based on the provisions of the Final Draft Recovery Plan (USDI 1992); plus buffers for other species associated with old-growth forests.	Riparian 1	50-11-40 rule plus retention of green trees, logs, and snags based on Forest and District Plan prescriptions.
Option 5	LS/OG1s and LS/OG2s within marbled murrelet zone 1; plus designated conservation areas; plus reserved pair areas; plus residual habitat areas; plus occupied marbled murrelet sites; plus buffers for other species associated with old-growth forests. Management based on treatment of younger stands and limited salvage adapted from provisions of the Final Draft Recovery Plan (USDI 1992).	Managed pair areas -- number and management based on the provisions of the Final Draft Recovery Plan (USDI 1992); plus buffers for other species associated with old-growth forest.	Riparian 2	50-11-40 rule plus retention of green trees, logs, and snags based on Forest and District Plan prescriptions.
Option 6	LS/OG1s; plus owl additions; plus LS/OG2s within marbled murrelet zone 1; plus occupied marbled murrelet sites. Timber harvest limited to treatment of younger forest stands and limited salvage.		Riparian 2	50-11-40 rule plus retention of six large green trees, two snags, and two logs per acre.
Option 7	Designated conservation areas; plus reserved pair areas; plus residual habitat areas. Management based on federal agency interpretation of the provisions of the Final Draft Recovery Plan (USDI 1992).	Managed pair areas -- number and management based on the provisions of the Final Draft Recovery Plan (USDI 1992);	Riparian buffers as prescribed in the Forest and District Plans.	50-11-40 rule (as interpreted by the agencies) plus retention of trees, logs, and snags based on Forest and District Plan provisions.
Option 8	LS/OG1s; plus owl additions; plus LS/OG2s within marbled murrelet zone 1. Timber harvest only in younger stands and limited salvage within marbled murrelet zone 1. Outside marbled murrelet zone 1, timber harvest allowed in stands less than 180-years old to produce or maintain spotted owl habitat, and salvage allowed that meets Forest and District Plan standards.		Riparian 3	Retention of green trees, snags, and logs based on Forest and District Plan provisions.

Table 1. (continued)

Option	Late-Successional Reserves	Managed Late-Successional Areas	Riparian Reserve strategy	Matrix
Option 9	Portions of LS/OG1s, LS/OG2s, and designated conservation areas from Johnson et al. (1991) and USDI (1992); plus all LS/OG1s and LS/OG2s in marbled murrelet zone 1; plus occupied marbled murrelet sites; plus buffers for other species associated with old-growth forests. Placement of late-successional reserves in Key Watersheds emphasized. Management adapted from provisions of the Final Draft Recovery Plan for Northern Spotted Owls (USDI 1992).	Buffers for other species associated with old-growth forests.	Riparian 2	Coastal OR and WA Forests - No retention of green trees. Other National Forests in OR and WA - retention of 15 percent of the volume of a cutting unit in individual green trees or aggregation of 0.5 to 4 acres. Federal Forests in CA - 180-year rotations in conifer forests, 100-year rotations in hardwood forests. BLM-administered lands in OR - Provisions of the revised preferred alternatives of Draft Resource Management Plans.
Option 10	Same as Option 6	Same as Option 6	Same as Option 6	Retention of six large green trees, two snags, and two logs per acre.

Explanatory notes -

LS/OG1, LS/OG2, LS/OG3, owl additions - Terms for late-successional/old-growth reserve areas from Alternatives for Management of Late-Successional Forests of the Pacific Northwest (Johnson et al. 1991).

Designated conservation areas, reserved pair areas, residual habitat areas; and managed pair areas - Terms from the Final Draft Recovery Plan for the Northern Spotted Owl (USDI 1992).

Occupied marbled murrelet sites - Forest stands outside reserves found to be occupied by marbled murrelets.

Marbled murrelet zone 1 - Washington, coast-inland 40 miles; Oregon, coast-inland 35 miles; California, coast-inland 35 miles narrowing to 10 miles (also referred to in this paper as "marbled murrelet near zone").

Buffers for other species associated with old-growth forests - Forest areas around sites occupied by species identified in the report of the Scientific Analysis Team (Thomas et al. 1993) that will be protected from cutting (late-successional reserves) or managed under special guidelines (managed late-successional areas) to provide protection for the occupied sites.

Forest and District Plan elements - Land allocations or standards and guidelines from National Forests or on BLM District land and resource management plans that protect late-successional forests (late-successional reserves) or provide for timber harvest consistent with definitions of managed late-successional areas.

50-11-40 rule - A prescription that calls for at least 50 percent of the forest stands on federal lands to be at least 11" dbh and for such stands to have a canopy closure of at least 40 percent.

Table 2. Administrative unit abbreviations.

National Forests		Bureau of Land Management			
Forest	Abbreviation	District	Abbreviation	Sustained Yield Units	Abbreviation
Deschutes*	DES	Coos Bay	COO	South Coast	SCT
Gifford Pinchot	GIP				
Mt Baker Snoqualmie	MBS	Eugene	EUG	Upper Willamette	UPW
Mt. Hood	MTH			Siuslaw	SIU
Okanogan*	OKA				
Olympia	OLY	Lakeview	LAK	Klamath	KLA
Rogue River	ROR				
Siskiyou	SIS	Medford	MED	Josephine	JOS
Siuslaw	SIU			Jackson	JAC
Umpqua	UMP			Klamath	KLA
Wenatchee	WEN				
Willamette	WIL	Roseburg	ROS	Douglas	DOU
Winema*	WIN			South Umpqua	SOU
Klamath	KLA				
Mendocino	MEN	Salem	SAL	Columbia	COL
Shasta-Trinity	SHA/TRN			Clackamas	CLA
Six Rivers	SXR			Alsea	ALS
				Santiam	SAN
		Ukiah	UKI		

* Study includes only the portion of these National Forests within the owl region.

Table 3. Description of approaches taken to estimate PSQ by option.

OPTION	ADMINISTRATIVE UNIT[1]		
	National Forest Region 5	National Forest Region 6[2]	Bureau of Land Management
1	FORPLAN	15% of Option 2	50-11-40 simulator
2	FORPLAN	Modification of other National Forest simulations	50-11-40 simulator
3	FORPLAN	2/3 * Option 2 + 1/3 * Option 6	2/3 * Option 2 + 1/3 * Option 6
4	FORPLAN	National Forest simulations	50-11-40 simulator
5	FORPLAN	National Forest simulations	50-11-40 simulator
6	FORPLAN	National Forest simulations	50-11-40 simulator
7	FORPLAN	National Forest simulations	TRIM-PLUS
8	FORPLAN	Modification of another National Forest simulation	Per acre production coefficient from Option 7
9	FORPLAN	National Forest simulations	Per acre production coefficient from Option 7
10	FORPLAN	National Forest simulations	Modification of Option 6 for removal of 50-11-40 rule using 2/3 of removal effect from Option 7

[1] For a more detailed description see Appendix B.

[2] Each National Forest in Region 6 developed PSQ estimates using FORPLAN, spatial data base analyses, or a combination of both.

Table 4. Some features of probable sale quantity (PSQ) modeling of FEMAT options.

Option	Late-Successional Reserves Withdrawals from Suitable Timber Base	Riparian Reserves: Withdrawals from Suitable Timber base			Riparian Reserves	Timber Suitable Base	
		Buffers	Unstable land	Inoperable	Slope/Horizontal Distance PSQ Adjustments	Green Tree Retention PSQ Adjustments	Special Management Rules for Adaptive Mgmt. Areas
1	X	X		X	X	X	
2	X	X	X	X	X	X	
3	X	X	X	X	X	X	
4	X	X		X	X		
5	X	X	X	X	X		
6	X	X	X	X	X	X	
7	X	X					
8	X	X	X	X	X		
9	X	X	X	X	X	X	X
10	X	X	X	X	X	X	

Table 5. Minimum widths of riparian reserves expressed as whichever slope distance is greatest. (In addition, riparian reserves must include the 100-year floodplain, inner gorge, unstable, potentially unstable areas, and riparian vegetation.)

Riparian Reserve Scenario	Applicable Lands	Stream Category: Fish Bearing	Stream Category: Permanent Flowing Non-fish Bearing	Stream Category: Intermittent
		(# of tree heights/minimum distance in feet)		
1	All lands	2/300	1/150	1/100
2	Tier 1 Key Watershed	2/300	1/150	1/100
	Tier 2 Key Watershed and other lands	2/300	1/150	1/2 /50
3	All lands	2/300	1/2 /75	1/6 /25

Note: Options 1 and 4 use scenario 1, Options 2, 3, 5, 6, 9 and 10 use scenario 2 and Option 8 uses scenario 3. Option 7 uses the riparian standards and guidelines in the Forest and District Plans.

Table 6. Estimated height of Douglas-fir site-potential trees from data from the Forest Service and Bureau of Land Management.

Administrative Unit	Oregon and Washington McArdle Site Class (Site Index)			
	II (180)	III (145)	IV (110)	V (90)
	feet			
Bureau of Land Management	250	210	170	140
Siuslaw National Forest	230	190	150	--
Willamette National Forest	--	190	155	130
Olympic National Forest	--	210	170	140

Table 7. Extent of riparian reserves using site-potential tree height to define width and quad assessment to establish density.

Administrative Unit	Site Class	Site Potential Tree Height	Land Base '000 acres	Miles of Stream by Stream Class I/II	III	IV	Stream Density (mi./sq.mi.)	Percent of Land Base Within Riparian Reserves ----Reserve Scenario---- 1	2	3
National Forests - Region 6 - Oregon										
DES	5	140	1,621	403	112	1,000	0.60	4	3	2
MTH	4	170	1,063	3,700	4,200	1,742	5.81	51	47	37
ROR	4	170	632	860	566	2,582	4.06	31	24	16
SIS	4	170	1,092	2,446	4,044	8,087	8.54	62	54	32
SIU	2	250	631	1,200	2,000	4,084	7.39	74	59	38
UMP	4	170	984	773	977	7,447	5.98	40	30	13
WIL	4	170	1,675	1,249	2,001	11,825	5.76	39	27	12
WIN	5	140	1,043	190	110	1,000	0.80	5	3	2
NF - Oregon Total			**8,741**	**10,821**	**14,010**	**37,767**				
National Forests - Region 6 - Washington										
GIP	4	170	1,372	1,840	2,840	10,639	7.15	50	37	20
MBS	4	170	1,723	807	10,720	6,727	6.78	43	39	18
OKA	5	140	1,706	321	603	11,413	4.63	24	14	6
OLY	3/4	190	632	896	1,277	5,777	8.05	61	44	24
WEN	5	140	2,164	1,768	1,795	25,245	8.52	47	35	13
NF - Washington Total			**7,597**	**5,632**	**17,235**	**59,801**				
NF - Region 6 Total			**16,338**	**16,453**	**31,245**	**97,568**				
National Forests - Region 5 - California										
KLA		179	1,680	1,195	2,675	9,736	5.18	40	28	14
MEN		165	894	319	1,127	11,042	8.94	55	36	13
SXR		200	958	850	1,109	6,810	5.86	46	38	17
SHA/TRN		190	2,121	1,900	745	16,752	5.85	45	34	16
NF - California Total			**5,653**	**4,264**	**5,656**	**44,340**				
National Forest Total			**21,991**	**20,717**	**36,901**	**141,908**				
Bureau of Land Management Districts - Oregon/California										
SAL	3	210	398	776	820	2,165	6.05	55	42	29
EUG	3	207	315	640	963	1,303	5.90	54	45	31
ROS	3	194	419	1,028	646	2,017	5.64	55	44	33
COO	2	226	327	556	1,695	1,254	6.86	69	58	38
MED/LAK	4	170	919	554	1,646	5,826	5.59	37	25	13
UKI			16	168	305	324				
BLM Total			**2,394**	**3,722**	**6,075**	**12,889**				
Total			**24,385**	**24,439**	**42,976**	**154,797**				

Note: The percent of land base within the riparian reserves shown is to illustrate the use of site-potential tree height combined with quad measured stream density. Administrative units may have developed their own GIS based estimates of riparian reserves for use in probable sale quantity (PSQ) estimation.

Table 8. Factors used in modifying probable sale quantity (PSQ) estimates. After PSQ's calc'd by forests from table 7 + other data, these %'s were used in PSQ.

Administrative Unit	Percent Change: *Additional nonriparian as a result of Slope/Horizontal correction Riparian Reserve 1	2	3	Additional Riparian Riparian Reserve 1	2	Additional Inoperable acres Riparian Reserve 1	2 and 3	Additional Unstable Lands	Additional Green tree retention Option 9	Options 1, 2, 6, 10
National Forests - Region 6 - Oregon										
DES	0	0	0	0	0	1	1	0.5	9	4
MTH	4	4	3	0	0	4	3	4	13	18
ROR	3	3	2	0	0	2	2	8	13	18
SIS	7	7	4	3	2	10	8	6	15	20
SIU	9	6	3	0	0	10	8	4	0	18
UMP	5	4	2	0	0	4	3	8	10	15
WIL	4	2	1	4	2	4	3	3	5	10
WIN	0	0	0	0	0	1	1	0.5	10	5
National Forests - Region 6 - Washington										
GIP	5	4	2	2	1	6	5	5	13	18
MBS	6	5	2	-5	-3	6	6	5	0	17
OKA	3	2	1	0	0	5	4	2	7	7
OLY	7	5	3	3	2	6	5	4	0	13
WEN	4	3	1	13	7	5	4	5	13	13
National Forests - Region 5 - California										
KLA	NA**	NA**	NA**	0	0	7	5.5	8	-8	0
MEN	NA**	NA**	NA**	0	0	7	5.5	8	-7	0
SXR	NA**	NA**	NA**	0	0	7	5.5	4	-26	0
SHA/TRN	NA**	NA**	NA**	0	0	7	5.5	5	-6	0
Bureau of Land Management Districts - Oregon (District / Sustained Yield Unit)										
SAL COL	5	4	2	0	0	10	10	4	0	11
CLA	3	3	2	0	0	10	10	4	0	0
ALS	5	4	2	0	0	10	10	4	0	9
SAN	3	3	2	0	0	10	10	3	0	5
EUG UPW	3	3	2	0	0	10	10	3	0	6
SIU	5	4	3	0	0	10	10	4	0	22
ROS SOU	4	4	2	0	0	10	10	8	0	5
DOU	4	3	2	0	0	10	10	8	0	0
COO SCT	4	3	2	0	0	10	10	4	0	4
MED JOS	2	1	1	0	0	10	10	6	0	0
JAC	2	1	1	0	0	10	10	8	0	0
LAK KLA	2	1	1	0	0	10	10	1	0	0

* Calculated as: (Proportion of slope/horizontal distance x Percent of land area in Riparian reserve) / Percent of land area in nonriparian

** Not available.

Table 9. Evolution of federal sale quantities consistent with protection of the northern spotted owl.

Administrative Unit	Forest/District Plans with ISC Strategy Hamilton Report (1990) (MMBF)	Forest/District Plans with ISC Strategy Northern Spotted Owl FEIS (1992) (MMBF)	Forest/District Plans with Northern Spotted Owl Recovery Plan (1993) (MMBF)
National Forests - Region 6 - Oregon			
DES	27	22	19
MTH	154	138	132
ROR	85	50	29
SIS	119	126	118
SIU	198	172	119
UMP	273	263	149
WIL	333	275	152
WIN	42	45	47
NF - Oregon Total	**1231**	**1091**	**763**
National Forests - Region 6 - Washington			
GIP	189	166	135
MBS	45	32	32
OKA	14	14	8
OLY	43	20	19
WEN	83	54	36
NF - Washington Total	**374**	**286**	**230**
NF - Region 6 Total	**1605**	**1377**	**994**
National Forests - Region 5 - California			
KLA	110	103 *	82
MEN	66	25	23
SXR	129	65 *	43
SHA/TRN	92	85	90
NF - California Total	**397**	**278**	**237**
National Forest Total	**2002**	**1655**	**1230**
Bureau of Land Management Districts Oregon/California			
SAL	51	NA	71
EUG	49	NA	53
ROS	85	NA	56
COO	79	NA	71
MED/LAK	101	NA	81
UKI	3	NA	1
BLM Total	**368**	**NA**	**333**
Total	**2370**	**NA**	**1563**

* 103 MMBF reflects the RPA alternative on the Klamath National Forest; 65 MMBF reflects the current (No-Action) alternative on the Six Rivers National Forest. The preferred alternative on the Klamath National Forest had a harvest level of 87 MMBF and the preferred alternative Six Rivers National Forest had a harvest level of 45 MMBF. At that time, both Forests proposed harvest in the HCAs. Since that was not permitted in the FEIS, another alternative was used.

Table 10. Historic federal harvests and probable sale quantities (PSQ) in the first decade by option.*

Administrative Unit	Average Harvest 1980-89	Average Harvest 1990-92	Option 1	2	3	4	5	6	7	8	9	10
	----------	----------	----------	----------	----------	million board feet, Scribner	----------	----------	----------	----------	----------	----------
National Forests - Owl Forests												
Region 6 - Owl Forests												
Washington	1019	528	16	104	112	103	151	129	230	202	155	152
Oregon	2029	997	40	265	298	340	449	365	763	518	471	412
Total	3048	1525	55	369	410	443	600	494	994	720	626	564
Region 5 - Owl Forests												
California	561	291	17	113	125	111	141	150	237	222	184	198
Bureau of Land Management - Owl Forests												
Oregon/California	915	573	41	142	150	158	189	167	413	290	240	196
Total Owl Forests	**4524**	**2389**	**113**	**624**	**686**	**712**	**931**	**811**	**1643**	**1232**	**1050**	**958**

* Probable sale quantities include no "other wood" estimates. To obtain "other wood" estimates, add 10%. Historic numbers are "gross" volumes and thus include historic levels of "other wood". Historic numbers for 1990-92 are estimates.

Table 11. Total acres, forested acres, acres tentatively suitable for timber production, and acres suitable for timber production by Forest and District Plans and by FEMAT option.

Administrative Unit	Total	Forested	Tentatively Suitable	Forest Plans	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10
	'000 Acres			Suitable for Timber Production '000 Acres										
National Forests - Region 6 - Oregon														
DES	486	426	333	252	NA*	192	NA*	200	221	203	228	NA*	184	203
MTH	1063	949	678	388	NA*	113	NA*	183	230	193	339	NA*	215	193
ROR	632	561	391	315	NA*	69	NA*	98	142	102	218	NA*	139	102
SIS	1092	1037	616	510	NA*	75	NA*	91	110	109	402	NA*	104	109
SIU	631	582	538	369	NA*	97	NA*	23	35	39	169	NA*	33	39
UMP	984	905	729	621	NA*	143	NA*	261	338	312	466	NA*	266	312
WIL	1675	1504	1032	774	NA*	211	NA*	249	390	322	536	NA*	431	322
WIN	209	200	165	143	NA*	67	NA*	30	49	73	96	NA*	100	100
NF - Oregon Total	**6772**	**6164**	**4482**	**3372**	NA*	**968**	NA*	**1134**	**1513**	**1352**	**2454**	NA*	**1473**	**1380**
National Forests - Region 6 - Washington														
GIP	1372	1162	947	676	NA*	142	NA*	142	248	209	388	NA*	299	209
MBS	1723	1301	597	423	NA*	48	NA*	69	80	108	178	NA*	65	108
OKA	648	565	267	208	NA*	67	NA*	98	146	110	190	NA*	85	110
OLY	632	584	447	352	NA*	60	NA*	48	62	69	159	NA*	65	69
WEN	2164	1451	792	576	NA*	141	NA*	194	226	255	277	NA*	290	255
NF - Washington Total	**6539**	**5063**	**3050**	**2235**	NA*	**458**	NA*	**551**	**762**	**752**	**1192**	NA*	**803**	**752**
NF - Region 6 Total	**13311**	**11227**	**7532**	**5607**	NA*	**1426**	NA*	**1685**	**2276**	**2104**	**3646**	NA*	**2276**	**2132**
National Forests - Region 5 - California														
KLA	1680	1406	950	595	150	425	NA*	372	437	493	594	NA*	395	429
MEN	894	621	343	151	16	72	NA*	82	115	105	151	NA*	99	98
SXR	958	676	434	244	45	77	NA*	105	134	125	244	NA*	123	127
SHA/TRN	2001	1655	1078	528	125	368	NA*	301	394	386	529	NA*	396	373
NF - California Total	**5533**	**4358**	**2805**	**1518**	**336**	**942**	NA*	**860**	**1080**	**1109**	**1518**	NA*	**1013**	**1027**
National Forest Total	**18844**	**15585**	**10337**	**7125**	NA*	**2368**	NA*	**2545**	**3356**	**3213**	**5164**	NA*	**3288**	**3159**
Bureau of Land Management Districts - Oregon/California														
District / Sustained Yield Unit														
SAL COL	112	107	95	72	22	30	NA*	25	30	30	72	38	29	29
CLA	72	68	50	33	10	16	NA*	15	22	18	33	22	20	17
ALS	121	116	107	29	12	17	NA*	11	13	17	29	19	15	16
SAN	93	86	76	47	13	19	NA*	18	31	22	47	28	28	23
Salem Total	**398**	**377**	**327**	**181**	**57**	**82**	NA*	**69**	**96**	**87**	**182**	**106**	**92**	**84**
EUG UPW	154	147	141	84	42	52	NA*	49	63	64	84	61	75	62
SIU	161	155	145	64	24	30	NA*	27	33	33	64	32	36	31
Eugene Total	**315**	**302**	**286**	**148**	**65**	**82**	NA*	**77**	**96**	**97**	**148**	**93**	**111**	**93**
ROS SOU	109	105	97	60	13	28	NA*	33	44	36	60	43	45	36
DOU	310	291	274	132	40	75	NA*	75	99	95	133	103	100	91
Roseburg Total	**419**	**396**	**371**	**192**	**53**	**103**	NA*	**108**	**143**	**131**	**193**	**146**	**144**	**127**
COO SCT	327	308	273	149	67	109	NA*	91	101	109	149	118	97	105
Coos Bay Total	**327**	**308**	**273**	**149**	**67**	**109**	NA*	**91**	**101**	**109**	**149**	**118**	**97**	**105**
MED/LAK JOS	429	402	288	169	43	124	NA*	112	136	144	169	146	142	143
JAC	395	347	239	179	38	123	NA*	130	157	162	179	171	178	160
KLA	96	87	71	49	9	23	NA*	21	41	28	49	27	40	28
Medford Total	**920**	**836**	**599**	**397**	**90**	**269**	NA*	**264**	**333**	**335**	**396**	**343**	**359**	**331**
BLM Total	**2379**	**2219**	**1855**	**1067**	**333**	**645**	NA*	**608**	**770**	**757**	**1068**	**807**	**803**	**741**
Total	**21223**	**17804**	**12192**	**8192**	NA*	**3013**	NA*	**3154**	**4125**	**3971**	**6232**	NA*	**4092**	**3899**

* See Table 3. - Description of approaches taken to estimate PSQ in different options.

Note: Tentatively suitable = Total forested - forest in Wilderness, unstable forest, and unproductive forest. Suitable = Portion of the tenatively suitable in land use allocations that allow harvest.

Table 12. Probable sale quantities (PSQ) in millions of board feet (MMBF) by FEMAT option.

Administrative Unit		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10
						MMBF					
National Forests - Region 6 - Oregon											
DES		2	13	14	14	15	14	19	18	18	18
MTH		7	45	50	68	85	59	132	77	72	59
ROR		1	5	6	11	16	10	29	31	31	25
SIS		3	20	22	27	34	27	118	41	27	27
SIU		3	21	23	19	29	27	119	38	29	27
UMP		10	66	75	89	108	92	149	125	95	98
WIL		10	64	77	88	129	104	152	147	161	120
WIN		5	32	32	23	33	33	47	40	39	39
NF - Oregon Total		**40**	**265**	**298**	**340**	**449**	**365**	**763**	**518**	**471**	**412**
National Forests - Region 6 - Washington											
GIP		9	58	62	58	94	71	135	97	86	72
MBS		2	10	12	12	15	16	32	24	13	19
OKA		1	5	5	5	6	6	8	10	7	9
OLY		1	8	8	7	9	9	19	15	13	12
WEN		4	23	25	22	28	28	36	57	35	41
NF - Washington Total		**16**	**104**	**112**	**103**	**151**	**129**	**230**	**202**	**155**	**152**
NF - Region 6 Total		**55**	**369**	**410**	**443**	**600**	**494**	**994**	**720**	**626**	**564**
National Forests - Region 5 - California											
KLA		7	39	44	38	50	55	82	102	74	92
MEN		0	12	12	11	13	13	23	21	19	19
SXR		6	12	15	19	23	19	43	24	24	21
SHA/TRN		4	50	54	43	55	63	90	75	67	67
NF - California Total		**17**	**113**	**125**	**111**	**141**	**150**	**237**	**222**	**184**	**198**
National Forest Total		**72**	**482**	**535**	**554**	**742**	**644**	**1230**	**942**	**810**	**762**
Bureau of Land Management Districts - Oregon											
District	Sustained Yield Unit										
SAL	COL	4	9	9	8	10	9	28	14	10	10
	CLA	1	5	6	6	9	7	17	11	10	10
	ALS	1	3	3	3	3	4	22	14	9	6
	SAN	1	6	7	5	12	8	24	14	13	9
	Salem Total	**8**	**23**	**25**	**23**	**35**	**29**	**91**	**53**	**42**	**35**
EUG	UPW	10	18	20	22	28	24	46	42	30	29
	SIU	6	9	9	9	10	9	21	12	9	10
	Eugene Total	**16**	**27**	**29**	**31**	**38**	**33**	**67**	**54**	**39**	**40**
ROS	SOU	1	5	5	7	9	6	20	12	12	7
	DOU	3	14	15	18	22	17	54	39	34	22
	Roseburg Total	**4**	**19**	**20**	**25**	**31**	**23**	**74**	**51**	**46**	**29**
COO	SCT	12	41	41	44	44	43	95	66	50	52
	Coos Bay Total	**12**	**41**	**41**	**44**	**44**	**43**	**95**	**66**	**50**	**52**
MED/LAK	JOS	0	14	15	14	16	16	38	30	26	17
	JAC	0	15	16	17	19	19	39	32	31	19
	KLA	0	3	3	3	6	4	8	4	5	4
	Medford Total	**1**	**32**	**34**	**35**	**42**	**39**	**85**	**66**	**63**	**40**
BLM Total		**41**	**142**	**150**	**158**	**189**	**167**	**413**	**290**	**240**	**196**
Total		**113**	**624**	**686**	**712**	**931**	**811**	**1643**	**1232**	**1050**	**958**

Table 13. Probable sale quantities (PSQ) in millions of cubic feet (MMCF) by FEMAT option.

