LARGE-SCALE INTEGRATED-MANAGEMENT EXPERIMENT ON THE OLYMPIC EXPERIMENTAL STATE FOREST

Study Proposal

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Table of Contents

Summary

The Washington Department of Natural Resources (DNR) and the University of Washington's Olympic Natural Resources Center (UW-ONRC) propose to implement a long-term, landscape-level management experiment within the Olympic Experimental State Forest (OESF) to evaluate the ecological and economic feasibility of integrated forest management – a management strategy of integrating revenue production and ecological values across the landscape. We describe in this document the need and scientific justification for a large-scale experiment and the suitability of the OESF as a place to conduct it. As a first step, we propose key research questions, a study design, and an implementation plan. As a result of this analysis, both DNR and UW-ONRC have agreed that the study is feasible and intend to move forward with writing a comprehensive study plan for the experiment. Assuming scientific vetting, the pace of implementation will depend in large part on the support of key stakeholders.

Institutional Background

As manager of State trust lands, DNR has a fiduciary responsibility to manage these trust lands in perpetuity to provide revenue for specific public institutions designated as trust beneficiaries. The DNR manages state trust lands by abiding to all federal and state laws and by its own policies. To comply with the Endangered Species Act, DNR has developed a multispecies habitat conservation plan (HCP), which covers all state lands in western Washington (DNR 1997). In this plan, DNR has committed for certain landscape and forest stand conditions that provide habitat for northern spotted owl, marbled murrelet, salmonids and other species. Through its sustainable management practices, DNR seeks to assure intergenerational equity of revenue and to maintain ecological values to meet a vision for a productive, healthier, biologically diverse, and structurally complex forests that supports native wildlife species. The DNR manages about 270,000 acres of forested lands on the western Olympic Peninsula designated as the Olympic Experimental State Forest (OESF), which was created to intentionally learn how to integrate revenue production and ecological values across the landscape and to deliver the knowledge to land managers for continuous improvement of forest practices on state lands and beyond.

The ONRC was established by the Washington Legislature as a teaching and research campus of the University of Washington, in large part to provide independent science assistance to managers trying to integrate economic and ecological systems. The ONRC now brings to the table a broad vision for long-term, rural-ecosystem sustainability based on improving benefits to both ecological and community wellbeing, along with an independent, collaborative, and structured learning approach. The sustainability vision stems from the collaborative movement in places like eastern Oregon and Washington, where defining ecological/community "win-wins" provided a new integrated goal framework that most citizens and stakeholders could agree on. The structured learning approach comes from a wide variety of research-management efforts, some quite successful in applying adaptive management at a large scale (Bormann and Kiester 2004).

When the OESF and the ONRC were created in early 1990s—in response to several recommendations of the Commission on Old Growth Alternatives for Washington's Forest Trust Lands in 1989—the OESF was to provide a place for experimentation with integrated management, and the ONRC was to work as an impartial research institution to attract and facilitate more robust research than DNR could pursue on its own.

The DNR's focus on improving the integrated management strategy on the OESF fits closely with the ONRC sustainability mission. By providing participants and land in the OESF, the DNR makes realization of the study possible. The ONRC offers a collaborative learning approach that addresses key questions posed by DNR and others. With the adoption of the 2016 OESF Forest Land Plan (DNR 2016b), which includes detailed landscape-scale management strategies and a framework for learning and adaptive management, the unique partnership between DNR and UW-ONRC can be more fully realized. This inter-institutional proposal seeks to take maximum advantage of this partnership for the public good.

Scientific Background

A debate has been underway in the science and land management communities since about 1990 about the best basis for managing forest lands. Three main approaches have dominated:

- A tree-farm model (practiced on most private lands) that focuses on renewable wood production with mitigation for habitat and other issues, often just enough to satisfy limited state and federal regulations. Decisions are based on owner objectives, which can vary substantially among organizations, but typically are to maximize revenue.
- On most public lands, the current dominant approach uses a conservation-biology basis for management (also known as a zoned or land-sparing approach). This approach calls for dividing the land into large land-use designations - blocks managed for individual purposes, such as late-successional habitat in reserves or timber production in non-reserved lands (matrix). Conservation biologists have emphasized habitat reserves as a means to protect endangered species (Schafer 1981, Wilcove et al. 1986, Franklin 1993). Lawsuits based on the endangered species act provide legal precedent by mandating habitat reserves to support recovery of listed threatened and endangered species (e.g., the Northern spotted owl; Murphy and Noon 1992). An example is managing the national forests under the Northwest Forest Plan (FEMAT 1993). One of the main criticisms of the zoned approach is that it ignores temporal dynamics created by natural disturbances—to which most species would seem to be adapted. Future disturbance can be expected and even exacerbated through climate change, affecting habitat attributes through mechanisms such as increasing tree mortality rates (Van Mantgem et al. 2009), thus requiring recruitment of new suitable habitat. Late-seral conditions naturally develop over several centuries (Franklin et al. 2002), and key drivers of late successional habitat are not yet firmly established (Donato et al. 2012). Therefore, we cannot be certain that the zoned land management approach is the best way to assure viable populations of listed species.

- A third approach has long been under discussion, but has not been widely applied. It is based on disturbance ecology as an alternative basis for management by recognizing a natural array of successional forest stages that shift in space over time through disturbances in a shifting mosaic pattern (Pickett and White 1985). It is also called un-zoned or land-sharing management. A similar paradigm has emerged for streams, viewing them as dynamic in space and time, exhibiting a range of potential conditions, as do the terrestrial systems in which they are imbedded (Reeves et al. 2016 and the references therein). The temporal variability of individual streams and watersheds depend on landscape context (e.g., topography, geology) and past natural and management disturbances (Benda 1998, Reeves 1995, Wondzell 2007). Management approach for riparian areas under this paradigm is "context-dependent" and most often is expressed as varying the width of the riparian buffers. This new approach for managing uplands and riparian areas seems to have the potential to better integrate timber production and habitat conservation (Reeves et al. 2016) and better consideration of ecological processes that underpin long-term ecosystem productivity (Bormann and Kramer 1998).

When the DNR created the OESF, it decided to implement and evaluate the third approach, naming it "integrated management." This term was first introduced in the HCP (DNR 1997) and recently refined in the OESF draft Forest Land Plan (DNR 2016b) to mean an experimental management approach based on the principle that a forested landscape can be managed with different level of intensity through time and space to provide both revenue production and ecological values. Because integrated management was new and has not been tried in the Pacific Northwest before, the DNR recognized early on the need for research, monitoring, and adaptive management to evaluate and continuously improve the approach, and built this into the HCP to assure the HCP goals are met (DNR 1997). The learning effort proposed here supports this objective.

Why the study is needed now

Implementing integrated management in the OESF, as proposed in the founding legislation and subsequent 1997 HCP, have been challenging for DNR. Multiple factors contributed to that, including: (1) lack of clear vision and specific strategies how to implement this new experimental approach (2) lack of robust tools for modeling relevant data sets across a large spatial scale (hundreds of thousands of acres) and long time period (one hundred years); (3) insufficient adaptive-management framework and the associated institutional structure and funding to learn through research and monitoring and to implement the new knowledge in management; (4) pressures from stakeholders and federal regulators, which arose after the 1997 HCP from concerns about federally listed species such as Northern Spotted Owl and Marbled Murrelet, protection of riparian and aquatic habitat, and uncertainties around effects of timber harvests on steep and unstable slopes; (5) changes in market conditions, such as timber prices and availability of mills, which affected the volume, type and location of timber extracted from the OESF; and (6) insufficient leadership from the university and