Administrative Unit		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10
		MMCF									
National Forests - Region 6 - Oregon											
DES		0	2	2	3	3	3	3	3	3	3
MTH		1	8	9	12	15	10	23	14	13	10
ROR		0	1	1	2	3	2	5	6	6	5
SIS		1	4	4	5	6	5	22	8	5	5
SIU		1	4	5	4	6	5	24	8	6	5
UMP		2	12	14	16	19	16	27	22	17	18
WIL		2	13	16	18	24	21	28	29	31	24
WIN		1	5	5	4	6	5	8	6	6	6
NF - Oregon Total		**7**	**50**	**55**	**63**	**82**	**67**	**140**	**96**	**87**	**76**
National Forests - Region 6 - Washington											
GIP		2	11	12	11	17	13	24	18	16	13
MBS		0	2	3	2	3	3	7	5	3	4
OKA		0	1	1	1	1	1	2	2	1	2
OLY		0	2	2	1	2	2	4	3	3	2
WEN		1	4	5	4	5	5	7	10	6	7
NF - Washington Total		**3**	**20**	**22**	**19**	**28**	**24**	**43**	**38**	**29**	**29**
NF - Region 6 Total		**10**	**70**	**77**	**83**	**110**	**92**	**183**	**134**	**116**	**104**
National Forests - Region 5 - California											
KLA		1	6	7	6	8	8	12	16	11	14
MEN		0	2	2	2	2	2	4	3	3	3
SXR		1	2	2	3	3	3	6	4	4	3
SHA/TRN		1	8	8	7	9	10	14	12	10	10
NF - California Total		**3**	**17**	**19**	**17**	**22**	**23**	**36**	**34**	**29**	**30**
National Forest Total		**13**	**87**	**96**	**100**	**132**	**114**	**219**	**168**	**144**	**135**
Bureau of Land Management Districts - Oregon											
District	Sustained Yield Unit										
SAL	COL	1	2	2	2	2	2	5	3	2	2
	CLA	0	1	1	1	2	1	2	2	2	2
	ALS	0	1	1	1	1	1	3	3	2	1
	SAN	0	1	1	1	2	1	4	3	2	2
	Salem Total	**2**	**5**	**5**	**5**	**7**	**6**	**14**	**10**	**8**	**7**
EUG	UPW	2	4	4	5	6	5	7	8	6	6
	SIU	1	2	2	2	2	2	4	2	2	2
	Eugene Total	**3**	**6**	**6**	**6**	**8**	**7**	**11**	**11**	**8**	**8**
ROS	SOU	0	1	1	1	2	1	3	2	2	1
	DOU	1	3	3	4	5	4	8	8	7	4
	Roseburg Total	**1**	**4**	**4**	**5**	**6**	**5**	**11**	**11**	**9**	**6**
COO	SCT	3	8	8	9	9	8	14	13	10	10
	Coos Bay Total	**3**	**8**	**8**	**9**	**9**	**8**	**14**	**13**	**10**	**10**
MED/LAK	JOS	0	3	3	3	3	3	8	6	5	3
	JAC	0	3	3	4	4	4	8	6	6	4
	KLA	0	1	1	1	1	1	2	1	1	1
	Medford Total	**0**	**7**	**7**	**7**	**9**	**8**	**18**	**13**	**13**	**8**
BLM Total		**9**	**30**	**31**	**32**	**38**	**34**	**67**	**58**	**48**	**39**
Total		**22**	**117**	**127**	**131**	**170**	**148**	**286**	**226**	**193**	**174**

Table 14. Probable sale quantities (PSQ) per suitable acre per year in board feet (BF) by FEMAT option.

Administrative Unit	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10
	BF/Ac/Yr									
National Forests - Region 6 - Oregon										
DES	NA*	69	NA*	72	70	70	82	NA*	95	87
MTH	NA*	402	NA*	373	368	304	389	NA*	335	308
ROR	NA*	69	NA*	111	110	94	133	NA*	220	239
SIS	NA*	261	NA*	300	308	248	292	NA*	259	248
SIU	NA*	211	NA*	835	847	707	703	NA*	866	707
UMP	NA*	464	NA*	340	320	294	320	NA*	358	314
WIL	NA*	303	NA*	357	331	323	283	NA*	373	373
WIN	NA*	468	NA*	770	686	451	486	NA*	389	385
National Forests - Region 6 - Washington										
GIP	NA*	405	NA*	407	380	337	349	NA*	289	343
MBS	NA*	213	NA*	169	186	148	180	NA*	207	172
OKA	NA*	78	NA*	49	39	51	41	NA*	80	82
OLY	NA*	126	NA*	140	142	124	118	NA*	202	167
WEN	NA*	165	NA*	115	122	110	131	NA*	122	160
National Forests - Region 5 - California										
KLA	47	91	NA*	103	114	112	137	213	186	213
MEN	13	167	NA*	134	117	122	152	189	194	189
SXR	131	160	NA*	179	171	153	174	166	194	166
SHA/TRN	29	136	NA*	144	140	162	170	180	170	180

Bureau of Land Management Districts - Oregon

District	Sustained Yield Unit	Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10
SAL	COL	163	302	NA*	340	348	300	325	371	359	356
	CLA	144	315	NA*	439	421	421	323	502	495	608
	ALS	101	166	NA*	248	234	267	517	724	610	365
	SAN	102	327	NA*	288	380	351	453	515	455	378
EUG	UPW	247	351	NA*	446	450	377	416	686	397	477
	SIU	246	298	NA*	316	288	282	278	376	257	331
ROS	SOU	74	174	NA*	216	209	168	267	283	268	195
	DOU	79	189	NA*	244	224	181	298	379	343	237
COO	SCT	186	374	NA*	480	432	393	477	560	520	497
MED/LAK	JOS	8	112	NA*	129	122	112	212	204	187	118
	JAC	4	121	NA*	131	121	116	209	186	175	120
	KLA	29	144	NA*	150	149	142	155	154	133	144

* See Table 3. - Description of approaches taken to estimate PSQ in different options.

Table 15. Probable sale quantities (PSQ) per suitable acre per year in cubic feet (CF) by FEMAT option.

Administrative Unit		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6	Option 7	Option 8	Option 9	Option 10
		CF/Ac/Yr									
National Forests - Region 6 - Oregon											
DES		NA*	12	NA*	13	13	12	15	NA*	17	15
MTH		NA*	72	NA*	66	65	54	69	NA*	59	54
ROR		NA*	14	NA*	20	20	18	24	NA*	41	44
SIS		NA*	52	NA*	56	57	46	54	NA*	48	46
SIU		NA*	43	NA*	165	169	140	142	NA*	174	140
UMP		NA*	85	NA*	61	57	53	57	NA*	64	56
WIL		NA*	62	NA*	71	63	64	52	NA*	73	75
WIN		NA*	71	NA*	127	114	70	80	NA*	60	58
National Forests - Region 6 - Washington											
GIP		NA*	77	NA*	75	69	62	63	NA*	52	63
MBS		NA*	47	NA*	36	39	31	37	NA*	42	35
OKA		NA*	14	NA*	9	7	10	8	NA*	15	16
OLY		NA*	28	NA*	30	30	27	24	NA*	43	36
WEN		NA*	31	NA*	21	22	20	24	NA*	22	29
National Forests - Region 5 - California											
KLA		7	14	NA*	16	17	17	21	32	28	32
MEN		0	25	NA*	21	18	19	23	30	29	30
SXR		20	23	NA*	27	25	23	26	25	37	25
SHA/TRN		5	21	NA*	22	22	25	26	28	26	28
Bureau of Land Management Districts - Oregon											
District	Sustained Yield Unit										
SAL	COL	33	63	NA*	66	68	59	64	72	70	71
	CLA	30	64	NA*	89	81	85	65	97	95	124
	ALS	21	36	NA*	50	47	53	99	145	122	73
	SAN	22	72	NA*	57	75	65	87	102	90	70
EUG	UPW	52	76	NA*	92	91	77	84	139	80	99
	SIU	52	65	NA*	65	59	62	61	77	53	71
ROS	SOU	17	38	NA*	44	42	34	53	57	54	40
	DOU	17	42	NA*	50	46	38	59	78	71	47
COO	SCT	39	77	NA*	94	85	77	93	110	102	98
MED/LAK	JOS	2	24	NA*	26	25	23	46	42	38	24
	JAC	1	26	NA*	27	25	24	46	38	36	25
	KLA	6	30	NA*	31	31	30	36	32	28	30

* See Table 3. - Description of approaches taken to estimate PSQ in different options.

Table 16. Timber suitable acres and matrix acres for Options 4, 7, and 9.*

Administrative Unit	Suitable Timber Production Acres					Matrix Acres					Percentage of Suitable Acres/Matrix Acres				
	Option 4 Acres	Option 7 Acres	AMA Option 9 Acres	OTHER Option 9 Acres	TOTAL Option 9 Acres	Option 4 Acres	Option 7 Acres	AMA Option 9 Acres	OTHER Option 9 Acres	TOTAL Option 9 Acres	Option 4 Percent	Option 7 Percent	AMA Option 9 Percent	OTHER Option 9 Percent	TOTAL Option 9 Percent
National Forests - Region 6 - Oregon															
DES	202	228	0	186	186	165	251	0	181	181	1.22	0.91	0.00	1.03	1.03
MTH	173	339	0	204	204	245	510	0	323	323	0.71	0.67	0.00	0.63	0.63
ROR	95	218	83	53	136	124	233	78	114	192	0.77	0.93	1.07	0.46	0.71
SIS	90	402	4	99	103	113	438	10	143	152	0.80	0.92	0.40	0.69	0.68
SIU	16	169	12	18	30	54	254	103	42	145	0.30	0.67	0.12	0.42	0.21
UMP	250	466	33	226	259	256	598	63	256	319	0.98	0.78	0.52	0.88	0.81
WIL	259	536	65	379	444	375	691	116	497	613	0.69	0.78	0.56	0.76	0.72
WIN	30	96	0	101	101	92	150	0	107	107	0.33	0.64	0.00	0.95	0.95
NF - Oregon Total	**1,115**	**2,454**	**197**	**1,266**	**1,463**	**1,423**	**3,124**	**370**	**1,663**	**2,032**					
National Forests - Region 6 - Washington															
GIP	142	388	62	239	301	162	402	100	231	331	0.88	0.96	0.62	1.04	0.91
MBS	59	178	10	47	57	133	231	86	163	249	0.44	0.77	0.12	0.29	0.23
OKA	99	190	0	86	86	161	279	0	125	125	0.61	0.68	0.00	0.68	0.68
OLY	47	159	65	0	65	60	167	137	0	137	0.79	0.95	0.47	0.00	0.47
WEN	231	277	47	279	326	317	488	64	382	446	0.73	0.57	0.73	0.73	0.73
NF -Washington Total	**578**	**1,192**	**184**	**651**	**835**	**832**	**1,566**	**388**	**901**	**1,289**					
NF - Region 6 Total	**1,693**	***3,646**	**381**	**1,918**	**2,298**	**2,256**	**4,691**	**757**	**2,564**	**3,321**					
National Forests - Region 5 - California															
KLA	372	594	135	260	395	277	512	141	238	379	1.34	1.16	0.96	1.09	1.04
MEN	82	151	0	99	99	176	351	0	227	227	0.47	0.43	0.00	0.44	0.44
SXR	105	244	25	98	123	168	375	86	147	233	0.63	0.65	0.29	0.67	0.53
SHA/TRN	301	529	118	278	396	525	918	246	449	695	0.57	0.58	0.48	0.62	0.57
NF - California Total	**860**	**1,518**	**278**	**735**	**1,013**	**1,145**	**2,157**	**473**	**1,061**	**1,534**					
National Forest Total	**2,553**	**5,164**	**659**	**2,653**	**3,311**	**3,401**	**6,848**	**1,230**	**3,625**	**4,855**					
Bureau of Land Management Districts - Oregon/California															
District															
Salem	64	182	21	66	87	71	181	111	74	185	0.89	1.00	0.19	0.89	0.47
Eugene	72	148	7	99	106	76	162	15	111	126	0.94	0.91	0.46	0.89	0.84
Roseburg	100	193	10	127	137	109	228	19	157	176	0.92	0.85	0.53	0.80	0.77
Coos Bay	86	149	0	93	93	95	169	0	117	117	0.90	0.88	0.00	0.79	0.79
Medford	256	396	60	292	352	381	609	113	529	641	0.67	0.65	0.53	0.55	0.55
Ukiah						112	156	33	104	137	0.00	0.00	0.00	0.00	0.00
BLM Total	**577**	**1,068**	**98**	**677**	**775**	**846**	**1,505**	**291**	**1,092**	**1,384**					
Total	**3,131**	**6,232**	**757**	**3,329**	**4,086**	**4,246**	**8,353**	**1,521**	**4,717**	**6,238**	**0.74**	**0.75**	**0.50**	**0.71**	**0.65**

* Prior to adjustments for slope distance for riparian reserves and inoperable lands (Nation Forests in Region 6 and BLM)

Note: Timber suitable acres and matrix acres are calculated using different approaches. Therefore, some anomalies occasionally result such as suitable acres greater than matrix acres.

Table 17a. Acres allocation for the seedling/sapling seral stage in Options 4, 7, and 9.

Administrative Unit	Matrix Acres ('000) Total	Option 4	Option 7	Option 9 AMA	Option 9 Other	Option 9 Total	Suitable Acres ('000) Total	Option 4	Option 7	Option 9 AMA	Option 9 Other	Option 9 Total
National Forests - Region 6 - Oregon												
DES	58	26	31	0	28	28	58	32	29	0	29	29
MTH	165	63	76	0	72	72	165	45	51	0	46	46
ROR	78	26	35	15	20	34	78	20	33	16	9	24
SIS	244	35	76	2	44	46	244	28	69	1	31	31
SIU	42	6	10	10	3	13	42	2	7	1	1	3
UMP	222	81	96	23	62	86	222	79	75	12	55	70
WIL	357	128	162	41	140	181	357	89	125	23	107	131
WIN	14	7	9	0	8	8	14	2	6	0	8	8
NF - Oregon Total	**1179**	**373**	**495**	**90**	**378**	**468**	**1179**	**297**	**394**	**52**	**285**	**341**
National Forests - Region 6 - Washington												
GIP	263	48	65	26	64	90	263	42	63	16	66	82
MBS	268	32	39	25	35	60	268	14	30	3	10	14
OKA	135	29	36	0	24	24	135	18	25	0	17	17
OLY	135	24	33	41	0	41	135	19	31	19	0	19
WEN	169	41	42	10	42	52	169	30	24	7	31	38
NF - Washington Total	**970**	**174**	**215**	**102**	**165**	**267**	**970**	**123**	**173**	**46**	**124**	**170**
NF - Region 6 Total	**2149**	**546**	**711**	**193**	**543**	**735**	**2149**	**419**	**567**	**98**	**409**	**511**
National Forests - Region 5 - California												
KLA	175	66	69	20	53	73	175	89	80	19	58	76
MEN	58	15	16	0	15	15	58	7	7	0	7	7
SXR	70	14	20	7	10	17	70	9	13	2	7	9
SHA/TRN	267	45	48	17	33	50	267	26	28	8	21	28
NF - California Total	**569**	**140**	**153**	**43**	**112**	**155**	**569**	**130**	**127**	**29**	**92**	**120**
National Forest Total	**2719**	**686**	**863**	**236**	**654**	**890**	**2719**	**550**	**695**	**127**	**501**	**631**
Bureau of Land Management Districts - Oregon/California												
SAL	146	33	43	45	30	75	146	30	43	8	27	35
EUG	153	49	63	3	64	67	153	47	58	2	57	56
ROS	153	56	66	10	63	72	153	52	56	5	50	56
COO	139	50	55	0	54	54	139	45	49	0	43	43
MED/LAK	165	94	102	21	85	106	165	63	66	11	47	58
UKI	3	0	0	0	0	0	3	0	0	0	0	0
BLM Total	**759**	**283**	**330**	**79**	**296**	**374**	**759**	**236**	**272**	**26**	**224**	**248**
Total	**3477**	**969**	**1194**	**315**	**950**	**1265**	**3477**	**785**	**967**	**153**	**725**	**879**

Table 17b. Acres allocation for the small conifer multistory seral stage in Options 4, 7, and 9.

Administrative Unit	Matrix Acres ('000) Total	Option 4	Option 7	Option 9 AMA	Option 9 Other	Option 9 Total	Suitable Acres ('000) Total	Option 4	Option 7	Option 9 AMA	Option 9 Other	Option 9 Total
National Forests - Region 6 - Oregon												
DES	441	100	133	0	104	104	441	123	120	0	106	106
MTH	509	134	169	0	156	156	509	94	113	0	99	99
ROR	269	73	101	38	62	101	269	56	95	41	29	71
SIS	384	40	82	6	51	56	384	32	75	2	35	38
SIU	380	50	93	28	36	63	380	15	62	3	15	13
UMP	273	88	102	9	86	94	273	86	79	4	76	77
WIL	321	67	78	14	77	91	321	46	61	8	58	66
WIN	186	65	83	0	70	70	186	21	53	0	66	66
NF - Oregon Total	**2763**	**616**	**841**	**95**	**641**	**735**	**2763**	**473**	**658**	**59**	**485**	**536**
National Forests - Region 6 - Washington												
GIP	487	75	98	38	90	128	487	66	94	24	93	117
MBS	371	50	63	20	60	80	371	22	49	2	17	18
OKA	241	31	57	0	18	18	241	19	39	0	12	12
OLY	252	33	45	77	0	77	252	26	43	36	0	36
WEN	503	83	89	5	95	100	503	60	50	3	70	73
NF - Washington Total	**1853**	**272**	**352**	**140**	**263**	**403**	**1853**	**194**	**275**	**66**	**193**	**257**
NF - Region 6 Total	**4616**	**888**	**1193**	**235**	**904**	**1139**	**4616**	**667**	**933**	**125**	**677**	**793**
National Forests - Region 5 - California												
KLA	11	1	1	0	1	1	11	2	2	0	1	1
MEN	47	16	17	0	17	17	47	8	7	0	7	7
SXR	4	0	0	0	0	0	4	0	0	0	0	0
SHA/TRN	101	34	38	9	26	36	101	19	22	4	16	20
NF - California Total	**163**	**51**	**56**	**9**	**44**	**53**	**163**	**29**	**31**	**4**	**25**	**29**
National Forest Total	**4778**	**939**	**1249**	**244**	**948**	**1192**	**4778**	**696**	**964**	**129**	**702**	**822**
Bureau of Land Management Districts - Oregon/California												
SAL	123	35	44	36	27	63	123	31	44	7	24	30
EUG	66	26	32	4	30	34	66	24	29	2	27	28
ROS	40	12	16	2	16	17	40	11	13	1	13	13
COO	35	17	18	0	18	18	35	15	15	0	14	14
MED/LAK	155	87	99	41	70	111	155	58	64	22	39	61
UKI	3	0	0	0	0	0	3	0	0	0	0	0
BLM Total	**422**	**177**	**207**	**82**	**160**	**242**	**422**	**141**	**166**	**31**	**116**	**146**
Total	**5201**	**1116**	**1457**	**326**	**1108**	**1434**	**5201**	**836**	**1130**	**160**	**818**	**968**

Table 17c. Acres allocation for the medium conifer single-story seral stage in Options 4, 7, and 9.

Administrative	Matrix Acres ('000)						Suitable Acres ('000)					
		Option	Option	Option 9				Option	Option	Option 9		
Unit	Total	4	7	AMA	Other	Total	Total	4	7	AMA	Other	Total
National Forests - Region 6 - Oregon												
DES	2	0	0	0	0	0	2	0	0	0	0	0
MTH	206	50	66	0	53	53	206	36	44	0	34	34
ROR	41	7	10	2	9	11	41	5	10	2	4	8
SIS	24	3	7	0	4	4	24	3	7	0	3	3
SIU	76	4	14	20	2	21	76	1	9	2	1	4
UMP	76	21	27	3	22	25	76	20	21	2	19	20
WIL	319	70	97	29	78	106	319	48	75	16	59	77
WIN	3	1	1	0	1	1	3	0	1	0	1	1
NF - Oregon Total	**747**	**155**	**223**	**54**	**168**	**222**	**747**	**113**	**167**	**22**	**121**	**147**
National Forests - Region 6 - Washington												
GIP	226	26	36	20	32	52	226	23	35	13	33	47
MBS	217	13	17	7	18	25	217	6	13	1	5	6
OKA	102	17	21	0	12	12	102	10	14	0	8	8
OLY	25	1	3	3	0	3	25	1	2	1	0	1
WEN	138	19	20	9	22	31	138	13	11	6	16	22
NF - Washington Total	**708**	**75**	**96**	**38**	**84**	**122**	**708**	**53**	**75**	**21**	**63**	**85**
NF - Region 6 Total	**1455**	**230**	**319**	**92**	**252**	**344**	**1455**	**166**	**242**	**43**	**183**	**232**
National Forests - Region 5 - California												
KLA	1	0	0	0	0	0	1	0	0	0	0	0
MEN	85	20	21	0	21	21	85	9	9	0	9	9
SXR	190	41	56	26	28	53	190	25	36	7	18	28
SHA/TRN	499	127	139	64	82	145	499	73	80	31	51	83
NF - California Total	**775**	**188**	**217**	**89**	**130**	**220**	**775**	**108**	**126**	**38**	**78**	**120**
National Forest Total	**2230**	**418**	**535**	**181**	**382**	**563**	**2230**	**274**	**368**	**81**	**261**	**352**
Bureau of Land Management Districts - Oregon/California												
SAL	50	3	9	11	5	16	50	3	9	2	4	8
EUG	52	4	10	7	8	15	52	3	9	3	7	13
ROS	93	22	33	4	31	35	93	20	28	2	25	27
COO	69	18	23	0	21	21	69	16	20	0	17	17
MED/LAK	89	34	42	5	34	40	89	22	28	3	19	22
UKI	22	1	1	0	1	1	22	0	0	0	0	0
BLM Total	**374**	**82**	**118**	**28**	**100**	**128**	**374**	**65**	**94**	**10**	**72**	**86**
Total	**2604**	**500**	**654**	**209**	**482**	**691**	**2604**	**340**	**462**	**92**	**333**	**438**

Table 17d. Acres allocation for the medium conifer multistory seral stage in Options 4, 7, and 9.

Administrative Unit	Matrix Acres ('000) Total	Matrix Option 4	Matrix Option 7	Matrix Option 9 AMA	Matrix Option 9 Other	Matrix Option 9 Total	Suitable Acres ('000) Total	Suitable Option 4	Suitable Option 7	Suitable Option 9 AMA	Suitable Option 9 Other	Suitable Option 9 Total
National Forests - Region 6 - Oregon												
DES	0	0	0	0	0	0	0	0	0	0	0	0
MTH	1	0	0	0	0	0	1	0	0	0	0	0
ROR	1	0	0	0	0	0	1	0	0	0	0	0
SIS	1	0	0	0	0	0	1	0	0	0	0	0
SIU	3	0	0	0	0	0	3	0	0	0	0	0
UMP	5	1	2	1	0	1	5	1	1	0	0	1
WIL	7	2	3	0	3	3	7	1	2	0	2	2
WIN	0	0	0	0	0	0	0	0	0	0	0	0
NF - Oregon Total	**17**	**4**	**6**	**1**	**4**	**5**	**17**	**3**	**4**	**1**	**3**	**3**
National Forests - Region 6 - Washington												
GIP	6	0	0	0	0	1	6	0	0	0	0	1
MBS	30	2	3	0	2	2	30	1	2	0	1	1
OKA	32	1	1	0	0	0	32	0	1	0	0	0
OLY	0	0	0	0	0	0	0	0	0	0	0	0
WEN	24	2	2	1	2	2	24	1	1	0	1	2
NF - Washington Total	**92**	**5**	**6**	**1**	**4**	**6**	**92**	**3**	**4**	**1**	**2**	**3**
NF - Region 6 Total	**110**	**8**	**12**	**3**	**8**	**11**	**110**	**6**	**9**	**2**	**5**	**7**
National Forests - Region 5 - California												
KLA	643	174	181	109	108	217	643	233	210	104	118	226
MEN	0	0	0	0	0	0	0	0	0	0	0	0
SXR	0	0	0	0	0	0	0	0	0	0	0	0
SHA/TRN	0	0	0	0	0	0	0	0	0	0	0	0
NF - California Total	**643**	**174**	**181**	**109**	**108**	**217**	**643**	**233**	**210**	**104**	**118**	**226**
National Forest Total	**752**	**182**	**193**	**111**	**116**	**227**	**752**	**239**	**218**	**105**	**123**	**232**
Bureau of Land Management Districts - Oregon/California												
SAL	25	3	6	7	3	10	25	3	6	1	3	5
EUG	17	1	3	0	2	2	17	1	3	0	2	2
ROS	84	18	28	2	29	31	84	16	24	1	24	24
COO	29	7	9	0	8	8	29	7	8	0	7	7
MED/LAK	249	107	130	20	118	137	249	72	85	10	65	75
UKI	0	0	0	0	0	0	0	0	0	0	0	0
BLM Total	**404**	**137**	**177**	**29**	**161**	**190**	**404**	**99**	**126**	**13**	**100**	**113**
Total	**1157**	**319**	**370**	**140**	**277**	**417**	**1157**	**338**	**344**	**118**	**223**	**345**

Table 17e. Acres allocation for the large conifer single-story seral stage in Options 4, 7, and 9.

Administrative	Matrix Acres ('000)						Suitable Acres ('000)					
		Option	Option	Option 9				Option	Option	Option 9		
Unit	Total	4	7	AMA	Other	Total	Total	4	7	AMA	Other	Total
National Forests - Region 6 - Oregon												
DES	121	25	36	0	28	28	121	31	33	0	28	28
MTH	30	6	8	0	8	8	30	4	5	0	5	5
ROR	65	8	13	8	5	13	65	6	12	9	2	9
SIS	41	4	8	1	5	6	41	3	8	1	3	4
SIU	0	0	0	0	0	0	0	0	0	0	0	0
UMP	118	35	42	7	32	39	118	34	33	4	28	32
WIL	76	8	11	1	10	10	76	6	8	0	7	7
WIN	39	11	14	0	12	12	39	4	9	0	11	11
NF - Oregon Total	**491**	**97**	**131**	**18**	**98**	**115**	**491**	**87**	**107**	**14**	**85**	**97**
National Forests - Region 6 - Washington												
GIP	74	8	12	4	9	14	74	7	11	3	10	12
MBS	105	3	7	0	5	5	105	1	5	0	2	1
OKA	22	4	5	0	3	3	22	2	3	0	2	2
OLY	4	0	0	0	0	0	4	0	0	0	0	0
WEN	239	35	39	2	43	46	239	25	22	2	32	33
NF - Washington Total	**445**	**49**	**62**	**7**	**60**	**67**	**445**	**36**	**42**	**4**	**45**	**49**
NF - Region 6 Total	**936**	**146**	**193**	**24**	**158**	**182**	**936**	**123**	**149**	**18**	**130**	**145**
National Forests - Region 5 - California												
KLA	2	0	0	0	0	0	2	0	0	0	0	0
MEN	156	24	26	0	26	26	156	11	11	0	11	11
SXR	1	0	0	0	0	0	1	0	0	0	0	0
SHA/TRN	201	18	31	10	13	22	201	10	18	5	8	13
NF - California Total	**359**	**42**	**57**	**10**	**38**	**48**	**359**	**22**	**29**	**5**	**19**	**24**
National Forest Total	**1295**	**188**	**250**	**34**	**197**	**231**	**1295**	**145**	**178**	**23**	**149**	**170**
Bureau of Land Management Districts - Oregon/California												
SAL	1	0	0	0	0	0	1	0	0	0	0	0
EUG	0	0	0	0	0	0	0	0	0	0	0	0
ROS	0	0	0	0	0	0	0	0	0	0	0	0
COO	6	1	1	0	1	1	6	1	1	0	1	1
MED/LAK	3	1	1	0	1	1	3	0	1	0	0	1
UKI	0	0	0	0	0	0	0	0	0	0	0	0
BLM Total	**10**	**1**	**2**	**0**	**2**	**2**	**10**	**1**	**2**	**0**	**1**	**1**
Total	**1305**	**190**	**252**	**34**	**198**	**233**	**1305**	**146**	**180**	**23**	**150**	**171**

Table 17f. Acres allocation for the large conifer multistory seral stage in Options 4, 7, and 9.

Administrative Unit	Matrix Acres ('000) Total	Option 4	Option 7	Option 9 AMA	Option 9 Other	Option 9 Total	Suitable Acres ('000) Total	Option 4	Option 7	Option 9 AMA	Option 9 Other	Option 9 Total
National Forests - Region 6 - Oregon												
DES	20	2	3	0	2	2	20	2	3	0	2	2
MTH	68	6	10	0	8	8	68	4	7	0	5	5
ROR	80	10	16	9	6	15	80	7	15	10	3	11
SIS	242	18	54	0	27	28	242	14	50	0	19	19
SIU	36	2	4	6	1	6	36	0	3	1	0	1
UMP	241	59	83	18	42	60	241	57	65	9	37	49
WIL	465	107	161	24	144	168	465	74	125	14	110	122
WIN	27	2	5	0	3	3	27	1	3	0	3	3
NF - Oregon Total	**1178**	**205**	**337**	**57**	**233**	**290**	**1178**	**161**	**270**	**34**	**179**	**211**
National Forests - Region 6 - Washington												
GIP	87	8	14	6	10	16	87	7	13	3	10	14
MBS	309	12	20	23	12	35	309	5	16	3	4	8
OKA	52	2	3	0	2	2	52	1	2	0	1	1
OLY	134	2	8	5	0	5	134	2	8	2	0	2
WEN	307	22	27	14	29	44	307	16	15	10	21	32
NF - Washington Total	**888**	**47**	**72**	**48**	**53**	**101**	**888**	**32**	**54**	**19**	**36**	**57**
NF - Region 6 Total	**2067**	**252**	**409**	**105**	**286**	**391**	**2067**	**193**	**324**	**52**	**215**	**268**
National Forests - Region 5 - California												
KLA	408	61	70	7	57	63	408	81	81	6	62	66
MEN	32	6	6	0	6	6	32	3	3	0	3	3
SXR	388	56	95	29	47	77	388	35	62	9	31	40
SHA/TRN	40	0	0	0	0	0	40	0	0	0	0	0
NF - California Total	**867**	**122**	**170**	**36**	**110**	**146**	**867**	**119**	**145**	**15**	**96**	**109**
National Forest Total	**2934**	**374**	**579**	**141**	**396**	**537 0**	**2934**	**312**	**469**	**67**	**311**	**377**
Bureau of Land Management Districts - Oregon/California												
SAL	5	0	1	0	0	1	5	0	1	0	0	0
EUG	0	0	0	0	0	0	0	0	0	0	0	0
ROS	1	0	0	0	0	0	1	0	0	0	0	0
COO	11	1	1	0	1	1	11	1	1	0	1	1
MED/LAK	11	4	5	1	5	5	11	3	3	0	3	3
UKI	0	0	0	0	0	0	0	0	0	0	0	0
BLM Total	**28**	**5**	**7**	**1**	**7**	**8**	**28**	**4**	**5**	**0**	**4**	**4**
Total	**2961**	**379**	**586**	**142**	**402**	**544 0**	**2961**	**315**	**474**	**67**	**315**	**382**

Table 18. Allocation of Adaptive Management Areas.

AMA	Administrative Unit	Total '000 Acres	Suitable '000 Acres	Suitable in Tier 1 Key Watersheds '000 Acres
Applegate		269		
	Rogue River NF		83	21
	Siskiyou NF		4	0
	Medford BLM		60	0
Blue River		153		
	Willamette NF		65	9
	Eugene BLM		7	4
Cispus		143		
	Gifford Pinchot NF		62	0
Finney		101		
	Mt. Baker Snoqualmie NF		6 *	3 *
Goosenest		170		
	Klamath NF		135	0
Hayfork		400		
	Shasta-Trinity NF		118	0
	Six Rivers NF		25	15 *
	Ukiah BLM		10 *	0
Little River		84		
	Umpqua NF		33	0
	Roseburg BLM		10	0
North Coast		247		
	Siuslaw NF		12	1
	Salem BLM		21	3
Olympic		145		
	Olympic NF		64	8
Snoqualmie Pass		261		
	Mt. Baker Snoqualmie NF		4 *	0
	Wenatchee NF		47	0
Total		**1973**	**766 ***	**64 ***

* Approximate

Table 19. Probable sale quantity (PSQ) for roadless areas in Option 9.

Administrative Unit	Total Roadless Area Acres	Suitable* for Timber Production Acres	MMBF/ Suitable Acre	MMBF/ Yr.
National Forests - Region 6 - Oregon				
DES	99,570	15,407	0.095	1,456
MTH	135,676	10,302	0.338	3,485
ROR	74,097	10,302	0.222	2,288
SIS	279,652	20,339	0.256	5,199
SIU	25,491	5,250	0.858	4,504
UMP	97,268	13,997	0.359	5,026
WIL	143,334	14,834	0.371	5,498
WIN	20,891	1,987	0.386	766
NF - Oregon Total	**875,979**	**92,417**		**28,222**
National Forests - Region 6 - Washington				
GIP	209,907	47,873	0.284	13,610
MBS	384,533	16,501	0.210	3,465
OKA	271,341	7,665	0.079	603
OLY	92,084	5,839	0.202	1,177
WEN	530,255	61,921	0.122	7,554
NF - Washington Total	**1,488,120**	**139,799**		**26,409**
NF - Region 6 Total	**2,364,099**	**232,216**		**54,631**
National Forests - Region 5 - California				
KLA	253,900	41,157	0.186	7,658
MEN	44,268	1,052	0.194	204
SXR	194,235	18,650	0.133	2,487
SHA/TRN	162,533	25,078	0.170	4,262
NF - Region 5 Total	**654,936**	**85,938**		**14,611**
Total	**3,019,035**	**318,153**		**69,242**

* Timber suitable acres shown here are less than timber suitable acres shown in the FEMAT Report, Table V-9, due to removal of riparian reserves.

Note: Bureau of Land Management administered lands contain no roadless areas. Roadless areas are not included on the Shasta portion of the Shasta-Trinity National Forest.

Table 20. Range of probable sale quantity (PSQ) estimates for each National Forest in Region 5 given different approaches to 180-year rotations.

Modeling Assumptions									PSQ Estimates MMBF				
Land Base		Geographic Definition for Area Control		Stand Method		Rotation Control			Klamath	Mendocino	Six Rivers	Shasta-Trinity	Total
Timber Suitable	Timber Suitable plus Lands Outside LS/OG Reserves and Wilderness	Forest-wide	Watershed*	Most Efficient	Average	Area Control	Minimum Regeneration Rotation	Minimum Exist and Regeneration Rotation					
X		X		X			X		84.6	22.9	27.3	76.8	211.6
	X	X		X		X			77.4	21.7	24.5	72.8	196.4
	X		X	X		X			73.5	19.2	23.9	67.3	183.9
X		X		X		X			63.9	18.8	22.3	54.0	159.1
X			X	X		X			48.9	14.5	17.8	42.6	123.8
X		X			X	X			30.3	10.4	17.3	33.9	91.9
X			X		X	X			23.4	8.9	13.4	23.9	69.6
X		X		X				X	9.3	1.9	--	8.8	20.0

* Approximate

NOTE: Option 9 without special harvest restrictions = 257 MMBF

Table 21. Acres suitable for timber production and probable sale quantity (PSQ) for variations on the SAT Report.

Administrative* Unit	Original Marbled Murrelet Full SAT Buffer — Suitable '000 Acres	Original Marbled Murrelet Full SAT Buffer — PSQ MMBF	Original Marbled Murrelet Half SAT Buffer — Suitable '000 Acres	Original Marbled Murrelet Half SAT Buffer — PSQ MMBF	Revised Marbled Murrelet Full SAT Buffer — Suitable '000 Acres	Revised Marbled Murrelet Full SAT Buffer — PSQ MMBF	Revised Marbled Murrelet Half SAT Buffer* (Option 5) — Suitable '000 Acres	Revised Marbled Murrelet Half SAT Buffer* (Option 5) — PSQ MMBF
National Forests - Region 6 - Oregon								
DES	221	15	221	15	221	15	221	15
MTH	228	83	231	85	228	83	230	85
ROR	106	12	146	16	106	12	142	16
SIS	107	15	122	18	98	30	110	34
SIU	29	14	42	19	23	19	35	29
UMP	314	99	346	110	314	99	338	108
WIL	349	127	396	130	349	127	390	129
WIN	49	33	49	33	49	33	49	33
NF - Oregon Total	**1403**	**399**	**1553**	**427**	**1388**	**419**	**1513**	**449**
National Forests - Region 6 - Washington								
GIP	193	77	259	97	192	77	248	94
MBS	38	7	42	8	78	14	80	15
OKA	128	5	149	6	128	5	146	6
OLY	49	4	66	6	48	7	62	9
WEN	209	25	232	28	209	25	226	28
NF -Washington Total	**616**	**119**	**748**	**145**	**654**	**128**	**762**	**151**
NF - Region 6 Total	**2019**	**518**	**2301**	**572**	**2042**	**548**	**2276**	**600**
National Forests - Region 5 - California								
KLA	358	30	404	37	386	42	437	50
MEN	88	12	116	13	88	12	115	13
SXR	63	9	78	10	109	21	134	23
SHA/TRN	337	48	392	55	322	48	394	55
NF - California Total	**846**	**99**	**990**	**115**	**905**	**123**	**1080**	**141**
National Forest Total	**2865**	**617**	**3291**	**687**	**2947**	**671**	**3356**	**742**
Bureau of Land Management Districts - Oregon								
District / Sustained Yield Unit								
SAL COL	25	6	29	7	26	9	30	10
CLA	19	9	23	10	19	8	22	9
ALS	14	2	16	2	11	3	13	3
SAN	27	10	32	12	27	10	31	12
Salem Total	**84**	**27**	**101**	**31**	**82**	**30**	**96**	**35**
EUG UPW	56	26	64	28	56	26	63	28
SIU	40	9	44	9	30	10	33	10
Eugene Total	**97**	**35**	**108**	**38**	**87**	**36**	**96**	**38**
ROS SOU	41	9	47	9	41	9	44	9
DOU	74	14	84	15	88	20	99	22
Roseburg Total	**114**	**22**	**130**	**25**	**129**	**29**	**143**	**31**
COO SCT	67	3	75	3	91	44	101	44
Coos Bay Total	**67**	**3**	**75**	**3**	**91**	**44**	**101**	**44**
MED/LAK JOS	112	14	129	16	119	15	136	16
JAC	137	18	158	19	137	18	157	19
KLA	35	5	41	8	35	6	41	6
Medford Total	**283**	**38**	**329**	**42**	**290**	**39**	**333**	**42**
BLM Total	**646**	**126**	**742**	**139**	**680**	**178**	**770**	**189**
Total	**3511**	**743**	**4033**	**826**	**3627**	**848**	**4125**	**931**

* Includes Full SAT in Key Watersheds.

Table 22. Suitable acres and board foot probable sale quantity (PSQ) for Option 9 with and without Tier 1 Key Watersheds in the timber suitable base.

Administrative Unit		With Tier 1 Key Watersheds Suitable '000 Acres	With Tier 1 Key Watersheds PSQ MMBF	Without Tier 1 Key Watersheds Suitable '000 Acres	Without Tier 1 Key Watersheds PSQ MMBF
National Forests - Region 6 - Oregon					
DES		184	18	184	15
MTH		215	72	157	52
ROR		139	31	122	28
SIS		104	27	74	18
SIU		33	29	31	27
UMP		266	95	206	81
WIL		431	161	392	142
WIN		100	39	100	39
NF - Oregon Total		**1473**	**471**	**1265**	**403**
National Forests - Region 6 - Washington					
GIP		299	86	256	75
MBS		65	13	33	8
OKA		85	7	70	6
OLY		65	13	57	12
WEN		290	35	127	19
NF - Washington Total		**803**	**155**	**543**	**120**
NF - Region 6 Total		**2276**	**626**	**1808**	**523**
National Forests - Region 5 - California					
KLA		395	74	299	39
MEN		99	19	67	10
SXR		123	24	65	15
SHA/TRN		396	67	265	46
NF - California Total		**1013**	**184**	**696**	**111**
National Forest Total		**3288**	**810**	**2504**	**633**
Bureau of Land Management Districts - Oregon					
District	Sustained Yield Unit				
SAL	COL	29	10	26	9
	CLA	20	10	18	9
	ALS	15	9	14	8
	SAN	28	13	23	11
	Salem Total	**92**	**42**	**81**	**38**
EUG	UPW	75	30	72	27
	SIU	36	9	36	9
	Eugene Total	**111**	**39**	**107**	**36**
ROS	SOU	45	12	29	8
	DOU	100	34	90	30
	Roseburg Total	**144**	**46**	**119**	**38**
COO	SCT	97	50	88	47
	Coos Bay Total	**97**	**50**	**88**	**47**
MED/LAK	JOS	142	26	127	24
	JAC	178	31	168	29
	KLA	40	5	39	5
	Medford Total	**359**	**63**	**334**	**58**
BLM Total		**803**	**240**	**729**	**216**
Total		**4092**	**1050**	**3233**	**849**

Table 23. Probable sale quantity (PSQ) comparison with and without the 50-11-40 rule for Option 7 and Option 6/10.

Administrative Unit		Option 7 with 50-11-40 PSQ MMBF	Option 7 without 50-11-40 PSQ MMBF	Option 6/10 with 50-11-40 PSQ MMBF	Option 6/10 without 50-11-40 PSQ MMBF
National Forests - Region 6 - Oregon					
DES		19	20	14	18
MTH		132	132	59	59
ROR		29	71	10	25
SIS		118	121	27	27
SIU		119	150	27	27
UMP		149	158	92	98
WIL		152	209	104	120
WIN		47	54	33	39
NF - Oregon Total		**763**	**915**	**365**	**412**
National Forests - Region 6 - Washington					
GIP		135	139	71	72
MBS		32	36	16	19
OKA		8	14	6	9
OLY		19	33	9	12
WEN		36	53	28	41
NF - Washington Total		**230**	**275**	**129**	**152**
NF - Region 6 Total		**994**	**1189**	**494**	**564**
National Forests - Region 5 - California					
KLA		82	150	55	92
MEN		23	36	13	19
SXR		43	43	19	21
SHA/TRN		90	125	63	67
NF - California Total		**237**	**354**	**150**	**198**
National Forest Total		**1230**	**1543**	**644**	**762**
Bureau of Land Management Districts - Oregon					
District	Sustained Yield Unit				
SAL	COL	23	28	9	10
	CLA	11	17	7	10
	ALS	15	22	4	6
	SAN	21	24	8	9
	Salem Total	**71**	**91**	**29**	**35**
EUG	UPW	35	46	24	29
	SIU	18	21	9	10
	Eugene Total	**53**	**67**	**33**	**40**
ROS	SOU	16	20	6	7
	DOU	40	54	17	22
	Roseburg Total	**56**	**74**	**23**	**29**
COO	SCT	71	95	43	52
	Coos Bay Total	**71**	**95**	**43**	**52**
MED/LAK	JOS	36	38	16	17
	JAC	37	39	19	19
	KLA	8	8	4	4
	Medford Total	**81**	**85**	**39**	**40**
BLM Total		**331**	**413**	**167**	**196**
Total		**1561**	**1956**	**811**	**958**

Table 24. Distribution of acres and volume among age classes and allocations on federal forests.

Distribution of acres and volume suitable for timber production in the Forest Plans on the Gifford Pinchot, Mt. Hood, Willamette, and Umpqua National Forests among age classes and between allocations in the Thomas Report (Thomas et al. 1990). (HCA = Habitat Conservation Area).

Age Class	Outside HCAs '000 Acres	Inside HCAs '000 Acres	Total '000 Acres	Outside HCAs Billion Cubic Feet	Inside HCAs Billion Cubic Feet	Total Billion Cubic Feet
0-20	370	170	540	0.0	0.0	0.0
21-40	150	170	320	0.2	0.1	0.3
41-60	40	20	60	0.1	0.0	0.1
61-80	0	0	0	0.0	0.0	0.0
81-100	120	60	180	0.5	0.4	0.9
101-150	150	50	200	0.8	0.2	1.0
151-200	250	70	320	2.4	0.7	3.1
201+	540	230	770	4.6	1.0	5.6
Total	**1620**	**770**	**2390**	**8.6**	**2.4**	**11.0**

Note: More acres may actually exist in the 40-80 year age classes. Inventory plot aggregations for harvest analysis often obscure stand age.

Distribution of acres excluding fragile sites, riparian buffers, Areas of Critical Environmental Concern (ACECs), and recreation sites between land allocations in Option 9 for BLM administered lands.

Age Class	Outside reserves '000 Acres	Inside reserves '000 Acres	Total '000 Acres
0-20	200	111	312
21-40	122	50	173
41-60	85	24	109
61-80	36	20	56
81-100	49	25	75
101-150	131	61	193
151-200	50	19	68
201+	102	88	190
Total	**775**	**397**	**1177**

Table 25. Catastrophic salvage in reserves.

Forest	Cubic Volume/Acre MCF/Acre	Proportion of volume <20" DBH percent	Cubic Volume/Acre <20" DBH MCF/Acre	Mature Stands L-S Reserves '000 Acres	Historical Fire Frequency: Probability %	Historical Fire Frequency: Burn acres/year Acres/year	Historical Fire Frequency: Salvage/year <20" DBH MCF/year	Twice Historical Fire Frequency: Probability %	Twice Historical Fire Frequency: Burn acres/year Acres/year	Twice Historical Fire Frequency: Salvage/year <20" DBH MCF/year
WIL	8.87	0.2	1.77	216	0.049	106	187.8	0.098	212	375.5
WIN	6.6	0.3	1.98	13	0.068	9	17.5	0.136	18	35.0
DES	1.5	0.3	0.45	77	0.110	85	38.1	0.220	169	76.2
MTH	8.84	0.3	2.65	60	0.067	40	106.6	0.134	80	213.2
ROR	5.22	0.3	1.57	37	0.026	10	15.1	0.052	19	30.1
SIS	5.69	0.2	1.14	101	0.519	524	596.5	1.038	1048	1193.1
SIU	11.59	0.15	1.74	68	0.008	5	9.5	0.016	11	18.9
UMP	8.02	0.2	1.60	173	0.056	97	155.4	0.112	194	310.8
GIP	8.18	0.25	2.04	104	0.030	31	63.8	0.060	62	127.6
OKA	1.45	0.3	0.43	23	0.160	37	16.0	0.320	74	32.0
OLY	7.48	0.35	2.62	118	0.044	52	135.9	0.088	104	271.9
WEN	4.68	0.3	1.40	183	0.335	613	860.7	0.670	1226	1721.4
MBS	7.59	0.25	1.90	110	0.009	10	18.8	0.018	20	37.6
Total				**1283**		**1619**	**2221.7**		**3237**	**4443.4**

Note: Mature stands in late successional reserves are net of congressional withdrawals and administrative withdrawals.

Table 26. Sale estimates by sale category and option for National Forests within the owl region. Volume is in millions of board feet.

	Category 1 Sold and Awarded Sales Total Sale Volume = 1808.1			Category 2 Planned, Enjoined Sales Total Sale Volume = 1199.2			Category 3&4 Planned, Not Enjoined Sales Total Sale Volume = 475.7			Category 5 Sold and Not Awarded Sales Total Sale Volume = 85.1		
Option	Volume in A+B+C	Volume in A+B+C+D	Total Volume outside A+B+C+D	Volume in A+B+C	Volume in A+B+C+D	Total Volume outside A+B+C+D	Volume in A+B+C	Volume in A+B+C+D	Total Volume outside A+B+C+D	Volume in A+B+C	Volume in A+B+C+D	Total Volume outside A+B+C+D
1	1732.2	1751.6	56.5	1179.1	1179.1	20.1	332.0	365.6	110.1	85.1	85.1	0.0
2	1099.7	1268.9	539.2	729.1	858.0	341.2	163.3	237.0	238.7	64.9	68.0	17.1
4	1039.8	1242.7	565.4	705.3	836.2	363.0	161.6	245.1	230.6	64.3	67.1	18.0
5	825.0	1088.3	719.8	563.8	715.1	484.1	106.1	193.7	282.0	55.7	65.1	20.0
6/10	959.1	1179.5	628.6	586.6	744.9	454.3	140.1	226.2	249.5	61.9	64.6	20.5
7	483.4	483.4	1324.7	219.9	219.9	979.3	27.8	27.8	447.9	32.6	32.6	52.5
9	923.2	1213.3	594.8	626.8	843.6	355.6	152.8	242.2	233.5	61.9	64.9	20.2

Option	A Murrelet Reserves	B Late-Successional Reserves	C Riparian Reserves	D Key Watersheds and/or AMAs
1		LS/OG1, LS/OG2, LS/OG3 & owl additions	Scenario 1	Key Watersheds
2		LS/OG1, LS/OG2 & owl additions	Scenario 2	Key Watersheds
4	LS/OG2 in near zone	DCAs and LS/OG1	Scenario 1	Key Watersheds
5	LS/OG1 & LS/OG2 in near zone	DCAs	Scenario 2	Key Watersheds
6/10	LS/OG2 in near zone	LS/OG1 & owl additions	Scenario 2	Key Watersheds
7		DCAs	Forest/District Plans	
9	LS/OG1 & LS/OG2 in near zone	"Option 9" System	Scenario 2	Key Watersheds and AMAs

Table 27. Sale estimates by sale category and marbled murrelet reserve strategy for National Forests within the owl region. Volume is in millions of board feet.

Alternative Marbled Murrelet Reserve Strategies	Category 1 Sold and Awarded Sales Total Sale Volume = 1808.1		Category 2 Planned, Enjoined Sales Total Sale Volume = 1199.2		Category 3&4 Planned, Not Enjoined Sales Total Sale Volume = 475.7		Category 5 Sold, Not Awarded Sales Total Sale Volume = 85.1	
	Volume Inside Reserve	Volume Outside Reserve	Volume Inside Reserve	Volume Outside Reserve	Volume Inside Reserve	Volume Outside Reserve	Volume Inside Reserve	Volume Outside Reserve
Murrelet near zone	411.6	1396.5	361.8	837.4	63.2	412.5	13.8	71.3
Murrelet near zone and/or sales requiring murrelet consultation	471.4	1336.7	379.4	819.8	63.2	412.5	39.5	45.6
LS/OG1 and LS/OG2 within murrelet near zone	239.3	1568.8	179.4	1019.8	24.6	451.1	13.8	71.3
LS/OG1 and LS/OG2 within murrelet near zone and/or sales requiring murrelet consultation	427.2	1380.9	224.9	974.3	24.6	451.1	39.5	45.6
LS/OG2 within murrelet near zone	42.9	1765.2	95.0	1104.2	8.5	467.2	0.0	85.1
LS/OG2 within murrelet near zone and/or sales requiring murrelet consultation	380.5	1427.6	159.2	1039.8	8.5	467.2	39.5	45.6

Table 28. Sale estimates by option that result when sales located in the marbled murrelet near zone and sales needing consultation are excluded from harvest on National Forests within the owl region. Volume is in millions of board feet.

	Option Components				Category 2 Planned, Enjoined Sales Total Sale Volume = 1199.2	Category 3&4 Planned, Not Enjoined Sales Total Sale Volume = 475.7
	A	B	C	D		
Option	Murrelet Reserves	Late-Successional Reserves	Riparian Reserves	Key Watersheds and/or AMAs	Total Volume outside A+B+C+D	Total Volume outside A+B+C+D
1	Murrelet near zone & consultation	LS/OG1, LS/OG2, LS/OG3 & owl additions	Scenario 1	Key Watersheds	12.0	105.5
2	Murrelet near zone & consultation	LS/OG1, LS/OG2 & owl additions	Scenario 2	Key Watersheds	264.9	231.2
4	Murrelet near zone & consultation	DCAs & LS/OG1	Scenario 1	Key Watersheds	306.1	224.5
5	Murrelet near zone & consultation	DCAs	Scenario 2	Key Watersheds	409.5	274.5
6/10	Murrelet near zone & consultation	LS/OG1 & owl additions	Scenario 2	Key Watersheds	376.8	242.0
7	Murrelet near zone & consultation	DCAs	Forest/District Plans	Forest/District Plans	661.6	386.8
9	Murrelet near zone & consultation	"Option 9" system	Scenario 2	Key Watersheds & AMAs	314.7	230.5

Table 29. Sale estimates by sale category and late-successional reserve system for National Forests within the owl region. Volume is in millions of board feet.

Alternative Late-Successional Reserve Systems	Category 1 Sold and Awarded Sales Total Sale Volume = 1808.1		Category 2 Planned, Enjoined Sales Total Sale Volume = 1199.2		Category 3&4 Planned, Not Enjoined Sales Total Sale Volume = 475.7		Category 5 Sold, Not Awarded Sales Total Sale Volume = 85.1	
	Volume Inside Reserve	Volume Outside Reserve	Volume Inside Reserve	Volume Outside Reserve	Volume Inside Reserve	Volume Outside Reserve	Volume Inside Reserve	Volume Outside Reserve
Designated Conservation Areas (DCAs)	483.4	1324.7	219.9	979.3	27.9	447.8	32.6	52.5
DCAs and LS/OG1	763.7	1044.4	406.3	792.9	95.6	380.1	56.1	29.0
LS/OG1 and owl additions	716.8	1091.3	311.3	887.9	80.2	395.5	56.1	29.0
LS/OG1, LS/OG2, and owl additions	930.0	878.1	553.4	645.8	115.7	360.0	60.5	24.6
LS/OG1, LS/OG2, LS/OG3, and owl additions	1712.9	95.2	1169.5	29.7	301.5	174.2	85.1	0.0
"Option 9" reserve system	662.9	1145.2	413.2	786.0	91.5	384.2	56.1	29.0

Table 30. Sale estimates inside spotted owl critical habitat units (CHUs) relative to late-successional reserve systems for National Forests within the owl region. Volume is in millions of board feet.

Alternative Late-Successional Reserve Systems	Category 2 Planned, Enjoined Sales Total Sale Volume = 1199.2		Category 3&4 Planned, Not Enjoined Sales Total Sale Volume = 475.7	
	Total Sale Volume	Volume Inside CHUs	Total Sale Volume	Volume Inside CHUs
Total Sales	1199.2	249.4	475.7	38.5
Inside Designated Conservation Areas (DCAs)	219.9	121.8	27.9	11.9
Inside DCAs and LS/OG1	406.3	160.1	95.6	23.0
Inside LS/OG1 and owl additions	311.3	110.3	80.2	22.1
Inside LS/OG1, LS/OG2, and owl additions	553.4	166.0	115.7	30.0
Inside LS/OG1, LS/OG2, LS/OG3, and owl additions	1169.5	243.3	301.5	34.1
Inside "Option 9" reserve system	413.2	140.0	91.5	24.3

Table 31. Sale estimates by sale category and riparian reserve scenario for National Forests within the owl region. Volume is in millions of board feet.

Alternative Riparian Reserve Scenarios	**Category 1** Sold and Awarded Sales Total Sale Volume = 1808.1		**Category 2** Planned, Enjoined Sales Total Sale Volume = 1199.2		**Category 3&4** Planned, Not Enjoined Sales Total Sale Volume = 475.7		**Category 5** Sold, Not Awarded Sales Total Sale Volume = 85.1	
	Volume Inside Reserve	Volume Outside Reserve	Volume Inside Reserve	Volume Outside Reserve	Volume Inside Reserve	Volume Outside Reserve	Volume Inside Reserve	Volume Outside Reserve
Scenario 1	474.5	1333.6	401.2	798.0	74.7	401.0	31.4	53.7
Scenario 2	394.3	1413.8	324.5	874.7	61.5	414.2	26.2	58.9
Current Forest/District Plans	0.0	1808.1	0.0	1199.2	0.0	475.7	0.0	85.1

Table 32. Sale estimates and harvest acres by sale category and age classes for National Forests within the owl region.

	Category 1 Sold and Awarded Sales Total Sale Volume = 1808.1			**Category 2** Planned, Enjoined Sales Total Sale Volume = 1199.2			**Category 3&4** Planned, Not Enjoined Sales Total Sale Volume = 475.7			**Category 5** Sold and Not Awarded Sales Total Sale Volume = 85.1		
		Even-age			Even-age			Even-age			Even-age	
Age Class (years)	Total Volume (MMBF)	Regen. Harvest (ACRES)	Other Harvest (ACRES)	Total Volume (MMBF)	Regen. Harvest (ACRES)	Other Harvest (ACRES)	Total Volume (MMBF)	Regen. Harvest (ACRES)	Other Harvest (ACRES)	Total Volume (MMBF)	Regen. Harvest (ACRES)	Other Harvest (ACRES)
0-80	99.9	742	7957	47.0	342	3842	189.4	564	20420	0.0	0	0
80-200	768.9	18221	23919	560.8	12951	21493	215.1	7937	63980	43.3	747	1282
200+	921.2	20161	11547	591.3	13547	17142	50.8	845	14688	41.8	1036	0
No age data	18.0	244	976	0.0	0	0	20.4	0	2851	0.0	0	0
Total	**1808.0**	**39368**	**44399**	**1199.1**	**26840**	**42477**	**475.7**	**9346**	**101939**	**85.1**	**1783**	**1282**

Table 33. Sale estimates by sale category, option, and age class for National Forests within the owl region. Volume is in millions of board feet.

Option	Category 1 Sold and Awarded Sales (Total Sale Volume = 1808.1; 200+ Sale Volume = 921.2) Total Volume outside A+B+C+D	Category 1 200+ Volume outside A+B+C+D	Category 2 Planned, Enjoined Sales (Total Sale Volume = 1199.2; 200+ Sale Volume = 591.3) Total Volume outside A+B+C+D	Category 2 200+ Volume outside A+B+C+D	Category 3&4 Planned, Not Enjoined Sales (Total Sale Volume = 475.7; 200+ Sale Volume = 50.8) Total Volume outside A+B+C+D	Category 3&4 200+ Volume outside A+B+C+D	Category 5 Sold and Not Awarded Sales (Total Sale Volume = 85.1; 200+ Sale Volume = 41.8) Total Volume outside A+B+C+D	Category 5 200+ Volum outside A+B+C+D
1	56.5	0.0	20.1	0.0	110.1	0.0	0.0	0
2	539.2	267.5	341.2	185.1	238.7	12.7	17.1	17.1
4	565.4	303.6	363.0	206.9	230.6	13.9	18.0	15.3
5	719.8	383.6	484.1	266.9	282.0	25.0	20.0	17.1
6/10	628.6	340.1	454.3	243.0	249.5	15.0	20.5	17.1
7	1324.7	654.5	979.3	495.0	447.9	46.7	52.5	20.9
9	594.8	324.7	355.6	217.2	233.5	20.1	20.2	17.1

Option	A Murrelet Reserves	B Late-Successional Reserves	C Riparian Reserves	D Key Watersheds and/or AMAs
1		LS/OG1, LS/OG2, LS/OG3 & owl additions	Scenario 1	Key Watersheds
2		LS/OG1, LS/OG2 & owl additions	Scenario 2	Key Watersheds
4	LS/OG2 in near zone	DCAs and LS/OG1	Scenario 1	Key Watersheds
5	LS/OG1 & LS/OC in near zone	DCAs	Scenario 2	Key Watersheds
6/10	LS/OG2 in near zone	LS/OG1 & owl additions	Scenario 2	Key Watersheds
7		DCAs	Forest/District Plans	
9	LS/OG1 & LS/OC in near zone	"Option 9" System	Scenario 2	Key Watersheds and AMAs

Table 34. Sale estimates by sale category and Option 9 allocations for National Forests within the owl region. Volume is in millions of board feet.

Land Allocation Classes	**Category 1** Sold and Awarded Sales (Total Sale Volume = 1808.1)		**Category 2** Planned, Enjoined Sales (Total Sale Volume = 1199.2)		**Category 3&4** Planned, Not Enjoined Sales (Total Sale Volume = 475.7)		**Category 5** Sold, Not Awarded Sales (Total Sale Volume = 85.1)	
	Total Volume	Riparian Reserve Volume	Total Volume	Riparian Reserve Volume	Total Volume	Riparian Reserve Volume	Total Volume	Riparian Reserve Volume
Total Sales	1808.1	394.3	1199.2	324.5	475.7	61.5	85.1	26.2
I. Inside Option 9 Murrelet and Late-Successional Reserves	722.1	193.2	471.6	169.2	110.2	18.9	56.1	20.5
A. Inside Adaptive Mgmt. Areas	31.2	9.0	19.6	10.7	13.7	1.2	0.0	0.0
1. Inside Key Watersheds	22.9	7.9	0.1	0.0	8.6	0.3	0.0	0.0
a. Inside Roadless	2.8	1.9	0.0	0.0	0.0	0.0	0.0	0.0
b. Outside Roadless	20.1	6.0	0.1	0.0	8.6	0.3	0.0	0.0
2. Outside Key Watersheds	8.3	1.1	19.5	10.7	5.1	0.9	0.0	0.0
a. Inside Roadless	0.7	0.2	2.2	1.8	0.0	0.0	0.0	0.0
b. Outside Roadless	7.6	0.9	17.3	8.9	5.1	0.9	0.0	0.0
B. Outside Adaptive Mgmt. Areas	690.9	184.2	452.0	158.5	96.5	17.7	56.1	20.5
1. Inside Key Watersheds	383.0	121.9	197.8	70.6	36.2	10.9	38.6	15.8
a. Inside Roadless	46.9	12.4	41.1	13.8	2.1	0.3	17.4	4.9
b. Outside Roadless	336.1	109.5	156.7	56.8	34.1	10.6	21.2	10.9
2. Outside Key Watersheds	307.9	62.3	254.2	87.9	60.3	6.8	17.5	4.7
a. Inside Roadless	17.1	3.1	14.8	3.9	0.0	0.0	0.0	0.0
b. Outside Roadless	290.8	59.2	239.4	84.0	60.3	6.8	17.5	4.7
II. Outside Option 9 Murrelet and Late-Successional Reserves	1086.0	201.1	727.6	155.3	365.5	42.6	29.0	5.7
A. Inside Adaptive Mgmt. Areas	132.6	29.7	144.1	43.7	38.7	7.9	0.0	0.0
1. Inside Key Watersheds	14.9	2.1	6.6	0.9	12.5	0.6	0.0	0.0
a. Inside Roadless	6.8	0.6	0.0	0.0	0.0	0.0	0.0	0.0
b. Outside Roadless	8.1	1.5	6.6	0.9	12.5	0.6	0.0	0.0
2. Outside Key Watersheds	117.7	27.6	137.5	42.8	26.2	7.3	0.0	0.0
a. Inside Roadless	9.1	1.1	12.9	2.5	0.0	0.0	0.0	0.0
b. Outside Roadless	108.6	26.5	124.6	40.3	26.2	7.3	0.0	0.0
B. Outside Adaptive Mgmt. Areas	953.4	171.4	583.5	111.6	326.8	34.7	29.0	5.7
1. Inside Key Watersheds	239.1	51.9	144.8	28.5	70.9	12.3	3.8	0.7
a. Inside Roadless	39.6	6.5	17.9	3.8	4.0	0.7	0.0	0.0
b. Outside Roadless	199.5	45.4	126.9	24.7	66.9	11.6	3.8	0.7
2. Outside Key Watersheds	714.3	119.5	438.7	83.1	255.9	22.4	25.2	5.0
a. Inside Roadless	24.4	4.6	19.9	5.2	13.5	0.4	0.0	0.0
b. Outside Roadless	689.9	114.9	418.8	77.9	242.4	22.0	25.2	5.0

Table 35. Sale estimates by sale category and option 9 allocations for lands administered by the BLM within the owl region. Volume is in millions of board feet.

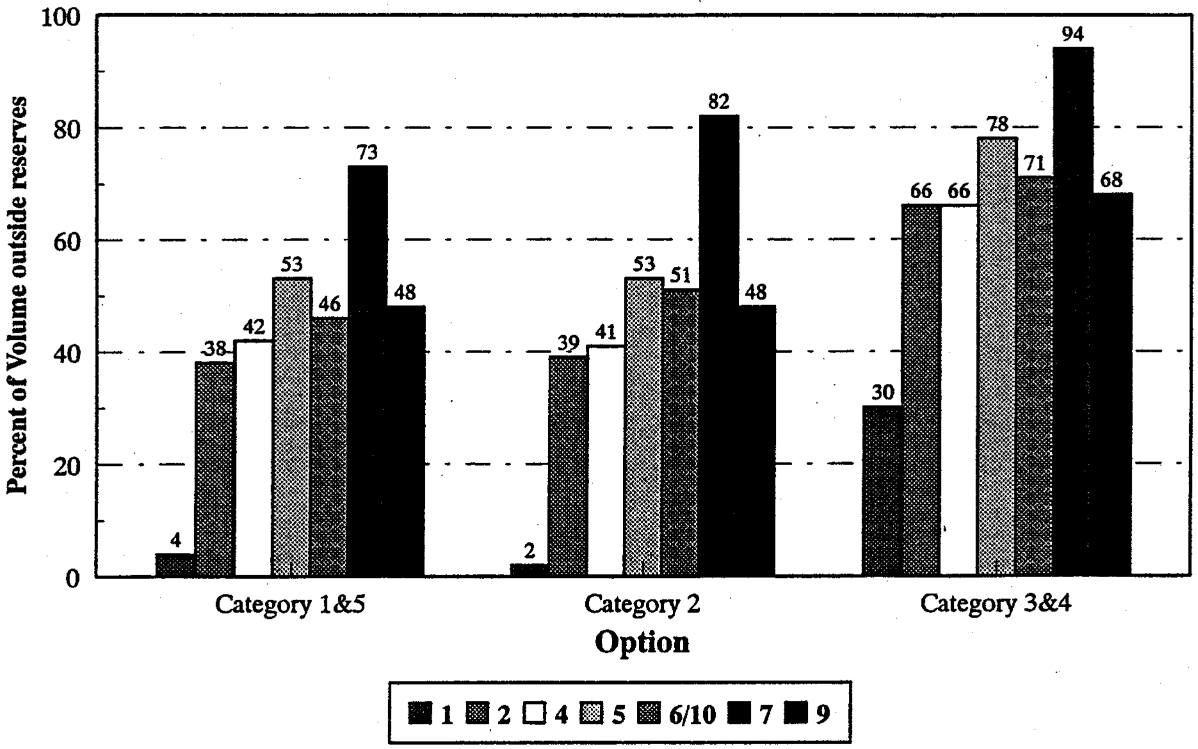
Land Allocation Classes	**Category 1** Sold, Awarded Sales Total Sale Volume = 131		**Category 2** Sold Awarded/Unawarded Enjoined Sales Total Sale Volume = 194		**Category 3&4** Planned, Not Enjoined Sales Total Sale Volume = 15		**Category 5** Sold, Not Awarded Sales Total Sale Volume = 103	
	Total Volume	Riparian Reserve Volume	Total Volume	Riparian Reserve Volume	Total Volume	Riparian Reserve Volume	Total Volume	Riparian Reserve Volume
Total Sales	131	31	194	51	15	2	103	44
I. Inside Option 9 Murrelet and Late-Successional Reserves	8	1	18	6	8	1	56	29
A. Inside Adaptive Mgmt. Areas	1	0	0	0	0	0	0	0
1. Inside Key Watersheds	1	0	0	0	0	0	0	0
2. Outside Key Watersheds	0	0	0	0	0	0	0	0
B. Outside Adaptive Mgmt. Areas	7	1	18	6	8	1	56	29
1. Inside Key Watersheds	0	0	11	3	0	0	11	7
2. Outside Key Watersheds	7	1	7	3	8	1	45	22
II. Outside Option 9 Murrelet and Late-Successional Reserves	123	30	176	45	7	1	47	15
A. Inside Adaptive Mgmt. Areas	13	4	22	7	0	0	0	0
1. Inside Key Watersheds	2	1	11	4	0	0	0	0
2. Outside Key Watersheds	11	3	11	3	0	0	0	0
B. Outside Adaptive Mgmt. Areas	110	26	154	38	7	1	47	15
1. Inside Key Watersheds	0	0	21	8	0	0	28	11
2. Outside Key Watersheds	110	26	133	30	7	1	19	4

Table 36. Sale estimates by sale category and option for National Forests within the owl region: sale information update. Volume is in millions of board feet.

	Category 1 Sold and Awarded Sales Total Sale Volume = 1457.0			**Category 2** Planned, Enjoined Sales Total Sale Volume = 1152.7			**Category 3&4** Planned, Not Enjoined Sales Total Sale Volume = 434.6			**Category 5** Sold and Not Awarded Sales Total Sale Volume = 74.1		
Option	Volume in A+B+C	Volume in A+B+C+D	Total Volume outside A+B+C+D	Volume in A+B+C	Volume in A+B+C+D	Total Volume outside A+B+C+D	Volume in A+B+C	Volume in A+B+C+D	Total Volume outside A+B+C+D	Volume in A+B+C	Volume in A+B+C+D	Total Volume outside A+B+C+D
1	1389.6	1400.3	56.7	1134.2	1134.2	18.5	284.9	335.1	99.5	74.1	74.1	0.0
2	887.5	1042.1	414.9	720.8	841.3	311.4	157.9	248.8	186.3	62.9	63.0	11.1
4	818.1	1006.7	450.3	652.1	784.4	368.3	125.0	243.5	191.1	54.3	54.4	19.7
5	659.0	905.4	551.6	553.6	708.1	444.6	80.3	217.7	216.9	48.4	54.4	19.7
6/10	785.9	979.5	477.5	587.0	737.5	415.2	119.2	239.1	195.5	56.2	56.3	17.8
7	412.9	412.9	1044.1	206.4	206.4	946.3	16.9	16.9	417.7	35.9	35.9	38.2
9	745.8	1033.3	423.7	616.1	831.4	321.3	143.4	267.2	167.4	57.3	61.8	12.3

Option	A Murrelet Reserves	B Late-Successional Reserves	C Riparian Reserves	D Key Watersheds and/or AMAs
1		LS/OG1, LS/OG2, LS/OG3 & owl additions	Scenario 1	Key Watersheds
2		LS/OG1, LS/OG2 & owl additions	Scenario 2	Key Watersheds
4	LS/OG2 in near zone	DCAs and LS/OG1	Scenario 1	Key Watersheds
5	LS/OG1 & LS/OG2 in near zone	DCAs	Scenario 2	Key Watersheds
6/10	LS/OG2 in near zone	LS/OG1 & owl additions	Scenario 2	Key Watersheds
7		DCAs	Forest/District Plans	
9	LS/OG1 & LS/OG2 in near zone	"Option 9" System	Scenario 2	Key Watersheds and AMAs

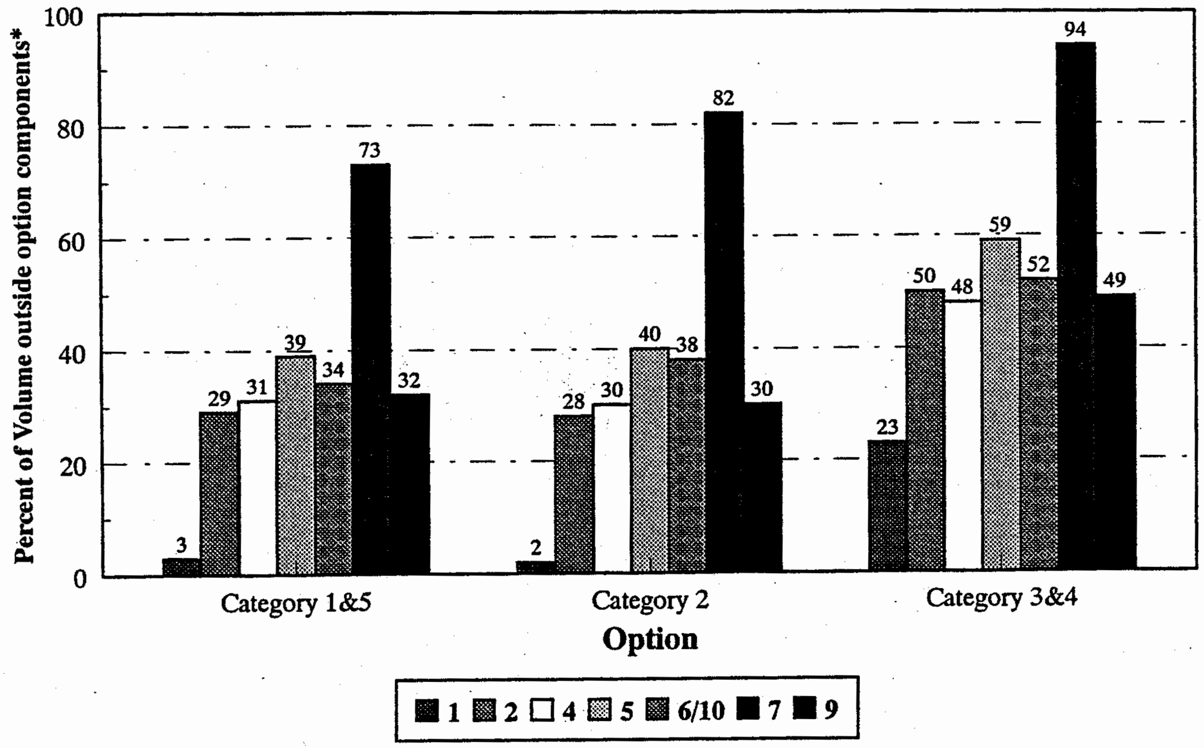
Figure 1. Volume outside of reserves as a percentage of total volume within each sale category* for National Forests within the owl region.



* Total sale volume by category (MMBF)

Category 1&5 - 1893.2
Category 2 - 1199.2
Category 3&4 - 475.7

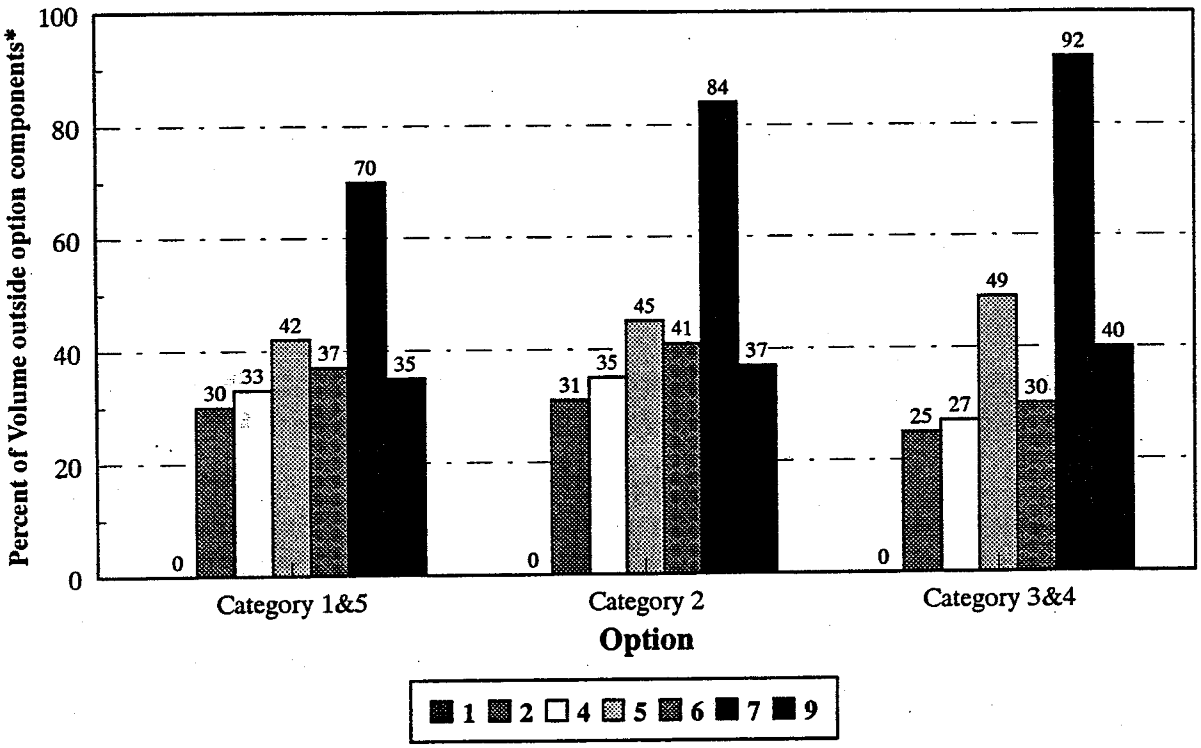
Figure 2. Volume outside of option components* as a percentage of total volume within each sale category** for National Forests within the owl region.



* Option components are:
- Marbled murrelet and late-successional reserves
- Riparian reserves
- Key Watersheds
- Adaptive Management Areas

** Total sale volume by category (MMBF)
- Category 1&5 - 1893.2
- Category 2 - 1199.2
- Category 3&4 - 475.7

Figure 3. 200+ years old sale volume outside of option components* as a percentage of total 200+ years old sale volume within each sale category** for National Forests within the owl region.



* Option components are:
- Marbled murrelet and late-successional reserves
- Riparian reserves
- Key Watersheds
- Adaptive Management Areas

** Total 200+ years old sale volume by category (MMBF)

Category 1&5 -	963.0
Category 2 -	591.3
Category 3&4 -	50.8

References

Ager, Alan. Personal communication. Forest Analyst, Forest Service, Umatilla National Forest, 2517 SW Hailey Way, Pendleton, Oregon 97801.

Birch, K.R. and Johnson, K.N. 1992. Stand level wood production costs of leaving live, mature trees at regeneration harvest in coastal Douglas-fir stands. Western Journal of Applied Forestry. 7 (3):65-68.

Johnson, K.N.; Stuart, T.W. and Crim S.A. 1986. FORPLAN version 2: an overview. Washington, DC: USDA Forest Service, Land Management Planning Systems. 110 p.

Johnson, K.N.; Franklin, J.F.; Thomas, J.W.; Gordon, J. 1991. Alternatives for management of late-successional forests of the Pacific Northwest. A report to the Agriculture Committee and the Merchant Marine Committee of the U.S. House of Representatives. 59 p.

Resource Economics Incorporated. 1988. TRIM-PLUS© Timber resource inventory model plus harvesting scheduling (enhanced). Corvallis, OR: Resource Economics Incorporated. 140 p.

Spies, Thomas. Personal communication. Research Forester, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3200 SW Jefferson Way, Corvallis, Oregon 97331.

Swanson, Frederick J. Personal communication. Principal Research Geologist, Forest Service, Pacific Northwest Research Station, Forestry Sciences Laboratory, 3200 SW Jefferson Way, Corvallis, Oregon 97331.

Thomas, J.W.; Forsman, E.D.; Lint, J.B.; [and others]. 1990. A conservation strategy for the northern spotted owl: a report of the Interagency Scientific Committee to address the conservation of the northern spotted owl. Portland, OR: U.S. Department of Agriculture, Forest Service; U.S. Department of the Interior, Bureau of Land Management, Fish and Wildlife Service, and National Park Service. 427 p.

Thomas, J.W.; Raphael, M.G.; Anthony, R.G.; [and others]. 1993. Viability assessments and management considerations for species associated with late-successional and old-growth forests of the Pacific Northwest. The Report of the Scientific Analysis Team. Portland, OR: USDA Forest Service, National Forest System, Forest Service Research. 530 p. (Also referred to as the "SAT Report").

USDA, USDI. 1990. Economic effects of implementing a conservation strategy for the northern spotted owl. 66 p. (Also referred to as the "Hamilton Report").

USDA, USDI, U.S. Department of Commerce, Environmental Protection Agency. 1993. Forest ecosystem management: an ecological, economic, and social assessment. Report of the Forest Ecosystem Management Assessment Team. Portland, OR: USDA, Forest Service; U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service; USDI Bureau of Land Management, Fish and Wildlife Service, National Park Service; Environmental Protection Agency. 1033 p. (Also referred to as the "FEMAT Report").

USDI 1992. Final draft recovery plan for the northern spotted owl. Portland, OR: U.S. Department of the Interior. 2 vols. Unpublished manuscript.

Appendix A
Authorizing letter from the Clinton Administration

This appendix consists of the Preface from "Forest Ecosystem Management: An Ecological, Economic, and Social Assessment", also referred to as the "FEMAT Report".

Preface

Following the April 2, 1993, Forest Conference in Portland, Oregon, President Clinton created three interagency working groups: the Forest Ecosystem Management Assessment Team, the Labor and Community Assessment Team, and the Agency Coordination Team. Direction for the Teams came in a Statement of Mission letter. The following excerpts from that letter outline the mission for the Forest Ecosystem Management Team.

TO: **FOREST CONFERENCE INTER-AGENCY WORKING GROUPS**
Ecosystem Management Assessment
Labor and Community Assistance
Agency Coordination

FROM: **FOREST CONFERENCE EXECUTIVE COMMITTEE**

Department of Agriculture
Department of Interior
Department of Labor
Department of Commerce
Environmental Protection Agency
Office on Environmental Policy
Office of Science and Technology
National Economic Council
Council of Economic Advisors
Office of Management and Budget

RE: **STATEMENT OF MISSION**

Together, we are working to fulfill President Clinton's mandate to produce a plan to break the gridlock over federal forest management that has created so much confusion and controversy in the Pacific Northwest and northern California. As well, that mandate means providing for economic diversification and new economic opportunities in the region. As you enter into the critical phase of your work reviewing options and policy, this mission statement should be used to focus and coordinate your efforts. It includes overall guidance and specific guidance for each team.

BACKGROUND

President Clinton posed the fundamental question we face when he opened the Forest Conference in Portland.

"How can we achieve a balanced and comprehensive policy that recognizes the importance of the forests and timber to the economy and jobs in this region, and how can we preserve our precious old-growth forests, which are part of our national heritage and that, once destroyed, can never be replaced?"

And he said, "The most important thing we can do is to admit, all of us to each other, that there are no simple or easy answers. This is not about choosing between jobs and the environment, but about recognizing the importance of both and recognizing that virtually everyone here and everyone in this region cares about both."

The President said five principles should guide our work:

"First, we must never forget the human and the economic dimensions of these problems. Where sound management policies can preserve the health of forest lands, sales should go forward. Where this requirement cannot be met, we need to do our best to offer new economic opportunities for year-round, high-wage, high-skill jobs.

"Second, as we craft a plan, we need to protect the long-term health of our forests, our wildlife, and our waterways. They are a... gift from God; and we hold them in trust for future generations."

"Third, our efforts must be, insofar as we are wise enough to know it. scientifically sound, ecologically credible, and legally responsible."

"Fourth, the plan should produce a predictable and sustainable level of timber sales and nontimber resources that will not degrade or destroy the environment."

"Fifth, to achieve these goals, we will do our best, as I said, to make the federal government work together and work for you. We may make mistakes but we will try to end the gridlock within the federal government and we will insist on collaboration not confrontation."

ECOSYSTEM MANAGEMENT ASSESSMENT

Our objectives based on the President's mandate and principles are to identify management alternatives that attain the greatest economic and social contribution from the forests of the region and meet the requirements of the applicable laws and regulations, including the Endangered Species Act, the National Forest Management Act, the Federal Land Policy Management Act, and the National Environmental Policy Act. The Ecosystem Management Assessment working group should explore adaptive management and silvicultural techniques and base its work on the best technical and scientific information currently available.

Your assessment should take an ecosystem approach to forest management and should particularly address maintenance and restoration of biological diversity, particularly that of the late-successional and old-growth forest ecosystems; maintenance of long-term site productivity of forest ecosystems; maintenance of sustainable levels of renewable natural resources, including timber, other forest products, and other facets of forest values; and maintenance of rural economies and communities.

Given the biological requirements of each alternative, you should suggest the patterns of protection, investment, and use that will provide the greatest possible economic and social contributions from the region's forests. In particular, we encourage you to suggest innovative ways federal forests can contribute to economic and social well-being.

You should address a range of alternatives in a way that allows us to distinguish the different costs and benefits of various approaches (including marginal cost/benefit assessments), and in doing so, at least the following should be considered:

- timber sales, short and long term;
- production of other commodities;

- effects on public uses and values, including scenic quality, recreation, subsistence, and tourism;

- effect on environmental and ecological values, including air and water quality, habitat conservation, sustainability, threatened and endangered species, biodiversity and long-term productivity;

- jobs attributable to timber harvest and timber processing; and, to the extent feasible, jobs attributable to other commodity production, fish habitat protection, and public uses of forests; as well as jobs attributable to investment and restoration associated with each alternative;

- economic and social effects on local communities, and effects on revenues to counties and the national treasury,

- economic and social policies associated with the protection and use of forest resources that might aid in the transitions of the region's industries and communities;

- economic and social benefits from the ecological services you consider;

- regional, national, and international effects as they relate to timber supply, wood product prices, and other key economic and social variables.

As well, when locating reserves, your assessment also should consider both the benefits to the whole array of forest values and the potential cost to rural communities.

The impact of protection and recovery of threatened and endangered species on nonfederal lands within the region of concern should be minimized. However, you should note specific nonfederal contributions that are essential to or could significantly help accomplish the conservation and timber supply objectives of your assessment.

In addition, your assessment should include suggestions for adaptive management that would identify high priority inventory, research, and monitoring needed to assess success over time, and essential or allowable modifications in approach as new information becomes available. You should also suggest a mechanism for a coordinated interagency approach to the needed assessments, monitoring, and research as well as any changes needed in decisionmaking procedures required to support adaptive management.

You should carefully examine silvicultural management of forest stands -- particularly young stands -- especially in the context of adaptive management. The use of silviculture to achieve those ends, or tests of silviculture, should be judged in an ecosystem context and not solely on the basis of single species or several species response.

Your conservation and management assessment should cover those lands managed by the Forest Service, the Bureau of Land Management, and the National Park Service that are within the current range of the northern spotted owl, drawing as you have on personnel from those agencies and assistance from the Fish and Wildlife Service, the National Marine Fisheries Service, and the Environmental Protection Agency. To achieve similar treatment on all federal lands involved here, you should apply the "viability standard" to the Bureau of Land Management lands.

In addressing biological diversity you should not limit your consideration to any one species and, to the extent possible, you should develop alternatives for long-term management that meet the following objectives:

- maintenance and/or restoration of habitat conditions for the northern spotted owl and the marbled murrelet that will provide for viability of each species -- for the owl, well distributed along its current range on federal lands, and for the murrelet so far as nesting habitat is concerned;

- maintenance and/or restoration of habitat conditions to support viable populations, well-distributed across their current ranges, of species known (or reasonably expected) to be associated with old-growth forest conditions;

- maintenance and/or restoration of spawning and rearing habitat on Forest Service, Bureau of Land Management, and National Park Service lands to support recovery and maintenance of viable populations of anadromous fish species and stocks and other fish species and stocks considered "sensitive" or "at risk" by land management agencies, or listed under the Endangered Species Act; and,

- maintenance and/or creation of a connected or interactive old-growth forest ecosystem on the federal lands within the region under consideration.

Your assessment should include alternatives that range from a medium to a very high probability of ensuring the viability of species. The analysis should include an assessment of current agency programs based on Forest Service plans (including the Final Draft Recovery Plan for the Northern Spotted Owl) for the National Forests and the Bureau of Land Management's revised preferred alternative for its lands.

In your assessment, you should also carefully consider the suggestions for forest management from the recent Forest Conference in Portland. Although we know that it will be difficult to move beyond the possibility considered in recent analysis, you should apply your most creative abilities to suggest policies that might move us forward on these difficult issues. You also should address shot-term timber sale possibilities as well as longer term options.

Finally, your assessment should be subject to peer review by appropriately credentialed reviewers.

CONCLUSION

We appreciate your efforts and recognize, as President Clinton did, that these are difficult issues with difficult choices. And, we'll remind you of something else the President said at the Forest Conference, talking to the people of the Pacific Northwest and northern California: "We're here to begin a process that will help ensure that you will be able to work together in your communities for the good of your businesses, your jobs, and your natural environment. The process we (have begun) will not be easy. Its outcome cannot possibly make everyone happy. Perhaps it won't make anyone completely happy. But the worst thing we can do is nothing."

Appendix B
Modeling Approaches of the Different Agencies

PSQ Modeling of the FEMAT Options on National Forests in the Pacific Northwest Region (Region 6)

Forest Service analysts were given 14 to 16 alternatives to simulate. Each alternative was composed of a particular land allocation and set of management rules. The Regional Geographic Information System (GIS) staff developed map layers to reflect the various land allocations contained in these alternatives. Next, Forest Service analysts integrated these maps with their Forest Plan suitable acreage information to determine location, acres, and vegetative conditions of the resulting available timber base. The Forest analysts were then asked to calculate sustainable harvest levels for each of the alternatives.

In performing these calculations the analysts were asked to conform to the following direction:

1. Use the Forest Plan allocations, standards and guidelines as the base. Alternative land allocations will be layered on top of the Forest Plan allocations, and the most restrictive will apply unless otherwise specified.

2. Harvest schedules should achieve nondeclining yield over time subject to not exceeding the long-term sustained yield capacity.

3. Use the latest information available on land base, inventory, yields and related information.

4. Harvest schedules should be feasible/implementable and be consistent with standards and guidelines in Forest Plans (including knowledge gained during plan implementation) as well as any additional standards from the new options.

Sustainable harvest levels were developed by the Forest analysts using FORPLAN (Johnson et al. 1986), spatial data base analyses, or a combination of both. Eight of the Forest analysts used FORPLAN as their primary analysis tool for calculating harvest schedules. FORPLAN is an optimization tool used by the Forest Service in the development of harvest schedules for Forest Plans. The remaining five Forests relied principally on spatial data bases to determine the maximum acres available for harvest under each of the alternatives and then used Forest or Ranger District-level yield information to determine probable first decade harvest levels. Various Forest and Ranger District-level staff were then consulted by all Forests to assess the feasibility of the estimates.

PSQ estimates for three of the options (Options 1, 2 and 3) were not calculated by the Forest analysts. Option 2 is a modification of a slightly different alternative simulated by Forest Service analysts. The alternative evaluated by the analysts contained the same late-successional reserve system as Option 2, but different rules for riparian buffer widths on intermittent streams, as well as longer rotations in Tier 1 Key Watersheds. Information gained through simulating the modified alternative, the results for Options 6 and 10, and data on suitable acres in Key Watersheds were used to develop PSQ estimates for Option 2.

Option 1 basically precludes harvesting in stands 80 years and older. PSQ estimates for this option were based on Forest level acreage and age class information and the PSQ estimates derived for Option 2. The PSQ estimates for Option 3 were based on information concerning timber suitable acres within LS/OG2 areas on each of the National Forests, management rules for 250 to 350 year rotations, and the results of Option 2 and Option 6. Option 3 differs from Option 2 in that it permits limited harvesting in managed LS/OG2 areas. This option differs from Option 6 in that harvesting permitted in LS/OG2 areas is more restricted than it is in Option 6.

PSQ estimates developed by the field units were the basis for the estimates reported for the remaining seven options. We adjusted the PSQ estimates obtained from the analysts for Options 4 through 6 and 8 through 10 to reflect inoperable land concerns, a change in measuring buffer widths from horizontal to slope distance, a change in the estimate of intermittent stream miles, green tree retention standards, and changes in the riparian reserve buffer widths. Table B-1 displays what adjustments were made to the PSQ estimates obtained from the field units.

Table B-1. Adjustments to PSQ estimates calculated by Forest analysts

FEMAT Option Number	No Adjustment	Stream Miles and Slope/ Horizontal Distance Adjustment	Operability Adjustment	GTR* Adjustment	Modified Riparian Reserves Adjustment
4		X	X		
5		X	X		X
6		X	X	X	X
7	X				
8		X	X		X
9		X	X	X	
10		X	X	X	X

*GTR = green tree retention

Inoperable Land Adjustments

A study was conducted by Forest and Regional staff to determine if the riparian reserve networks outlined in the FEMAT Report would result in suitable acres becoming inoperable due to fragmentation. Forty sample quads from across the owl region were examined. The Forest and Regional staff working on this problem found that riparian reserve strategies 1 and 2 would result in 1-10 percent withdrawal of suitable acres due to the slivers caused by the riparian networks. Percentage reduction factors were then developed for Options 4 through 6 and 8 through 10 to reflect these findings, and the PSQ estimates obtained from the Forest analysts for these options were adjusted accordingly.

Miles of Intermittent Stream Adjustment

After the field units finished their PSQ analyses, the Aquatic/Watershed Group changed the number of miles of intermittent streams on six of the National Forests. The PSQ estimates for FEMAT Options 4 through 6 and 8 through 10 were modified for these Forests to reflect the latest data on intermittent streams. These adjustment factors ranged from a 9 percent increase to a 25 percent decrease in probable sale quantities.

Slope to Horizontal Distance Adjustments

The final options require riparian buffer widths based on slope rather than horizontal distance. The alternatives simulated by the field offices had buffer widths based on horizontal distance. As a result, the PSQ estimates obtained from the field for Options 4 through 6 and 8 through 10 had to be adjusted to reflect slope distances. This adjustment resulted in a 0-36 percent increase in the PSQ estimates obtained from Forest analysts.

Green Tree Retention (GTR) Adjustments

Each of the alternatives simulated by the field units reflect their Forest Plan standards for green tree retention with two exceptions. Options 4 and 5 require additional green trees and snags for woodpeckers on the eastern fringe of the owl range and the Klamath Province. The impacted Forests simulated this increased standard in both Options 4 and 5. For each of the remaining options requiring more GTR than called for in the Forest Plans, we determined the percentage of volume left in leave trees under the various GTR standards, subtracted the amount stipulated in the Forest Plans, and applied the difference to the percent of volume derived from even-age regeneration harvest methods in the first decade. We then reduced the PSQ estimates obtained from the field to reflect the increase in GTR standards called for under three of the options. This resulted in a 0-20 percent downward adjustment in PSQ estimates developed by the field units for Options 6, 9 and 10.

Riparian Reserve Buffer Width Adjustments

Options 5, 6 and 10 contain riparian reserve strategy 2 which requires riparian reserve 1 protection or "SAT" buffers on intermittent streams in key watersheds and half the protection of riparian reserve 1 or "half SAT" buffers on intermittent streams elsewhere. Forest Service analysts simulated Options 5, 6 and 10 with "half SAT" buffers on intermittent streams in and out of key watersheds. We adjusted the PSQ estimates obtained from the analysts for these options to reflect this change in riparian direction. This adjustment resulted in a 0-5 percent reduction in the PSQ estimates for these options.

Option 8 has riparian reserve strategy 3 which requires riparian reserve 1 protection on fish bearing streams, half riparian reserve 1 protection on nonfish bearing permanent streams, and 1/6 the riparian reserve 1 protection on intermittent streams. Forest analysts simulated Option 8 with riparian reserve 1 protection on all permanent streams and half riparian reserve 1 protection on intermittent streams. Bringing PSQ estimates for Option 8 into compliance with riparian reserve strategy 3 resulted in a 0-23 percent increase in the PSQ estimates obtained from the field.

PSQ Modeling of the FEMAT Options on National Forests in the Pacific Southwest Region (Region 5)

Acres

More than 200,000 individual forest stands were mapped and classified in Forest Service GIS data bases. For the purpose of analysis for the FEMAT Report, these individual polygons were aggregated into analysis areas based on the forest type, condition class, slope class, Forest Plan allocation, timber regulation class, and inclusion in one or more of the FEMAT allocations. The boundaries of the FEMAT allocations (Key Watersheds, Option 9 reserves, late-successional reserves, Adaptive Management Areas, etc.) were supplied to the National Forests in Region 5 by the Regional Office GIS staff. Economics and logging methods were not considered in this analysis. Riparian buffers, additional unstable lands, and inoperable lands proposed under FEMAT were not mapped. These areas were sampled and adjustment factors were applied to represent their acreage. Polygons with similar attributes were merged and placed into a relational data base and spreadsheet. Riparian buffers and operable acres were analyzed using a spreadsheet to adjust and re-merge acres into the various analysis areas for input into FORPLAN.

PSQ Calculation

FORPLAN was used in almost all cases to calculate PSQs. Forest yield coefficients and constraints from each Forest's preferred alternative were used in developing the matrix by Forest. The models for each Forest were standardized except for unique acres, yields, and constraints; however, a set of similar identifiers were used for all forest models. This provided needed standardization for the FEMAT analysis. Acres for each option were determined at each Forest.

The objective function used for all the options was: maximize timber harvest (in cubic feet) for the first period. A 150-year planning horizon was used. FORPLAN analysis for the four northern California National Forests was performed by the Region 5 team.

PSQ Modeling of the FEMAT Options on Lands Managed by the Bureau of Land Management

There are over 66,000 individual forest stands identified on the Western Oregon lands administered by the BLM. For all of the options analyzed, the land base acreage information for each stand was calculated using the Western Oregon Digital Database (WODDB/GIS), and stored in the forest stand inventory data base Micro©Storms. Each stand has an hierarchical representation of acres for the area in roads, nonforest, fragile sites unsuitable for timber harvest, riparian buffers, Areas of Critical Environmental Concern, and recreations sites. Each forest stand is described for it's stand and site quality characteristics and land use allocation: reserve, LS/OG1, Key Watershed, matrix, etc. The "suitable acres" are defined by the net area remaining at the bottom of the hierarchy for the land use allocations that are available for timber production.

The BLM did not estimate the PSQ for FEMAT Options 3, and 10.

Three different modeling approaches were used in the BLM harvest estimations for the options in the FEMAT Report.

The BLM 50-11-40 Model

Options 1, 2, 4, 5, and 6 applied the 50-11-40 rule for the matrix land prescription. TRIM-PLUS© (REI 1988) is the standard harvest scheduling model used by the BLM for PSQ estimation. However, the TRIM-PLUS model in its current configuration cannot track the spatial constraints of quarter township compliance to the 50-11-40 rule through time. Therefore, the BLM developed a simple harvest scheduling model in the forest inventory database Micro©Storms which can track the spatial constraint of 50-11-40 through time. The model contains acreage distribution by age class and by stocking level divided into lands suitable and unsuitable for timber harvest outside the reserve system for each quarter township. For a given period in time the model can assess the area above the 50 percent threshold which is available for harvest. Each quarter township is constrained to minimize excessive harvest within an area and to facilitate the long-term even flow for the Sustained Yield Unit. A yield function is used to estimate the volume production for a given age class which is harvested. This yield function accounts for the average site quality of the Sustained Yield Unit, green tree retention, snag/down log retention and approach to normality.

TRIM-PLUS

Option 7, characterized by the BLM's proposed Resource Management Plans (RMPs), used the TRIM-PLUS Harvest Scheduling model. TRIM-PLUS models non-declining harvest levels based on different management regimes for different categories of land use allocations over time. The model tracks forest inventory through the interaction of existing stand conditions and yield curves which model a variety of stand management scenarios. Yield curves were developed through the use of the BLM empiric inventory data, ORGANON, and Stand Projection System (SPS) growth and yield models.

Production Coefficient Estimation

The PSQ estimates for Options 8 and 9 were derived from production coefficients. A production coefficient is the average yield per acre of land base for a given land use allocation. The production coefficients were derived from the first decade TRIM-PLUS modeling efforts of the BLM proposed RMP. These production coefficients incorporated green tree retention, snag/down log retention, and average site quality for each allocation from the BLM proposed RMP. The Deferred and Non-deferred Old Growth Emphasis Areas in the Option 9 matrix lands were reallocated to a mixture of connectivity and general forest management. The Reserve and Managed Pair Areas in the Option 8 and 9 matrix lands were modeled as connectivity. It is recognized that the change in acreage distribution between land use allocations and between age classes from the BLM draft plans to Option 9 could affect the production coefficients and the resultant harvest level estimates. The amount of effect due to these changes is uncertain. The time constraint of the FEMAT process did not permit the use of the TRIM-PLUS model to estimate harvest levels for Options 8 or 9.

Further descriptions of these models are available in the Salem, Eugene, Roseburg, Coos Bay, Medford, and Lakeview Resource Management Plans and Environmental Impact Statements, Volume 2, August 1992.

ATTACHMENT C

esa ECOSPHERE

Carbon stocks and accumulation rates in Pacific Northwest forests: role of stand age, plant community, and productivity

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Abstract. Forest ecosystems are removing significant amounts of carbon from the atmosphere. Both abiotic resource availability and biotic interactions during forest succession affect C accumulation rates and maximum C stocks. However, the timing and controls on the peak and decline in C accumulation rates as stands age, trees increase in size, and canopy gaps become prevalent are not well-understood. Our study examines measured change in live and dead woody C pools from 8767 inventory plots on 9.1 million ha of Pacific Northwest National Forest lands to determine how the balance of tree growth, mortality, and dead wood decomposition varied by stand age, plant community type, and site productivity; and to compare the contribution of different tree sizes to C accumulation. Maximum non-mineral soil C for old-growth stands varied significantly by productivity class within plant community types, but on average stands accumulated 75% of maximum stocks by age 127 ± 35 yr. We did not see a decline in net primary production of wood (NPP_w) with age in moderate and low-productivity classes, but found a 33% reduction in high-productivity classes. Mortality increased with stand age such that net change in live tree biomass, and change in total woody C, was not significantly different from zero in old-growth stands over age 400 (0.15 ± 0.64 Mg $C \cdot ha^{-1} \cdot yr^{-1}$ for woody C). However, significant though modest C accumulation was found in forests 200–400 yr old (0.34–0.70 Mg $C \cdot ha^{-1} \cdot yr^{-1}$, depending on age class). Mortality of trees >100 cm diameter exceeded or equaled NPP_w, but trees were growing into the larger sizes at a high-enough rate that a net increase in large tree C was seen across the region. Although large trees accumulated C at a faster rate than small trees on an individual basis, their contribution to C accumulation rates was smaller on an area basis, and their importance relative to small trees declined in older stands compared to younger stands. In contrast to recent syntheses, our results suggest that old-growth and large trees are important C stocks, but they play a minor role in additional C accumulation.

Key words: carbon flux; disturbance; national forests; tree growth; tree mortality.

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Introduction

Forest ecosystems play a major role in the global carbon cycle because they can attain high levels of carbon storage, and can gain or lose carbon relatively rapidly (McKinley et al. 2011). These carbon (C) stocks are present in above- and below-ground live, dead, and highly decayed vegetation components that cycle with the atmosphere on time scales of days to centuries.

Although approximately one-quarter of the C in the atmosphere is fixed by photosynthesis in a year, relatively little ends up in carbon pools with long residence times such as trees or soil (Falkowski et al. 2000). Understanding the magnitude and drivers of C flux between forests and the atmosphere has been a focus of research given concerns about the effects of rising levels of atmospheric carbon dioxide on climate change (IPCC Core Writing Team 2007). Much of the terrestrial annual carbon accumulation in recent decades is believed to be occurring in northern hemisphere forests, but uncertainty remains about where and by how much (Pan et al. 2011, Hayes et al. 2012).

In addition to combustion and harvest, the rate at which different forest types store and release C is determined by available resources and environmental conditions, which control net primary production (NPP) and heterotrophic respiration (Rh). The species composition of different forests may also determine the maximum stocks attainable on a site due to species' differences in longevity, growth, and decomposition rates (Waring and Franklin 1979, Harmon et al. 1986). Predicting relevant site-specific resource levels given wide variation in climate, topography, and soils is challenging (e.g., Coops et al. 2012). In practice, forest managers often use empirical relationships with site index and community classifications, which integrate conditions at individual locations, to predict forest productivity and evaluate alternative management actions (e.g., Hemstrom et al. 1987, Barnes et al. 1998, Hoover and Rebain 2011). This approach is a useful framework for assessing C flux.

The net rate of C accumulation also changes with forest age and successional stage, depending on relative rates of NPP vs. Rh. A net loss of C usually occurs in the initial period of postdisturbance secondary succession, dominated by the decomposition of remnants of the previous stand (Janisch and Harmon 2002). As new forest vegetation dominates the site, C accumulation tends to peak early in stand development as NPP reaches a maximum soon after tree canopy closure, and then declines as stands age due to declines in NPP and increases in decomposition of dead matter produced by the new stand (Rh) (Ryan et al. 2004, McKinley et al. 2011). The hypothesized causes of decline in NPP in older stands include: increased autotrophic respiration as live biomass accumulates (but see Ryan et al. 2004); changes in allocation of carbon to less quantifiable below-ground structures, or inability of subordinate trees in multilayered old stands to use resources as efficiently as overstory trees (Binkley et al. 2002); or inability of large trees to obtain and/or distribute water and nutrients to the foliage in large, tall crowns (McDowell et al. 2002). Despite their low net C accumulation rates, old-growth forests provide useful estimates of maximum C storage and reference points for evaluating the effects of human and natural disturbances on regional C stocks (Smithwick et al. 2002).

Old-growth forests store large amounts of C per unit area, but a recent study suggests that substantial rates of C accumulation may be more common than previously thought (Luyssaert et al. 2008). However, mortality of large trees in old-growth stands may be increasing in the western United States (van Mantgem et al. 2009), with the potential to reduce NPP. Tree mortality resulting in canopy gaps in older forests may either lead to lower rates of C accumulation as space is not fully occupied by photosynthesizing plants (Coomes et al. 2012), or to greater rates because live biomass and NPP recovers quickly, while dead biomass decomposes slowly (Luyssaert et al. 2008). Decomposition rates of standing dead trees and downed wood differ, so the timing of gap events and snag fall rates affect stand-level Rh. Several of these hypotheses about NPP and stand age focus on absolute tree size as well as within-stand relative position (i.e., dominant or subordinate). Despite small increments in diameter, individual large trees accumulate more mass annually than small trees (Stephenson et al. 2014). However, large trees are typically less numerous than small trees and take up more space within a stand, so C accumulation on an area basis may not be that different.

Most of the empirical research on forest C stocks and accumulation rates is based on chronosequences, experiments, long-term measurements of a few plots, or one-time inventories. Many of these studies are conducted in archetypal stands selected to minimize confounding factors, which usually means they are fully stocked and have not been disturbed recently (Botkin and Simpson 1990). The focus of forestry research has often been on the more productive

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Table 1. Area and key characteristics of forested plots on Pacific Northwest national forests by climax plant association zones (PAZs). PAZs are sorted from lowest estimated mean carbon density (Mg/ha) to highest.

Climax PAZ	Code	N plots	Area (1000 ha)	Reserved land (%)	Most common species (ranked)†
Juniperus occidentalis	JUOC	118	97	1	JUOC, PIPO
Pinus ponderosa	PIPO	1338	1102	2	PIPO
Pinus contorta	PICO	441	416	17	PICO, PIPO, LAOC
Pseudotsuga menziesii	PSME	1260	1212	16	PSME, PIPO
Abies lasiocarpa	ABLA	612	776	40	PSME, ABLA, PIEN, PICO
Abies concolor and *A. grandis*	ABCOGR	1745	1669	14	PSME, ABCOGR, PIPO
Tsuga mertensiana and subalpine parkland	TSMEpark	618	924	63	TSME, ABAM, ABMAS, ABLA, PSME
Lithocarpus densiflorus	LIDE3	186	229	35	PSME, LIDE3, ARME
Tsuga heterophylla and *Picea sitchensis*	TSHEPISI	1691	1742	16	PSME, TSHE
Abies amabilis	ABAM	758	910	35	ABAM, TSHE, PSME

Notes: †Listed most common species make up at least 80% of the live tree carbon in a climax zone. In addition to the species names and codes shown in the first two columns: LAOC, *Larix occidentalis*; PIEN, *Picea engelmanii*; ABMAS, *Abies magnifica* var. *shastensis*; ARME, *Arbutus menziesii*.

(i.e., economically valuable) vegetation types in a region, and many of the experimental studies on NPP and succession have been done in relatively simple or single-species stands (e.g., Ryan et al. 2004). As a result, it is not clear how well the patterns and processes found by those studies apply to the larger population of forests in a region that are rarely fully stocked, occur on a wide variety of edaphic conditions, and have likely experienced a number of management, biotic, and abiotic mortality events during their development. In addition, few landscape and regional assessments of C flux have been based on measured, as opposed to modeled, changes in live and dead woody C pools.

Our objectives in this study were to assess the role of stand age, plant community type, and productivity on forest C stocks (excluding organic C in mineral soil) and the net changes in woody C over a diverse range of forest conditions. We analyzed a systematic inventory of National Forests in the Pacific Northwest, United States, with repeat measurements of most aboveground C pools. Previous work with these data summarized regional patterns of C stocks and change aggregated to landscape scales (Gray and Whittier 2014), while this study is focused on patterns and processes related to stand-level attributes. Specific null hypotheses include: (1) The rate at which stands accumulate C stocks, and the balance of tree growth, mortality, and decomposition, do not vary by plant community type and site productivity; (2) Most carbon accumulation occurs in young stands, and net accumulation in old-growth stands is essentially zero; and (3) Small trees contribute as much to the change in live C stocks within stands as do large trees. We focus on the dynamics of relatively undisturbed stands (i.e., no logging or fire between measurements), but also provide some comparisons with all stands in the region combined to determine the net effects of disturbance.

Methods

Study area

We assessed C stocks and their change on the 9.1 million ha of forested federal land administered by the Pacific Northwest (PNW) Region of the National Forest System (NFS). These lands are found primarily in the states of Oregon and Washington as well as parts of California and Idaho, USA, between 41.8 ° and 49.0° N latitude and 116.3 ° and 124.7° W longitude. NFS lands in this region occur in a great variety of conditions, with annual precipitation ranging from 25 to over 350 cm, mean annual temperature from −1 to 12 °C, and elevations from 0 to 3300 m above sea level (Franklin and Dyrness 1973). We grouped individual plots into 10 plant association zones (PAZs; Table 1) designated by the climax tree

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species as classified by field crews using local NFS guides (Hall 1998), and assessed geographic outliers by examining tree records and overlaying plot locations with a model of PAZs (Henderson 2009). Twenty-three percent of NFS forest land was "reserved" (i.e., where management for production of wood products was precluded; 85% of this was designated Wilderness) with the majority found in the ABLA, TSMEpark, and ABAM zones (*Abies lasiocarpa*, *Tsuga mertensiana* and alpine parklands, and *Abies amabilis* zones, respectively; Table 1).

The data and compilation methods we used for this study are similar to those used in Gray and Whittier (2014). We summarize the methods that were the same and provide full details on calculations and variables not used in that paper.

Field data

The primary data used in this study were collected by the US Forest Service for a strategic inventory of vegetation conditions on all NFS lands in the PNW Region using a probability-based sample design (Max et al. 1996). The sample consisted of a systematic square grid at a 5.47 km spacing across all lands, and a denser grid at a 2.74 km spacing outside of designated Wilderness areas, providing a sample density of one plot per 3000 and 750 ha, respectively. Plots were installed using the Current Vegetation Survey (CVS) design (Max et al. 1996) between 1993 and 1997 ("time 1") and remeasured between 1997 and 2007 ("time 2") in four spatially- and temporally balanced panels. The CVS plot remeasurement period ranged from 1 to 14 yr with a mean of 7.1 yr. To avoid high sample errors associated with estimating annual rates of change from short remeasurement periods on small numbers of plots, we only used plots from the last three panels, which were remeasured more than 2 yr after installation. The same grid of points was also measured with the nationally standardized Forest Inventory and Analysis (FIA) design starting in 2001 (USDA Forest Service 2006); we applied the FIA land classification distinguishing forest from non-forest, and FIA measurements of organic soil horizons (i.e., duff and litter depths measured at eight points per plot), to the data in this study.

The CVS plot design consisted of a cluster of five points within a 1-ha circle, with nested circular plots of different sizes used to measure live and standing dead trees of different sizes. Crews sampled downed wood with the line-intercept method and estimated line-intersect cover of shrub and forb vegetation on a 15.6 m transect at each point. Changes in understory biomass appeared unreliable due to changes in vegetation protocol (Gray and Whittier 2014); we therefore do not report estimates of change in understory vegetation C.

Data classification and compilation

There were 8767 plots within NFS lands that had forested conditions measured 3 or more years apart. Forest land is defined as land areas ≥0.4 ha that support, or previously supported, ≥10% canopy cover of trees and were not primarily managed for a non-forest land use. Systematically placed plots often straddle different conditions; we only used portions of plots classified as forest in our analysis. We assigned values for stand age, site index, and forest type based on the FIA compilation of the FIA sample of the same plot (e.g., Donnegan et al. 2008) where available, or from an FIA compilation of the first CVS plot measurement (Waddell and Hiserote 2005). We estimated site productivity in terms of production of wood at culmination of mean annual increment (MAI, $m^3 \cdot ha^{-1} \cdot yr^{-1}$) from the site index tree measurements (Hanson et al. 2002). We identified the nature and year of human and natural disturbances on each plot from a combination of field records and spatial data layers. Most analyses in this paper were based on a set of "undisturbed" plots that consisted of plots where tree cutting or fire had not occurred between measurements (N = 7647).

We used a combination of CVS status codes, estimated growth rates, and disturbance information to validate changes in individual tree status, calculate growth rates, and estimate diameters and heights of trees when they died (N = 1 008 943 tree records). Estimates of above- and below-ground live tree and standing dead tree woody C used the procedures documented in Woodall et al. (2011) and tree foliage and coarse-root ratios from Jenkins et al. (2003). Above- and below-ground biomass estimates

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for standing dead trees were reduced to account for decay and proportional bark and branch loss from Harmon et al. (2011). A standard "trees per hectare" expansion factor derived from the appropriate fixed-area plot size was used to convert individual live tree and standing dead tree C to an area basis (Mg/ha), and to calculate ratios of means for selected tree attributes (e.g., growth per tree or per unit basal area). We calculated C in downed dead woody material (DWM) from line-intercept diameter (for pieces >7.6 cm diameter) and counts by diameter class (for smaller pieces) using the procedures in Woodall and Monleon (2008) and density-reduction constants by decay class from Harmon et al. (2011). Forest-floor C was calculated from the annual FIA duff and litter depth measurements using forest type-specific bulk densities (Woodall and Monleon 2008). Additional details on C calculations are found in Gray and Whittier (2014).

We calculated three components of change for live tree C. "NPP_w" consisted of the woody mass increment of trees alive at both measurements, the increment of trees up to the estimated size and year of mortality or harvest, and the size of trees that grew over the minimum 2.5 cm DBH threshold during the remeasurement interval (equivalent to the forestry term "gross growth"). Differences in estimates of NPP_w among stands should reflect differences in NPP, though we did not attempt to estimate turnover in foliage and fine roots to calculate NPP. The "Mortality" and harvest components of change were the estimated mass of trees when they died. The net change in live trees (ΔLive), is NPP_w minus mortality (equivalent to the forestry term "net growth"). The net change in snags (ΔSnags) and downed woody material (ΔDWM) were based on differences in C between time 1 and 2 measurements. We refer to the net change in all pools (ΔLive + ΔSnags + ΔDWM) as net change in woody carbon "NetΔC_w". To put all plots on the same footing, components of change were annualized (i.e., $Mg\ C\cdot ha^{-1}\cdot yr^{-1}$) by dividing by the plot measurement interval. Most C results are presented on a per unit area basis (Mg C/ha), though occasionally we refer to estimates of total C for a stand type (Tg C). Most available volume and biomass equations and decay-reduction factors are based on limited data with unknown bias when applied to regional analyses (Temesgen et al. 2015); we did not attempt to incorporate these additional errors into our sample error estimates.

Statistical analyses

Statistical analyses of survey estimates differ from approaches commonly applied to designed studies (e.g., ANOVA). We calculated means and variances for all values using the equations for double-sampling for stratification based on sampled condition classes (Cochran 1977, Scott et al. 2005). Essentially, stratum weights for each plot estimate its proportional contribution to the overall population, taking into account differences in sampling intensity due to design and inaccessible plots, and the variation in remotely sensed vegetation attributes, to improve the precision of plot-based estimates. Strata were defined using national forest boundaries, Wilderness boundaries, and classified Landsat satellite imagery (Dunham et al. 2002, Homer et al. 2004). The ratios of the number of pixels in each stratum to the known area of sampled NFS lands in each estimation unit were used to assign population weights to each plot (e.g., MacLean 1972), and ratio estimates (e.g., Mg/ha) and their variances were calculated using the ratio of means estimator (Scott et al. 2005).

Plots are merely samples of forest stands and in most cases do not describe the mean and variance of conditions within a single stand with much precision. Therefore, we grouped plots with similar stand attributes (e.g., PAZ, MAI, stand age) and estimated mean C values using ratio of means (e.g., total C in a group of plots divided by the total area sampled by that group). The statistical significance of estimated means and variances was assessed with the Type I error for the *Z*-statistic (Zar 1984). We report most error estimates as the 95% confidence interval around the mean. We also calculated the Holm–Bonferroni adjustment to estimate the "family-wise" error rate for multiple comparisons (Ludbrook 2000) to identify cases where a value of interest that was not within a confidence interval was not significant (identified as *P*′).

We grouped plots within each PAZ into classes with similar estimated productivity (i.e., MAI) and stand age for analysis and display, based primarily on available sample size for most of the groups. Three MAI classes described as low,

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medium, and high grouped plots with MAIs of <3.5, 3.5–8.4, and >8.4 $m^3 \cdot ha^{-1} \cdot yr^{-1}$, respectively. Stand age classes were 0–20, 20–40, 40–60, 60–80, 80–100, 100–125, 125–150, 150–175, 175–200, 200–250, 250–300, 300–400, and >400 and identified by the mid-point ages of each class: 10, 30, 50, 70, 90, 113, 138, 163, 188, 225, 275, 350, 450, respectively (age intervals increase with age because precision of stand age estimates and sample sizes decline with age). Most analyses present empirically based estimates by categories of interest to assess differences in C across a diverse region. Alternative analyses applying models to continuous variables would require introducing a number of assumptions, including the shape of the relationships between dependent and independent variables, and the nature of the interactions among independent variables. In addition, many of the responses (e.g., NPP and changes in dead wood with age) do not seem to conform to simple linear or nonlinear curves. We provide graphs of many of the responses with continuous variables in the Appendix for context.

To estimate maximum C stocks for different forest conditions and the age at which stands attain 75% of the maximum, we regressed total C (not including mineral soil) on stand age for each PAZ × MAI class group. We used a cumulative two-parameter Weibull model used extensively to model stand-level growth in terms of basal area and volume (Curtis 1967, Hanus et al. 1999): allCdens = exp(a0 + a1 × (stdage^{a2})) where allCdens was total C (Mg C/ha), stdage was stand age (yr), and a0, a1, and a2 were parameters to be estimated. Modeling was done using proc NLIN in SAS (SAS Institute 2008) and data sets were restricted to stand age 300 (150 for the PICO—*Pinus contorta*—PAZ) to avoid problems with extrapolation of models into regions of sparse data. Model predictions were compared to splines to evaluate potential problems with model fits.

To assess the importance of different sizes of live trees to C accumulation, we used absolute diameter classes to assess change across the region, as well as relative diameter classes to assess changes in growth and dominance in stands of different ages and on different PAZs, because absolute tree sizes varied greatly among forest types. Five relative diameter classes (RDCs) of equal basal area (m^3/ha) were defined on each plot, populated with trees of increasing diameter. Growth and mortality rates of absolute and relative diameter classes were calculated for each class, as well as recruitment from one size class into the next through diameter growth. Total C changes for absolute diameter classes ($Mg\ C \cdot ha^{-1} \cdot yr^{-1}$) were calculated by multiplying individual tree measurements by their trees-per-hectare expansion, summing by diameter class per plot, multiplying by plot stratum weights to estimate totals by class and estimating means by dividing with total (weighted) area sampled. Estimating C change for relative diameter classes was similar, but compared different metrics of occupancy because tree density is commonly characterized in a variety of ways (e.g., numbers of trees, basal area, crown area, or biomass). For example, instead of dividing with area sampled as shown above, sums by RDC were divided with total (weighted) number of trees to get per tree change, or with total (weighted) basal area to get per unit basal area change.

Results

The ten PAZs are presented in the results sorted from low mean C stocks (Mg C/ha) to high, as sampled and estimated in this study (Table 1). The lowest-C PAZs tended to be the driest and/or highest in elevation. Douglas-fir (*Pseudotsuga menziesii* (Mirbel) Franco) was an important or dominant component of many of the PAZs (species composition and selected attributes by PAZ are shown in Appendix Figs. A1 and A2).

Carbon stocks and chronosequence

The maximum mean C stocks (live and dead woody pools, tree foliage, understory vegetation, and forest floor combined; not including mineral soil) and the apparent rate at which it was reached varied by PAZ and productivity (MAI) class. The Weibull model results identified significant differences in the maximum C attainable by PAZ × MAI class (Fig. 1). Trends of mean C with stand age were not always smooth and were affected by sample size for some PAZ × MAI class combinations (see Appendix Fig. A3). The modeled curves of C up to stand age 300 (150 for PICO zone) were able to smooth the empirical irregularities comparable to fitting splines and identified differences in the

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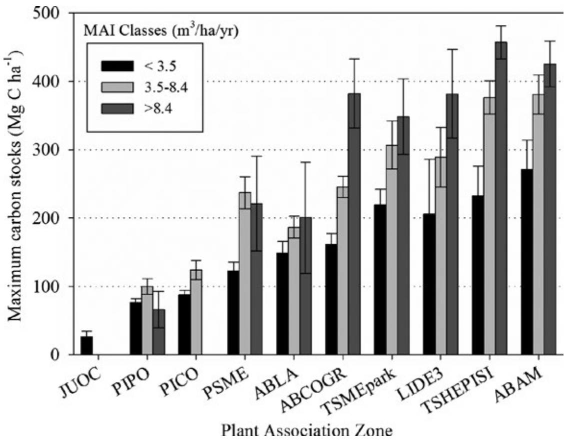

Fig. 1. Predicted maximum non-mineral soil carbon at stand age 300 (150 for PICO) by plant association zone (PAZ; see Table 1) and MAI class. Bars are 95% confidence intervals around the mean.

maximum attainable C over time (see Appendix Fig. A4). Maximum C was significantly greater in more productive MAI classes than in less productive MAI classes within the ABAM, TSHEPISI (*Tsuga heterophylla* and *Picea sitchensis*), and ABCOGR (*Abies concolor* and *A. grandis*) PAZs (Z = 1.99, 4.64, and 5.09; Holm–Bonferroni adjusted P' = 0.023, <0.001, and <0.001, respectively), and varied among PAZs. The apparent rate of C accumulation (i.e., the steepness of the curve) also differed among PAZs, with TSMEpark and ABCOGR showing the oldest stand age to attain 75% of maximum C, and PIPO (*Pinus ponderosa*) and JUOC (*Juniperus occidentalis*) zones the youngest (Z = 5.12, P' < 0.001; Table 2). The mean stand age required to reach the 75% level across PAZs was 127 ± 35 yr (95% confidence interval).

The proportion of total C in different pools varied significantly among PAZs and was likely affected by inherent differences in vegetation types as well as differences in recent and past disturbance and logging. Most of the non-mineral soil forest C was in the live tree pool, which showed the greatest differences in C among PAZs as indicated by their 95% confidence intervals (Fig. 2A). The largest C stocks were found in the TSHEPISI and ABAM zones, and were more than twice as high as the those of the five lowest-density zones (Z = 4.49, P' < 0.001). The ABAM zone tended to have older stands (median = 137 yr), while the TSHEPISI zone tended have stands with higher estimated MAI (median = 8.9 $m^3 \cdot ha^{-1} \cdot yr^{-1}$), than other PAZs (medians = 94 yr and 4.6 $m^3 \cdot ha^{-1} \cdot yr^{-1}$;

Table 2. Predicted age at which stands attain 0.75 of maximum non-mineral soil C, by plant association zone (PAZ), with 95% confidence interval.

PAZ	Age (yr)	95% CI
JUOC	62	±26
PICO	72	±14
PIPO	94	±12
LIDE3	110	±83
TSHEPISI	126	±36
ABLA	130	±27
ABAM	141	±47
PSME	158	±31
ABCOGR	176	±35
TSMEpark	196	±42

Note: High-MAI classes excluded for PIPO, PSME, and ABLA due to low N. PAZs sorted from low age to high.

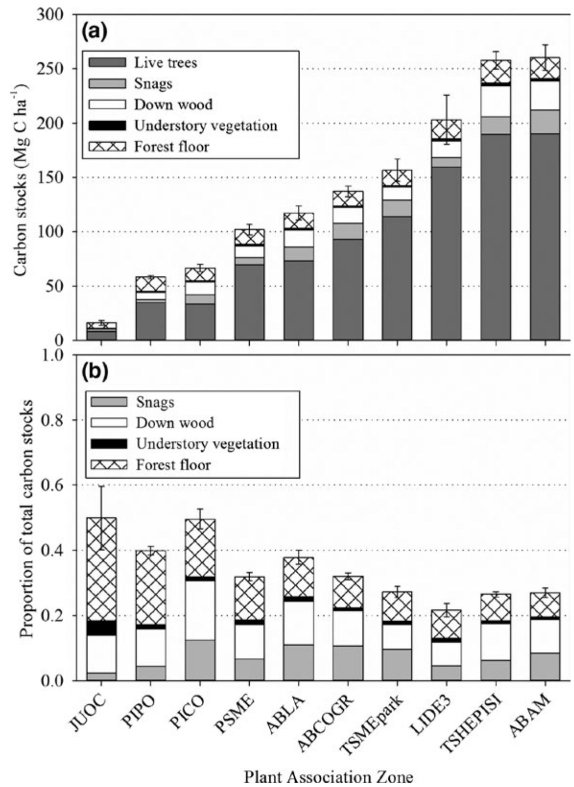

Fig. 2. Distribution of (a) mean carbon by plant association zone, and (b) proportion of total carbon by non-live tree pool type and plant association zone. Bars are 95% confidence intervals around the mean.

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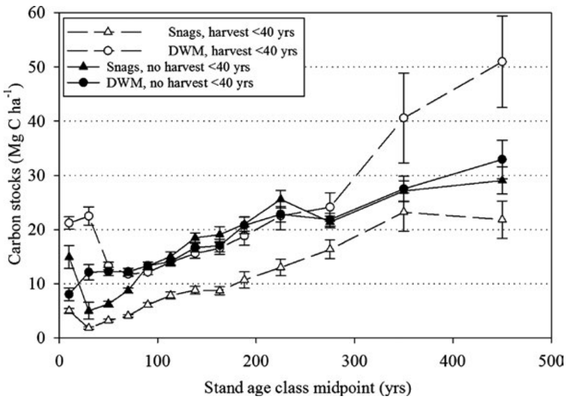

Fig. 3. Mean carbon in dead wood by stand age for standing dead trees ("snags") and down woody material (DWM), shown for forested plots with and without records of tree cutting ("harvest") within 40 yr prior to measurement. Bars are standard errors around the mean.

see Appendix Fig. A2). The proportion of total stand C in the non-live tree pools differed by PAZ as well (Fig. 2B), with the lowest proportions (0.2–0.35) found in the four PAZs with the greatest mean C (Z = 1.93, P' = 0.027). Proportions of total C in dead wood (snags and downed woody material (DWM)) were highest in the PICO and ABLA zones (0.31 and 0.24, respectively). In much of the region, *Pinus contorta* Dougl. ex Loud. (lodgepole pine) and *Abies lasiocarpa* (Hook.) Nutt. (subalpine fir) have experienced elevated mortality in recent years from mountain pine beetle (*Dendroctonus ponderosae* (Hopkins)) and western spruce budworm (*Choristoneura occidentalis* Freeman), respectively. Proportions of total stand C in dead wood ranged between 0.1 and 0.2 in the other PAZs.

The C stocks (Mg C/ha) of dead wood differed by stand age and management history, but the patterns were similar among PAZs, so we combined them for analysis (see Appendix Fig. A5 for chronosequences by PAZ and C pool). For plots with no record of tree cutting within 40 yr prior to measurement, C in standing dead trees (snags) was greater than in DWM for stands 0–20 yr old, but the reverse was true for stands 20–80 yr old as indicated by confidence intervals (Fig. 3). In contrast, in stands with any level of cutting within 40 yr, C in DWM was greater than in snags for all stand ages. C in DWM appeared similar between cut and uncut stands 60–300 yr of age, but C in snags was lower in cut than uncut stands for all age classes. Dead wood C (i.e., snags + DWM) was greater in stands >200 yr old than in younger stands (Z = 14.9, P < 0.0001). We expected that young stands <20 yr old that did not originate from harvest would have greater amounts of dead wood (snags and downed wood), and that they would be comparable to the live tree amounts in older stands from which they might have originated. When we removed sparse and non-stocked stands with no record of natural disturbance from the young-stand set, snag and DWM C stocks were higher than with the undisturbed young stands included (25 ± 3.3 and 9.5 ± 1.6 Mg C/ha for downed wood and snags, respectively), but the combined total (35 Mg C/ha) was still smaller than the mean live tree stocks for most PAZs.

Controls on carbon accumulation rates

On average, forests in all PAZs accumulated C on a net basis (NetΔC_w > 0), except for JUOC and PICO (Z = 0.13, P = 0.45 and Z = 1.50, P = 0.067, respectively; Fig. 4). NetΔC_w tended to be greater on PAZs with greater current C (Pearson r = 0.86), but there were notable exceptions. For example, NetΔC_w was lower in the ABAM zone than in the TSHEPISI zone (Z = 2.58, P' = 0.020), and was lower in the TSMEpark zone than in the ABCOGR zone (Z = 2.39, P' = 0.026). Stands in the ABLA zone experienced a net loss in live tree C on average (Z = 3.20, P' = 0.005). Some of the patterns are likely due to small-scale disturbance, with most C pools showing gains on forests that were not cut or burned ("undisturbed") between measurements (Fig. 4). The net change in live tree C was greater in the undisturbed forests than for all forests, and dominated the gains in all PAZs except for the PICO, ABLA, and ABCOGR zones, where large proportions of the gain in C (>0.4) was due to increases in downed wood. The net loss of snag C and gain of DWM C in the undisturbed PICO zone forests are suggestive of a prior disturbance pulse in a large number of stands (possibly due to mountain pine beetle) where snags fell and added to the downed wood pool.

C accumulation rates varied significantly with stand age. Rates of change with age for individual

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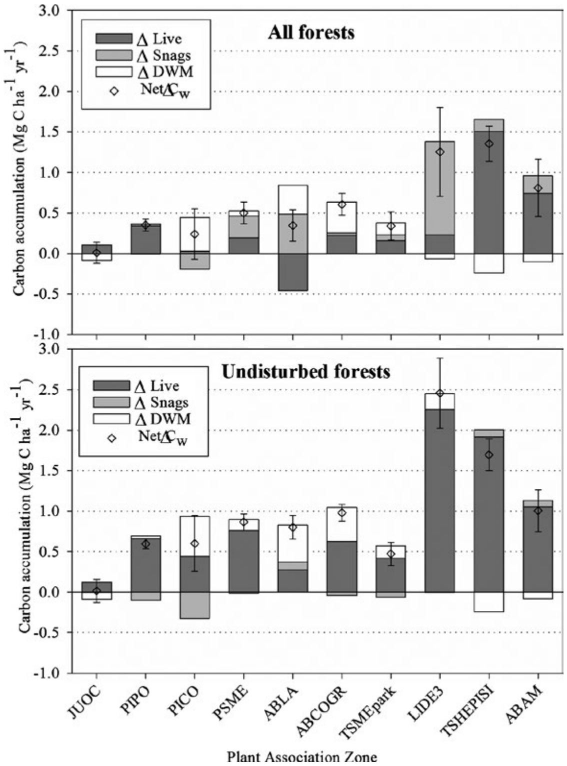

Fig. 4. Annual net change in C by pool and combined (NetΔC_w) by each plant association zone, for all forests and for undisturbed (not burned or cut during the measurement interval) forests only. Bars are 95% confidence intervals for NetΔC_w. Positive numbers are net gain, negative are net loss.

PAZ by MAI class groups indicated differences in the age at which ΔLive and NetΔC_w peaked and whether or how much they declined with age (Appendix Fig. A5). MAI class was the dominant effect on the patterns of NetΔC_w with stand age, so we aggregated plots by MAI class and stand age for further analysis. NPP_w increased to a plateau at the 80–100 yr age class on low MAI sites, rose more quickly to plateau in the 20–40 yr class on medium MAI sites, and peaked in the 20–60 yr ages and fell by ~33% in older stands on high-MAI sites (Fig. 5). Means with confidence intervals that did not overlap zero were also significantly different from zero in the Holm–Bonferroni tests except in the one case noted below. Mortality rates for the medium and high-MAI classes increased slowly but steadily as stand age increased, eventually matching the rates for NPP_w. Consequently, ΔLive was not significantly different from zero for stands over 250 yr old for these two groups. For the low MAI class group, although the effect of the rate of C change due to mortality was more variable (plateauing in the 100 to 300 yr old stands, increasing sharply then dropping again), ΔLive was not significantly different from zero for most stand age classes over 175 yr old.

The rates of change in the dead wood C pools varied less with stand age than live trees, resulting in less effect on the pattern of NetΔC_w with stand age. ΔSnag was negative in stands <20 yr old in all MAI classes but was variable and commonly not significantly different from zero in older stands. ΔDWM was significantly positive in most of the 75–200 yr ages for low and medium MAI site classes. On high-MAI site classes, ΔDWM was significantly negative for stands 0–60 yr of age; many stands likely originated from clearcuts, with little wood input from snags and small live trees to balance decomposition.

For all woody C pools combined, NetΔC_w was positive in stands 20–175 yr old on all sites, but was mostly not different from zero in stands <20 and >200 yr of age as indicated by the confidence intervals (except for the high-MAI value for 300–400 yr old stands, where $P' = 0.074$), though the mean values tended to be >0 and not less. For the combined set of undisturbed stands across all MAI classes, NetΔC_w was significantly >0 for all age classes except for the youngest (<20 yr) and oldest (≥400 yr) stands. The NetΔC_w rate for the ≥400 yr age class was 0.15 ± 0.64 Mg C·ha^{-1}·yr^{-1} (95% confidence interval; $Z = 0.47$, $P' = 0.64$). In age classes between 200–400 yr old, C accumulation was modest, but significant (0.34–0.70 Mg C·ha^{-1}·yr^{-1}; $P' < 0.001$ for 200–250 yr, $P' = 0.044$ for 250–300 yr, and $P' = 0.041$ for 300–400 yr age classes).

Tree size effects

Most of the accumulation of C in undisturbed stands across the study region was in the smallest tree sizes, reflecting in part their greater abundance compared to larger trees. Trees <50 cm DBH at time 1 accounted for 69% of the NPP_w and 87% of the ΔLive during the growth periods covered by the study (Fig. 6). NPP_w of the largest-diameter trees was offset by mortality, with ΔLive significantly <0 for trees 100–150 cm DBH at time 1 ($Z = 3.86$, $P' = 0.002$), and not different from zero for trees

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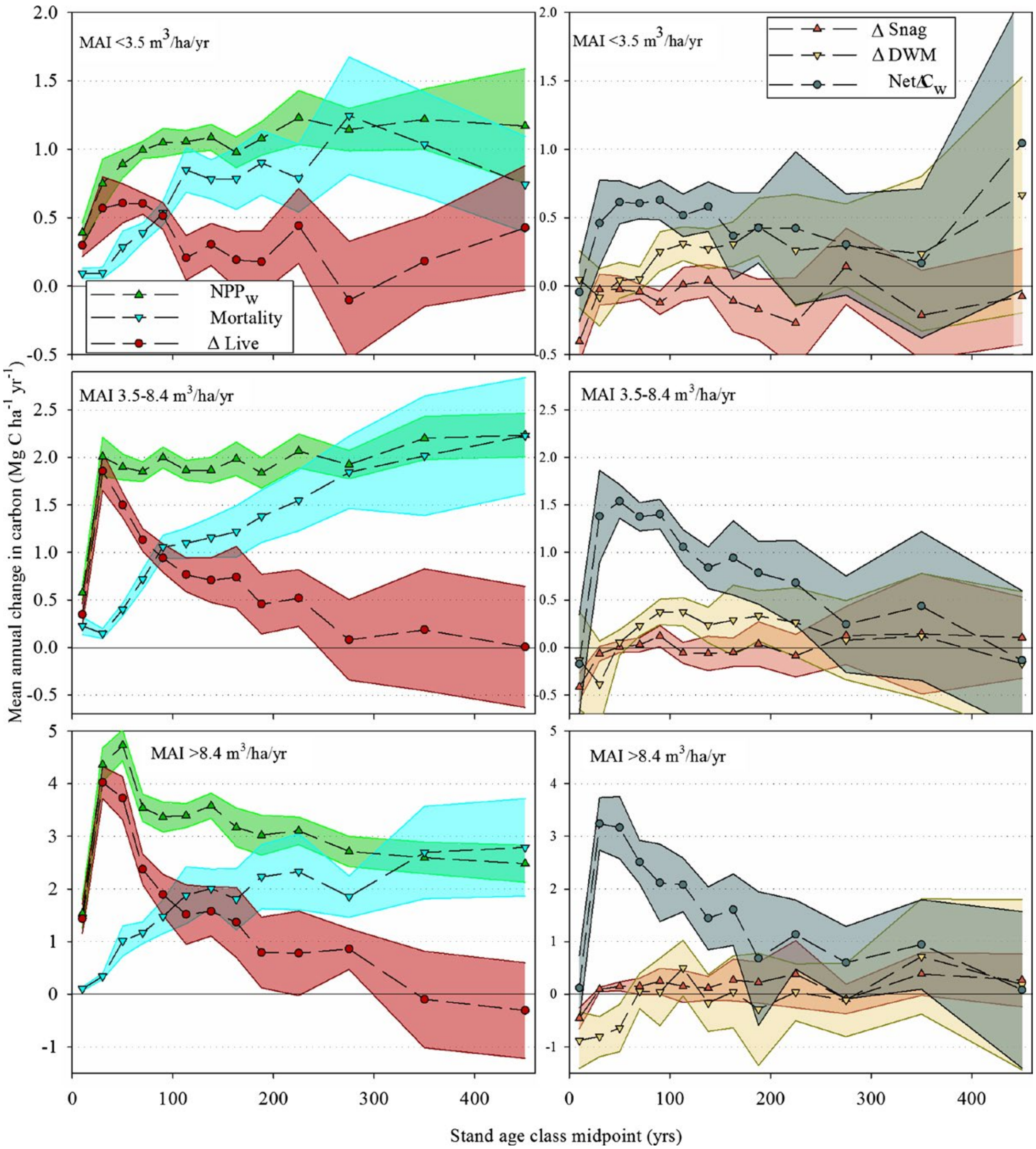

Fig. 5. Annual changes in carbon in undisturbed stands by MAI class and stand age. Live tree components of change are on the left; change in snags, down wood and all woody pools combined (NetΔC_w) are shown on the right. Bands are 95% confidence intervals around the mean. Scale differs among MAI classes.

>150 cm DBH. Nevertheless, C stocks in large trees (and all size classes >25 cm DBH) increased in undisturbed stands due to recruitment from smaller size classes ($P' < 0.033$ for each). The increase in C in large trees also held true when disturbed stands were included ($P' < 0.027$ for each), although increases were proportionately lower, particularly in the smaller tree sizes.

Determining which size classes of trees within undisturbed stands account for most of the annu-

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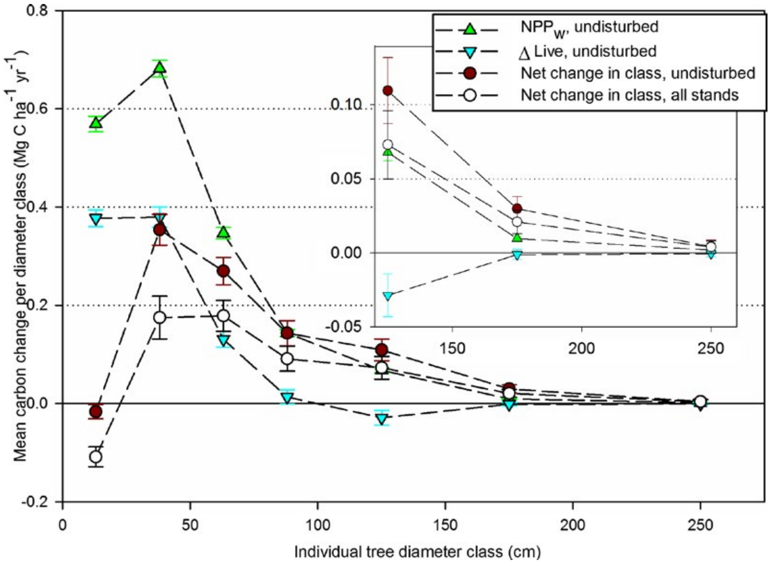

Fig. 6. Change in mean live tree carbon by tree size class across the region, showing NPP_w, ΔLive, and net change (growth into and out of a class plus ΔLive) for undisturbed stands and for all stands. Inset graph expands vertical scale for large trees. Bars are 95% confidence intervals around the mean.

Table 3. Mean net primary production (NPP_w) and net change in live trees (ΔLive) on undisturbed stands, by within-stand relative diameter class (and 95% confidence interval).

Diameter class	Mean DBH (cm)	NPP_w (Mg C·ha^{-1}·yr^{-1})	ΔLive (Mg C·ha^{-1}·yr^{-1})
1	8.2	0.38 (0.007)	0.19 (0.011)
2	20.9	0.42 (0.008)	0.23 (0.012)
3	28.8	0.41 (0.008)	0.22 (0.014)
4	37.1	0.37 (0.008)	0.18 (0.015)
5	50.5	0.30 (0.007)	0.10 (0.016)

Note: Each class made up 20% of the basal area (m^2/ha) on each plot; mean DBH is shown for all trees in each class on all plots.

al C accumulation depends on how occupancy, or the space used by each tree, is defined. Each relative diameter class made up 20% of the basal area (m^2/ha) in each plot; summaries across groups of plots therefore describe the relative contributions of different within-stand sizes of trees. Across the study area, NPP_w in undisturbed stands was evenly distributed among the first four relative diameter classes (RDCs) but was lowest for the largest size class (Z = 13.3, $P' < 0.001$; Table 3). Patterns in ΔLive with RDC were similar, but ΔLive was approximately half (49–54%) of NPP_w for the first four classes, but only a third (32%) of NPP_w for the largest tree size class, indicating a greater effect of mortality on live C stocks in the largest class. To examine trends of NPP_w with RDC using additional metrics of abundance (besides equal groupings of basal area), we calculated ratios of means using sums of growth divided by sums of tree density, C mass, crown area, and basal area per RDC (Fig. 7). As expected, NPP_w increased significantly with RDC on an individual tree basis. On an estimated crown-area basis, NPP_w also increased with tree size, but the differences among tree sizes were less than on a per tree basis and the largest tree sizes were more similar to each other (though still significantly different; Z = 2.07, P' = 0.019) than were the smallest tree sizes with each other. As discussed above but expressed in different units to aid comparison, on a per unit basal area basis NPP_w was lower for the largest trees than for the first 4 RDCs. Finally, on a mass basis (analogous to relative growth rate), smaller trees in stands had greater rates of NPP_w per unit mass than large trees.

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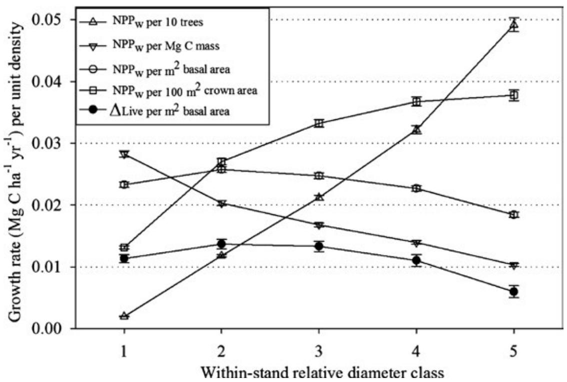

Fig. 7. Patterns of NPP_w for different sizes of trees in within-stand relative diameter classes, using different variables as a basis for density, including individual trees, mass, basal area, and crown area, and showing ΔLive for the basal area metric. Only undisturbed stands were used. Bars are 95% confidence intervals around the mean.

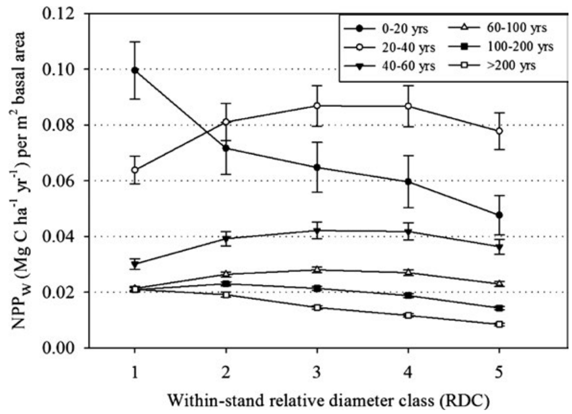

Fig. 8. NPP_w per unit basal area by within-stand relative diameter class and stand age class in undisturbed stands. Bars are 95% confidence intervals around the mean.

Table 4. Mean growth (NPPw) and net growth (ΔLive, growth minus mortality) per unit basal area of live trees by within-stand relative diameter class and MAI class, in undisturbed stands. Values are in Mg C·ha^{-1}·yr^{-1} per m^2 of basal area, with 95% confidence intervals in parentheses.

Within-stand relative diameter class	MAI class (m^3·ha^{-1}·yr^{-1})		
	<3.5	3.5–8.4	>8.4
NPP_w			
1	0.0173 (0.0006)	0.0226 (0.0006)	0.0298 (0.0010)
2	0.0182 (0.0007)	0.0252 (0.0006)	0.0337 (0.0010)
3	0.0172 (0.0006)	0.0241 (0.0006)	0.0329 (0.0011)
4	0.0160 (0.0007)	0.0217 (0.0006)	0.0308 (0.0011)
5	0.0132 (0.0006)	0.0173 (0.0006)	0.0254 (0.0010)
ΔLive			
1	0.0098 (0.0009)	0.0109 (0.0009)	0.0134 (0.0017)
2	0.0097 (0.0010)	0.0123 (0.0011)	0.0200 (0.0018)
3	0.0076 (0.0011)	0.0122 (0.0012)	0.0206 (0.0020)
4	0.0051 (0.0014)	0.0099 (0.0013)	0.0186 (0.0022)
5	−0.0006 (0.0017)	0.0051 (0.0013)	0.0137 (0.0022)

The patterns of NPP_w by RDC we found for all stands (described above; Table 3) were similar to those among PAZs (not shown) and MAI classes on undisturbed plots (Table 4). ΔLive rates, however, were highest for the three intermediate RDCs on high-productivity MAI class sites (Z = 3.06, P' = 0.001), but declined with increasing tree size on the low-productivity MAI class sites (RDCs 2–4; Z = 2.78, P' = 0.003), indicating disproportionately higher mortality in large trees on low-productivity sites. Differences in NPP_w by RDC varied among age classes as well. Except for stands <20 yr old, some of which were a combination of large old trees and younger regeneration, the majority of the NPP_w per unit basal area shifted from large tree to small tree basal area groups as stand age increased (Fig. 8).

Discussion

Chronosequences of carbon stocks

C stocks and accumulation rates varied significantly among PAZs and site productivity

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(MAI) classes. Predictably, the highest C stocks were in zones with abundant precipitation and moderate temperatures, but regional disturbance history had a role as well, with higher C stocks in the ABAM zone than the TSHEPISI zone, where site productivity was greater but stands were younger. Comparing mean current C stocks in the study area (157 Mg C/ha, or 1428 Tg total; not including mineral soil) with the estimated mean maximum from the oldest stands in each PAZ × MAI class (252 Mg C/ha, 2282 Tg total) suggests these forests currently store 63% of their potential maximum C. Of course even without harvest the maximum would never be reached across a region because of natural disturbances (e.g., severe wildfires, wind storms, and landslides; Smithwick et al. 2002), but under current management and disturbance regimes continued accumulation is likely. We do not consider C produced by the forest but stored off-site in buildings and landfills, or any energy or construction substitutions from use of wood products that might apply in some accounting approaches; comparisons with in-forest C storage are sensitive to assumptions about baselines, leakage, and disturbance regimes (e.g., McKinley et al. 2011). The maximum estimated C stocks for vegetation types found west of the Cascade crest from our study (<400 Mg C/ha for LIDE3 (*Lithocarpus densiflorus*), TSHEPISI, ABAM, and TSMEpark PAZs) are substantially lower than the >600 Mg C/ha (excluding mineral soil) from westside research plots in Smithwick et al. (2002), but similar to estimates for live trees by Raymond and McKenzie (2013), which was also based on forest inventory data. Across all forest PAZ × MAI classes, stands attained 75% of their estimated maximum C by age 127 yr. This and changes in ΔLive with stand age indicate that the speed and amounts of potential future annual C accumulation are greatest for forests with a large proportion of young stands, and that the potential for additional accumulation declines substantially as forests mature and stocks approach their maximum carrying capacity.

The contribution of dead wood to total C stocks varied among PAZs and did not match the expected chronosequence pattern well. The lowest proportions of total C in dead wood pools were found in the most productive PAZs. Differences in species' decomposition rate, susceptibility to insects and disease, or recent disturbance regimes may be responsible for higher dead wood proportions in less productive zones. Our chronosequence results of dead wood C did not follow a well-defined U-shaped curve of dead wood with stand age following stand-replacement fire in mature forests (Harmon et al. 1986). Dead wood C in young naturally disturbed stands is primarily determined by the live trees in the predisturbance stands, yet dead wood C in our study was lower in the youngest stands (<20 yr) than the live tree C in mature stands. Low C stocks in dead wood may be due to prior salvage-logging or the tendency for fires to burn at highest intensity in stands that are sparse to begin with (Azuma et al. 2004). Indeed, most of the unmanaged and burned stands in this study were in the low-productivity ABLA, PICO, PIPO, and PSME (*Pseudotsuga menziesii*) zones. Our analysis is probably not an appropriate chronosequence for dead wood because stands that began with different amounts of legacy wood were mixed together. The chronosequence did suggest a slow accumulation of dead wood in stands continuing past age 200 yr, which was also seen in the net change analysis. Stands with recent harvest had fewer snags than unharvested stands for all age classes, which could reflect less mortality due to reduced live tree density, or the felling of potentially hazardous snags in cutting units.

The value of a study based on a probabilistic forest inventory sample is that the scope of inference is well defined and results apply to all forests in the population of interest, albeit for a defined and relatively short period of time. Few studies have analyzed the components of change in live and dead C pools using repeat field measurements and design-based inference across the diverse set of ecosystems and stand conditions found here. One of the challenges of working with these data is that the large diversity of vegetation types and conditions does not always conform to simple conceptions of vegetation development. While the conceptual model of secondary succession is useful, many forests do not develop from a stand-replacing event without subsequent disturbance. Fire, cutting, or insect outbreaks can thin the original, or oldest tree cohort, allowing new trees to establish. These cohorts can rarely be distinguished by

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diameter alone, and the concept of "stand age" becomes tenuous. In these situations, the ages of the dominant trees reflect neither the time of stand origin or the last major disturbance, but a combination of events ("uneven aged" in forestry terminology). While the stand age estimate reflects the importance of the oldest trees, it often does not mean development of an "even aged" stand experiencing few mortality events since stand origin (J. T. Stevens et al. *in press*). Indeed, the notion of undisturbed old-growth stands is somewhat artificial, given that both understory reinitiation and the old-growth stage are characterized by gap dynamics; i.e., periodic mortality events affecting the dominant trees in a stand. Stand age and even site index may also not be as meaningful in harsh environments where snow or rock may limit stand development more than time since disturbance. For example, stands in the environmentally harsh ABLA and JUOC zones in this study did not show much pattern of C stocks or accumulation rates with stand age. In addition, site index and MAI estimates are based on a few commercial species in "fully stocked" stands, and are therefore rough approximations for non-commercial forest types (Hanson et al. 2002), and sites where substrate or drought conditions limit stands from ever attaining "full stocking" (Cochran et al. 1994). We believe that stand age and MAI are still useful concepts, but additional information on disturbance and management history and site edaphic conditions could improve our understanding of forest C accumulation potential.

Carbon accumulation rates

Overall, we found stability and perhaps slight increases in measured aboveground C pools in undisturbed old-growth forests. Live tree C accumulation rates measured as NPP_w were not lower in old stands than in young stands on low and moderate productivity sites, but were approximately one-third lower on the most productive sites. Speculation on why NPP_w apparently declined with age on high-productivity sites and not lower-productivity sites could include some of the mechanisms mentioned in the introduction, as well as the possibility that many of the productive stands <40 yr old were planted and tended and are more densely stocked than older stands. Our results suggest that declines in forest $Net\Delta C_w$ with stand age had little to do with declines in NPP_w, and were primarily due to increases in heterotrophic respiration as stands became fully occupied and large trees began to die and transition to dead wood (Coomes et al. 2012, Xu et al. 2012, Foster et al. 2014).

We did not see the ~2 $Mg\ C\cdot ha^{-1}\cdot yr^{-1}$ of total C accumulation ($Net\Delta C_w$) in old-growth stands indicated by Luyssaert et al. (2008). Although dead wood pools seemed to increase in older stands, overall net increases in measured pools in our oldest (>400 yr old) stands were 0.15 $Mg\ C\cdot ha^{-1}\cdot yr^{-1}$ and not significantly different from zero. Our findings of a rough balance between change in live and dead C also do not support Luyssaert et al.'s (2008) suggestion that positive accumulation rates in old-growth were due to slow decomposition of dead wood and fast recovery of living vegetation from gap events. It is possible that some old-growth forests that are intact or recovering from prior gap disturbances are accumulating C at high rates, while others are experiencing gap events and losing C. Indeed, Wharton et al. (2012) found high variation in eddy-flux covariance measurements of C accumulation rates in an old-growth *Pseudotsuga menziesii*-*Tsuga heterophylla* forest around a mean of 0.5 $Mg\ C\cdot ha^{-1}\cdot yr^{-1}$. This was in the range we found for 200–400 yr old stands (0.34–0.70 $Mg\ C\cdot ha^{-1}\cdot yr^{-1}$), suggesting a potentially large and sustained C sink as forests continue to age under current management and disturbance regimes.

There are a number of challenges to estimating C stocks and change accurately. It is possible that we would have more definitive estimates with longer remeasurement time spans and/or measurements of changes in the forest floor and mineral soil C pools. Soil C research in the region has suggested that C in the mineral soil does not change greatly with stand development, but C does accumulate in the litter and humus layers (Homann et al. 2005, Giesen et al. 2008). Much of the uncertainty and discrepancy among different published estimates of total ecosystem C accumulation rates may be due to assumptions with respect to soil processes (McKinley et al. 2011). Although we do not have age- and PAZ-appropriate estimates of leaf and fine root turnover for a complete assessment of NPP, there

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is little reason to think that we would find substantially different patterns between NPP_w and overall NPP (e.g., Kira and Shidei 1967, Ryan et al. 2004). The scope and applicability of available volume and biomass equations applied to regional analyses is unknown, though initial work is being done to address this (e.g., Temesgen et al. 2015). In particular, a single value is usually used to estimate the proportion of total tree biomass in coarse roots for a species, regardless of tree size or growing conditions, due to a lack of empirical information. Since proportional allocation of plants to below-ground structures usually increases as soil resources become more limiting (e.g., Santantonio and Hermann 1985), it is likely that the differences in above-ground NPP_w among vegetation types we report are greater than if we had better information on below-ground allocation.

Role of tree size

Most of the C accumulation in the region was due to the NPP_w of the smallest tree sizes (<50 cm DBH). Although large trees (>100 cm DBH) that remained alive did accumulate C (Stephenson et al. 2014), the change in live tree C due to mortality was greater for large trees than for smaller trees, with the net effect being a loss of live C or change not significantly different from zero. This should be expected since most living organisms grow large or old and eventually die. However, over this time period, the region was gaining C in large trees as trees from smaller sizes grew into larger sizes, more than replacing the live C lost from mortality. So despite apparent increases in mortality over time in the western USA (van Mantgem et al. 2009), and shifts in tree species' ranges on the west coast (Monleon and Lintz 2015), on balance these National Forest lands are gaining large trees. The change in large trees holds whether assessing all stands or only undisturbed stands, as mortality from fires and logging during this period disproportionately killed smaller trees. This is also not too surprising given the reduction in logging and shift in emphasis to restoration treatments on PNW national forests, and the low rates of intense wildfire on forestland (Moeur et al. 2011, Gray and Whittier 2014, T. R. Whittier and A. N. Gray 2016). Growth rates of large trees may be under-estimated, however, given the lack of data from large trees used in existing biomass equations (Temesgen et al. 2015), the use of diameter and height to predict biomass change, and the finding that some old trees accumulate more biomass on upper stems than at DBH (i.e., change taper; Sillett et al. 2010).

We found that larger individual trees do accumulate more C per tree than smaller trees, as has been found in other studies (e.g., Stephenson et al. 2014). Determining which sizes of trees within a stand accumulate more C per unit land area occupied turned out to depend greatly on the definition of occupancy. On a basal area basis (the most common density metric in forestry), NPP_w per unit basal area in the largest tree class was 76% of the mean of the smaller size classes; the differences were even more pronounced on a mass basis. On an estimated crown-area basis, however, NPP_w of the largest size class was similar to medium sizes and greater than the smallest sizes. The proportion of overall NPP_w accumulated by smaller trees increased as stand age increased. This is counter to the expected decline in growth efficiency as more trees in a stand become non-dominant (Binkley 2004). The difference might be that many natural stands have multiple species with multiple resource tolerances and that over time stands become more spatially heterogeneous and multilayered and use space more efficiently, with large amounts of foliage in upper and lower layers of stands (Van Pelt and Nadkarni 2004). Indeed, in mixed-species stands it can be the understory trees that respond the most with growth after disturbance events (Gray et al. 2012).

Conclusions

Analyses of probabilistic inventories of large areas of forest land are not only important for estimating C stocks and flux (e.g., Coulston et al. 2012), but can also provide insights into the ecological drivers behind the vegetation patterns seen across a region. These systems of permanent plots capture most of the range in site conditions, stochastic events, and stand structure at a finer resolution than is possible through other means. While inventory plots are not designed for intensive process-level studies, any improvements in

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site-specific information on disturbance and management history, microclimate, and edaphic conditions will improve our ability to interpret the vegetation changes that are measured. Revisiting our first hypothesis, we found that while forests in our region are accumulating woody C, the variation in accumulation rates is high and readily explained by differences in site productivity and stand age. Similarly, the potential C stocks in old-growth forests vary significantly by vegetation type and site productivity. Maintaining or increasing C stocks on the land is one of many management goals, but specific information on stocks and fluxes related to vegetation characteristics used in management could be helpful. With regard to the second hypothesis, our results suggest that the decline in C accumulation ($Net\Delta C_w$) with stand age was not due to a decline in tree growth (NPP), although some reduction in NPP on productive sites may have played a role; declines in $Net\Delta C_w$ were primarily related to increased decomposition-related losses of dead wood. We found that net C accumulation of wood in old (>200 yr) stands was low and indistinguishable from zero in the oldest (>400 yr) stands, but the dead wood pool may be where any increased accumulation is ending up in this age class. Finally, our analyses suggested that small trees play an important role in overall C accumulation, but that the C stored in large trees continues to increase in our region.

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Literature Cited

Azuma, D. L., J. Donnegan, and D. Gedney. 2004. *Southwest Oregon Biscuit fire: an analysis of forest resources and fire severity*, PNW-RP-560. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA.

Barnes, B. V., D. R. Zak, S. R. Denton, and S. H. Spurr. 1998. *Forest ecology*, Fourth edition. Wiley, New York, New York, USA.

Binkley, D. 2004. A hypothesis about the interaction of tree dominance and stand production through stand development. *Forest Ecology and Management* 190:265–271.

Binkley, D., J. L. Stape, M. G. Ryan, H. R. Barnard, and J. Fownes. 2002. Age-related decline in forest ecosystem growth: an individual-tree, stand-structure hypothesis. *Ecosystems* 5:58–67.

Botkin, D. B., and L. G. Simpson. 1990. Biomass of the North-American Boreal Forest – a step toward Accurate Global Measures. *Biogeochemistry* 9:161–174.

Cochran, W. G. 1977. *Sampling techniques*, Third edition. John Wiley & Sons, New York, New York, USA.

Cochran, P. H., J. M. Geist, D. L. Clemens, R. R. Clausnitzer, and D. C. Powell. 1994. *Suggested stocking levels for forest stands in Northeastern Oregon and Southeastern Washington*, RN PNW-513. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA.

Coomes, D. A., R. J. Holdaway, R. K. Kobe, E. R. Lines, and R. B. Allen. 2012. A general integrative framework for modelling woody biomass production and carbon accumulation rates in forests. *Journal of Ecology* 100:42–64.

Coops, N. C., R. H. Waring, and T. Hilker. 2012. Prediction of soil properties using a process-based forest growth model to match satellite-derived estimates of leaf area index. *Remote Sensing of Environment* 126:160–173.

Coulston, J. W., K. Nelson, C. W. Woodall, D. Meriwether, and G. A. Reams. 2012. The climate change performance scorecard and carbon estimates for national forests. Pages 170–176 *in* R. S. Morin, and G. C. Liknes, editors. *Moving from status to trends: Forest Inventory and Analysis (FIA) symposium 2012, Baltimore, MD, December 4–6, 2012*, NRS GTR-P-105. USDA Northern Research Station, USDA Forest Service, Newtown Square, Pennsylvania, USA.

Curtis, R. O. 1967. Height-diameter and height-diameter-age equations for second-growth Douglas-fir. *Forest Science* 13:365–375.

21508925, 2016, 1, Downloaded from https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecs2.1224, Wiley Online Library on [11/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

Donnegan, J., S. Campbell, and D. Azuma. 2008. *Oregon's forest resources, 2001–2005: five-year Forest Inventory and Analysis report*, PNW GTR-765. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA.

Dunham, P. A., D. L. Weyermann, and D. L. Azuma. 2002. A comparison of stratification effectiveness between the National Land Cover Data set and photointerpretation in western Oregon. Pages 63–68 *in* R. E. McRoberts, G. A. Reams, P. C. Van Deusen, and J. W. Moser, editors. *Proceedings of the Third Annual Forest Inventory and Analysis Symposium, Traverse City, Michigan, October 17-19, 2001*, NC GTR-230. North Central Research Station, USDA Forest Service, St. Paul, Minnesota, USA.

Falkowski, P., et al. 2000. The global carbon cycle: a test of our knowledge of earth as a system. *Science* 290:291–296.

Foster, J., A. D'Amato, and J. Bradford. 2014. Looking for age-related growth decline in natural forests: unexpected biomass patterns from tree rings and simulated mortality. *Oecologia* 175:363–374.

Franklin, J. F., and C. T. Dyrness. 1973. *Natural vegetation of Oregon and Washington*, PNW GTR-8. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA.

Giesen, T. W., S. S. Perakis, and K. Cromack. 2008. Four centuries of soil carbon and nitrogen change after stand-replacing fire in a forest landscape in the western Cascade Range of Oregon. *Canadian Journal of Forest Research* 38:2455–2464.

Gray, A. N., and T. R. Whittier. 2014. Carbon stocks and changes on Pacific Northwest national forests and the role of disturbance, management, and growth. *Forest Ecology and Management* 328:167–178.

Gray, A. N., T. A. Spies, and R. J. Pabst. 2012. Canopy gaps affect long-term patterns of tree growth and mortality in mature and old-growth forests in the Pacific Northwest. *Forest Ecology and Management* 281:111–120.

Hall, F. C. 1998. *Pacific Northwest ecoclass codes for seral and potential natural communities*, PNW GTR-418. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA.

Hanson, E. J., D. L. Azuma, and B. A. Hiserote. 2002. *Site index equations and mean annual increment equations for Pacific Northwest Research Station Forest Inventory and Analysis Inventories, 1985-2001*, PNW RN-533. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA.

Hanus, M. L., D. D. Marshall, and D. W. Hann. 1999. *Height-diameter equations for six species in the coastal regions of the Pacific Northwest*, Research Contribution 25. College of Forestry, Oregon State University, Corvallis, Oregon, USA.

Harmon, M. E., et al. 1986. Ecology of coarse woody debris in temperate ecosystems. *Advances in Ecological Research* 15:133–302.

Harmon, M. E., C. W. Woodall, B. Fasth, J. Sexton, and M. Yatkov. 2011. *Differences between standing and downed dead tree wood density reduction factors: a comparison across decay classes and tree species*, NRS RP-15. Northern Research Station, USDA Forest Service, Newtown Square, Pennsylvania, USA.

Hayes, D. J., et al. 2012. Reconciling estimates of the contemporary North American carbon balance among terrestrial biosphere models, atmospheric inversions, and a new approach for estimating net ecosystem exchange from inventory-based data. *Global Change Biology* 18:1282–1299.

Hemstrom, M. A., S. E. Logan, and W. Pavlat. 1987. *Plant association and management guide: Willamette National Forest*, R6-Ecol-257-B-86. Pacific Northwest Region, USDA Forest Service, Portland, Oregon, USA.

Henderson, J. A. 2009. *Modeled potential natural vegetation zones of Washington and Oregon*. Pacific Northwest Region, USDA Forest Service, Portland, Oregon, USA. http://ecoshare.info/2010/02/28/waor-washingtonoregon/

Homann, P. S., M. Harmon, S. Remillard, and E. A. H. Smithwick. 2005. What the soil reveals: potential total ecosystem C stores of the Pacific Northwest region, USA. *Forest Ecology and Management* 220:270–283.

Homer, C., C. Huang, L. Yang, B. Wylie, and M. Coan. 2004. Development of a 2001 national landcover database for the United States. *Photogrammetric Engineering and Remote Sensing* 70:829–840.

Hoover, C. M., and S. A. Rebain. 2011. *Forest carbon estimation using the Forest Vegetation Simulator: seven things you need to know*, NRS GTR-77. Northern Research Station, USDA Forest Service, Newtown Square, Pennsylvania, USA.

IPCC Climate Change. 2007. *Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change in* Core Writing Team, R. K. Pachauri, and A. Reisinger, editors. IPCC, Geneva, Switzerland, 104 pp.

Janisch, J. E., and M. E. Harmon. 2002. Successional changes in live and dead wood carbon stores: implications for net ecosystem productivity. *Tree Physiology* 22:77–89.

Jenkins, J. C., D. C. Chojnacky, L. S. Heath, and R. A. Birdsey. 2003. National-scale biomass estimators for United States tree species. *Forest Science* 49:12–35.

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Kira, T., and T. Shidei. 1967. Primary production and turnover of organic matter in different forest ecosystems of the Western Pacific. *Japanese Journal of Ecology* 17:70–87.

Ludbrook, J. 2000. Multiple inferences using confidence intervals. *Clinical and Experimental Pharmacology and Physiology* 27:212–215.

Luyssaert, S., E. D. Schulze, A. Borner, A. Knohl, D. Hessenmoller, B. E. Law, P. Ciais, and J. Grace. 2008. Old-growth forests as global carbon sinks. *Nature* 455:213–215.

MacLean, C. D. 1972. *Photo stratification improves northwest timber volume estimates*, PNW RN-150. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA.

van Mantgem, P. J., et al. 2009. Widespread increase of tree mortality rates in the Western United States. *Science* 323:521–524.

Max, T. A., H. T. Schreuder, J. W. Hazard, D. D. Oswald, J. Teply, and J. Alegria. 1996. *The Pacific Northwest region vegetation and inventory monitoring system*, PNW RP-493. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA.

McDowell, N. G., N. Phillips, C. Lunch, B. J. Bond, and M. G. Ryan. 2002. An investigation of hydraulic limitation and compensation in large, old Douglas-fir trees. *Tree Physiology* 22:763–774.

McKinley, D. C., et al. 2011. A synthesis of current knowledge on forests and carbon storage in the United States. *Ecological Applications* 21:1902–1924.

Moeur, M., J. L. Ohmann, R. E. Kennedy, W. B. Cohen, M. J. Gregory, Z. Yang, H. M. Roberts, T. A. Spies, and M. Fiorella. 2011. *Northwest Forest Plan, the first fifteen years (1994-2008): status and trend of late-successional and old-growth forest*, PNW GTR-853. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA.

Monleon, V. J., and H. E. Lintz. 2015. Evidence of tree species' range shifts in a complex landscape. *PLoS ONE* 10:e0118069.

Pan, Y. D., et al. 2011. A large and persistent carbon sink in the world's forests. *Science* 333:988–993.

Raymond, C. L., and D. McKenzie. 2013. Temporal carbon dynamics of forests in Washington, US: implications for ecological theory and carbon management. *Forest Ecology and Management* 310:796–811.

Ryan, M. G., D. Binkley, J. H. Fownes, C. P. Giardina, and R. S. Senock. 2004. An experimental test of the causes of forest growth decline with stand age. *Ecological Monographs* 74:393–414.

Santantonio, D., and R. K. Hermann. 1985. Standing crop, production, and turnover of fine roots on dry, moderate, and wet sites of mature Douglas-fir in western Oregon. *Annals of Forest Science* 42:113–142.

SAS Institute. 2008. *SAS/STAT user's guide*, version 9. SAS Institute, Cary, North Carolina, USA.

Scott, C. T., W. A. Bechtold, G. A. Reams, W. D. Smith, J. A. Westfall, M. H. Hansen, and G. G. Moisen. 2005. Sample-based estimators used by the forest inventory and analysis national information management system. Pages 43–67 *in* W. A. Bechtold, and P. L. Patterson, editors. *The enhanced Forest Inventory and Analysis Program – national sampling design and estimation procedures*, SRS GTR-80. Southern Research Station, USDA Forest Service, Asheville, North Carolina, USA.

Sillett, S. C., R. Van Pelt, G. W. Koch, A. R. Ambrose, A. L. Carroll, M. E. Antoine, and B. M. Mifsud. 2010. Increasing wood production through old age in tall trees. *Forest Ecology and Management* 259:976–994.

Smithwick, E. A. H., M. E. Harmon, S. M. Remillard, S. A. Acker, and J. F. Franklin. 2002. Potential upper bounds of carbon stores in forests of the Pacific Northwest. *Ecological Applications* 12:1303–1317.

Stephenson, N. L., et al. 2014. Rate of tree carbon accumulation increases continuously with tree size. *Nature* 507:90–93.

Stevens, J. T., et al. *in press*. Average stand age from forest inventory plots does not describe historical fire regimes in ponderosa pine and mixed-conifer forests of western North America. *Plos One*.

Temesgen, H., D. Affleck, K. Poudel, A. N. Gray, and J. Sessions. 2015. A review of the challenges and opportunities in estimating above ground forest biomass using tree-level models. *Scandinavian Journal of Forest Research* 30:326–335.

USDA Forest Service. 2006. *2006 field instructions for the annual inventory of Washington, Oregon, and California*. Pacific Northwest Research Station, USDA Forest Service, Portland, Oregon, USA. http://www.fs.fed.us/pnw/fia/local-resources/pdf/field_manuals/2006_field_manual.pdf

Van Pelt, R., and N. M. Nadkarni. 2004. Development of canopy structure in *Pseudotsuga menziesii* forests in the southern Washington Cascades. *Forest Science* 50:326–341.

Waddell, K. L., and B. Hiserote. 2005. The PNW-FIA Integrated Database, Version 2.0. http://www.fs.fed.us/pnw/fia/publications/data/data.shtml

Waring, R. H., and J. F. Franklin. 1979. Evergreen coniferous forests of the Pacific Northwest. *Science* 204:1380–1386.

Wharton, S., M. Falk, K. Bible, M. Schroeder, and K. T. Paw. 2012. Old-growth CO2 flux measurements reveal high sensitivity to climate anomalies across seasonal, annual and decadal time scales. *Agricultural and Forest Meteorology* 161:1–14.

Whittier, T. R., and A. N. Gray. 2016. A tree mortality based fire severity classification for forest

21508925, 2016, 1, Downloaded from https://esajournals.onlinelibrary.wiley.com/doi/10.1002/ecs2.1224, Wiley Online Library on [11/09/2024]. See the Terms and Conditions (https://onlinelibrary.wiley.com/terms-and-conditions) on Wiley Online Library for rules of use; OA articles are governed by the applicable Creative Commons License

inventory surveys: a Pacific Northwest national forests example. *Forest Ecology and Management* 359:199–209.

Woodall, C. W., and V. J. Monleon. 2008. *Sampling protocol, estimation, and analysis procedures for the down woody materials indicator of the FIA program*, NRS GTR-22. Northern Research Station, USDA Forest Service, Newtown Square, Pennsylvania, USA.

Woodall, C. W., L. S. Heath, G. M. Domke, and M. C. Nichols. 2011. *Methods and equations for estimating aboveground volume, biomass, and carbon for trees in the U.S. forest inventory, 2010*, NRS GTR-88. Northern Research Station, USDA Forest Service, Newtown Square, Pennsylvania, USA.

Xu, C. Y., M. H. Turnbull, D. T. Tissue, J. D. Lewis, R. Carson, W. S. F. Schuster, D. Whitehead, A. S. Walcroft, J. B. Li, and K. L. Griffin. 2012. Age-related decline of stand biomass accumulation is primarily due to mortality and not to reduction in NPP associated with individual tree physiology, tree growth or stand structure in a *Quercus*-dominated forest. *Journal of Ecology* 100:428–440.

Zar, J. H. 1984. *Biostatistical analysis*. Prentice-Hall Inc, Englewood Cliffs, New Jersey, USA.

Supporting Information

Additional Supporting Information may be found online at: http://onlinelibrary.wiley.com/doi/10.1002/ecs2.1224/supinfo

ATTACHMENT D

March 8, 2022

Cost-Benefit Analysis in Federal Agency Rulemaking

Since the 1970s, federal agencies have been required to consider the costs and benefits of certain regulations that are expected to have large economic effects. Under current requirements, most agencies are to design regulations in a cost-effective manner and ensure that the benefits of their regulations justify the costs.

Cost-benefit analysis of regulations is primarily required by Executive Order (E.O.) 12866, which was issued in 1993 and remains in effect. E.O. 12866 is one of the analytical requirements that are part of the federal rulemaking process, which includes other executive orders, guidance documents from the Office of Management and Budget (OMB), and statutory requirements.

This In Focus provides a brief overview and discussion of the key cross-cutting executive orders and statutes that require cost-benefit and other types of regulatory impact analysis in the federal rulemaking process.

Cost-Benefit Analysis vs. Regulatory Impact Analysis

Cost-benefit analysis involves describing the potential costs and benefits of a regulation in quantified and monetized—that is, assigned a dollar value—terms when possible, and otherwise in qualitative terms. Then, the potential costs and benefits of a rule are compared, with regard to both the quantified and qualitative considerations. The analysis federal agencies engage in during the rulemaking process often includes both quantified and non-quantified effects.

The phrase *regulatory impact analysis* is sometimes used interchangeably in general discussion with the phrase *cost-benefit analysis*. However, *regulatory impact analysis* is actually a broader, more encompassing term that includes cost-benefit analysis and other types of quantitative and qualitative analysis, such as cost-effectiveness analysis and distributional analysis.

Overview of Regulatory Cost-Benefit Analysis Requirements

The principal requirements of the federal rulemaking process were established by the Administrative Procedure Act (APA) of 1946. The APA itself does not include an explicit requirement for cost-benefit analysis, however. Rather, the primary cross-cutting requirement for agencies is in E.O. 12866, which requires covered agencies to conduct cost-benefit analysis for "economically significant" rules. E.O. 12866 also requires a less-detailed assessment of costs and benefits for a broader category of rules ("significant" rules), and it contains a number of considerations ("principles") relating to costs and benefits for all rules. OMB has expanded on the executive order's requirements by issuing various guidance documents, most significantly *Circular A-4*, which OMB issued in 2003.

Congress has enacted a handful of statutes with more narrowly applicable requirements for regulatory impact analysis. These include the Regulatory Flexibility Act, which requires agencies to consider the effects of their rules on small businesses; the Paperwork Reduction Act, which requires agencies to estimate the paperwork burden their rules will impose; and the Unfunded Mandates Reform Act, which requires agencies to consider whether their rules will impose an unfunded mandate on state and local governments.

The Role of Cost-Benefit Analysis in Regulatory Decisionmaking

Generally, the role of cost-benefit analysis in federal rulemaking is not necessarily for the analysis to be determinative or dispositive. That is, agencies do not typically make decisions solely on the outcome of their cost-benefit analyses. Other factors will likely be part of an agency's regulatory decision, such as statutory mandates and considerations, as well as the political and policy priorities of the current Administration. Regulatory impact analysis, including cost-benefit analysis, may be viewed as one of the key inputs into federal agencies' regulatory decisions.

Executive Order 12866

As noted previously, the principal analytical requirement for most agencies' regulations is in E.O. 12866.

Section 1 of E.O. 12866, entitled "Statement of Regulatory Philosophy and Principles," references the consideration of costs and benefits for all rules. For example, it encourages agencies to design their regulations "in the most cost-effective manner to achieve the regulatory objective" and to ensure that the benefits of a regulation justify the costs.

Section 6(a)(3)(B) of the order requires agencies to assess the potential costs and benefits of "significant" rules and to submit this assessment along with each rule to OMB's Office of Information and Regulatory Affairs (OIRA) for review. "Significant" rules are those that may

> (1) have an annual effect on the economy of $100 million or more or adversely affect in a material way the economy, a sector of the economy, productivity, competition, jobs, the environment, public health or safety, or State, local, or tribal governments or communities; (2) create a serious inconsistency or otherwise interfere with an action taken or planned by another agency; (3) materially alter the budgetary impact of entitlements, grants,

user fees, or loan programs or the rights and obligations of recipients thereof; or (4) raise novel legal or policy issues arising out of legal mandates, the President's priorities, or the principles set forth in the Executive order.

Although the order indicates agencies should conduct an assessment of costs and benefits for significant rules, the key requirement for cost-benefit analysis in E.O. 12866 is in Section 6(a)(3)(C), which requires a more rigorous and detailed cost-benefit analysis for "economically significant" rules. "Economically significant" rules are those that fall into the first category of "significant" above (e.g., rules that have a $100 million effect on the economy).

Specifically, Section 6(a)(3)(C) states that agencies should assess the costs, benefits, and "reasonably feasible alternatives" to the planned rule. The assessment is to include "to the extent feasible, a quantification" of costs and benefits that are anticipated from a regulation, as well as the costs and benefits of "potentially effective and reasonably feasible" alternatives.

OMB Circular A-4

In September 2003, OMB finalized *Circular A-4* on "Regulatory Analysis," which states that it was "designed to assist analysts in the regulatory agencies by defining good regulatory analysis … and standardizing the way benefits and costs of Federal regulatory actions are measured and reported." The circular recommends that an analysis include elements such as

- a statement of the need for the proposed action, including any statutory or judicial directive;
- an examination of alternative approaches; and
- an evaluation of qualitative and quantitative benefits and costs of the proposed action and the main alternatives.

The circular also provides guidance on when varying analytical approaches may be appropriate (e.g., when to use cost-benefit analysis vs. cost-effectiveness analysis). *Circular A-4* remains the current OMB guidance for agencies preparing analyses under E.O. 12866.

Other Developments Related to E.O. 12866

In 2011, President Barack Obama issued E.O. 13563, which emphasized his Administration's support for E.O. 12866. E.O. 13563 encouraged agencies to choose regulatory alternatives that "maximize net benefits" and to tailor their regulations "to impose the least burden on society, consistent with obtaining regulatory objectives, taking into account, among other things, and to the extent practicable, the costs of cumulative regulations."

In January 2017, President Donald Trump issued E.O. 13771, which established a "one-in, two-out" requirement for agencies to eliminate equivalent costs associated with at least two previously issued rules when issuing a new rule. E.O. 13771 also created a regulatory budgeting program, which involved setting cost caps for agencies' new regulations. Although this order shifted focus more onto regulatory costs, it did not directly amend or repeal E.O. 12866. On January 20, 2021, President Joseph Biden repealed E.O. 13771 and issued a presidential memorandum "reaffirm[ing] the basic principles" of E.O. 12866.

E.O. 12866 and Independent Regulatory Agencies

The analytical requirements in E.O. 12866 apply to most regulatory agencies, but they do not apply to the statutorily designated "independent regulatory agencies" that are listed in Title 44, Section 3502(5), of the *U.S. Code* and include, for example, the Federal Reserve Board and the Federal Communications Commission. However, the independent regulatory agencies may be required to conduct regulatory impact analyses under their own authorizing statutes or under the cross-cutting statutes discussed below.

Presidents have chosen to exempt these agencies from E.O. 12866, because Congress designed them to be independent of the President and, by extension, OIRA and OMB. In recent years, some Members of Congress and others have supported extending the analytical requirements of E.O. 12866 to the independent regulatory agencies.

Other Statutory Requirements for Cost-Benefit and Regulatory Impact Analysis

Congress has also enacted various statutory requirements for agencies to consider specific regulatory impacts.

The Regulatory Flexibility Act (RFA) of 1980 requires agencies to conduct regulatory flexibility analyses for proposed and final rules that will have a "significant economic impact on a substantial number of small entities" (defined as small businesses, governmental jurisdictions, and certain nonprofit organizations). For proposed rules, such an analysis is referred to as an "initial regulatory flexibility analysis," and for a final rule, it is a "final regulatory flexibility analysis." These analyses are to include elements such as a description and estimate of the number of small entities to which a rule would apply and "a description of the steps the agency has taken to minimize the significant economic impact on small entities."

The Paperwork Reduction Act (PRA) of 1980 established a requirement for agencies to estimate the paperwork burden resulting from regulations and other actions that result in a collection of information. The PRA is not a rulemaking statute per se, as its primary purpose is to empower OMB to monitor and reduce the government's overall paperwork burden. However, many rules contain a reporting or disclosure requirement, which would trigger the PRA's requirements for estimating paperwork burden and obtaining OMB approval for the information collection.

Title II of the Unfunded Mandates Reform Act of 1995 added requirements for agencies (other than independent regulatory agencies) to analyze costs resulting from regulations imposing federal mandates upon state, local, and tribal governments and the private sector. This analytical requirement is triggered when a rule may result in the expenditure of over $100 million (adjusted annually for inflation) in any one year. If an agency anticipates such a mandate, it is to conduct an assessment of quantitative and qualitative costs and benefits and other economic effects of the mandate.

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ATTACHMENT E

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SUMMARY DESCRIPTION OF MILL CLOSURE DATA FROM 1990 – 2010

This mill data is derived from direct contacts, individual analysis, industry reports, industry publications and many other sources, which we consider reliable. Updating information is a daily and ongoing process for us. We consider it necessary for our reports to maintain a reasonable degree of accuracy.

Lumber mills to be included in this data must process logs as part of their operation and produce in excess of 1.5 million board feed of lumber per year. We occasionally shift the bar on volume for a special mill. Many databases do not establish any limitation on volume of lumber produced by an individual sawmills in their data information. Trying to include small portable or sawmills producing less than 1.5 million board feet annually, leads to inconsistent data.

Plywood, composite board mills and pulp mills need no such restrictions on production volume to be included in our database. The initial investment required by these mills is many times larger than that needed for a small portable sawmill operation and this investment imposes its own limits on the size of a mill.

If you have any concern about the data we provide don't hesitate to call. We find inconsistent data collection is becoming more prevalent from numerous sources because of the turbulent economic times.

Paul F. Ehinger
12/15/10

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SUMMARY OF MILL CLOSURES

OREGON / WASHINGTON / CALIFORNIA / IDAHO / MONTANA
1990 - 2010

	TOTAL NUMBER OF MILL CLOSURES BY STATE	TOTAL NUMBER OF EMPLOYEES TERMINATED BY CLOSURES BY STATE
OREGON	145	12,334
WASHINGTON	97	8,436
CALIFORNIA	85	8,361
IDAHO	44	3,066
MONTANA	32	2,919
TOTALS:	403	35,116

12/16/10

Oregon Mill Closure Summary
1990-2010

		Number of Closed Mills	Number of Employees
2005-2010			
SAWMILLS		11	697
PLYWOOD		5	730
VENEER		4	222
PULP		0	0
BOARD		1	65
	Total:	**21**	**1,714**
2000-2004			
SAWMILLS		16	1,235
PLYWOOD		6	1,064
VENEER		7	292
PULP		1	160
BOARD		3	415
	Total:	**33**	**3,166**
1995-1999			
SAWMILLS		33	2,684
PLYWOOD		4	555
VENEER		7	263
PULP		2	365
BOARD		1	85
	Total:	**47**	**3,952**
1990-1994			
SAWMILLS		33	2,684
PLYWOOD		4	555
VENEER		7	263
PULP		0	0
BOARD		0	0
	Total:	**44**	**3,502**
Grand Total:		**145**	**12,334**

Paul F. Ehinger & Assoc

Washington Mill Closure Summary
1990-2010

		Number of Closed Mills	Number of Employees
2005-2010			
SAWMILLS		12	1,479
PLYWOOD		2	450
VENEER		2	105
PULP		0	0
BOARD		0	0
	Total:	**16**	**2,034**
2000-2004			
SAWMILLS		13	981
PLYWOOD		1	40
VENEER		2	35
PULP		2	1,150
BOARD		0	0
	Total:	**18**	**2,206**
1995-1999			
SAWMILLS		12	869
PLYWOOD		2	400
VENEER		2	48
PULP		1	360
BOARD		0	0
	Total:	**17**	**1,677**
1990-1994			
SAWMILLS		33	1,191
PLYWOOD		4	475
VENEER		7	208
PULP		2	645
BOARD		0	0
	Total:	**46**	**2,519**
Grand Total:		**97**	**8,436**

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California Mill Closure Summary
1990-2010

		Number of Closed Mills	Number of Employees
2005-2010			
SAWMILLS		8	730
PLYWOOD		0	0
VENEER		0	0
PULP		0	0
BOARD		0	0
	Total:	**8**	**730**
2000-2004			
SAWMILLS		15	1,670
PLYWOOD		0	0
VENEER		1	50
PULP		1	400
BOARD		3	387
	Total:	**20**	**2,507**
1995-1999			
SAWMILLS		11	879
PLYWOOD		1	170
VENEER		2	40
PULP		0	0
BOARD		0	0
	Total:	**14**	**1,089**
1990-1994			
SAWMILLS		40	3,533
PLYWOOD		1	120
VENEER		0	0
PULP		2	382
BOARD		0	0
	Total:	**43**	**4,035**
Grand Total:		**85**	**8,361**

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Idaho Mill Closure Summary
1990-2010

		Number of Closed Mills	Number of Employees
2005-2010			
SAWMILLS		6	650
PLYWOOD		0	0
VENEER		0	0
PULP		0	0
BOARD		0	0
	Total:	**6**	**650**
2000-2004			
SAWMILLS		4	375
PLYWOOD		2	415
VENEER		0	0
PULP		0	0
BOARD		0	0
	Total:	**6**	**790**
1995-1999			
SAWMILLS		16	934
PLYWOOD		0	0
VENEER		0	0
PULP		0	0
BOARD		1	80
	Total:	**17**	**1,014**
1990-1994			
SAWMILLS		15	612
PLYWOOD		0	0
VENEER		0	0
PULP		0	0
BOARD		0	0
	Total:	**15**	**612**
Grand Total:		**44**	**3066**

Paul F. Ehinger & Assoc

Montana Mill Closure Summary
1990-2010

		Number of Closed Mills	Number of Employees
2005-2010			
SAWMILLS		4	439
PLYWOOD		1	320
VENEER		0	0
PULP		0	0
BOARD		0	0
	Total:	**5**	**759**
2000-2004			
SAWMILLS		4	395
PLYWOOD		1	245
VENEER		0	0
PULP		0	0
BOARD		0	0
	Total:	**5**	**640**
1995-1999			
SAWMILLS		8	417
PLYWOOD		0	0
VENEER		0	0
PULP		0	0
BOARD		0	0
	Total:	**8**	**417**
1990-1994			
SAWMILLS		14	1,103
PLYWOOD		0	0
VENEER		0	0
PULP		0	0
BOARD		0	0
	Total:	**14**	**1,103**
Grand Total:		**32**	**2919**

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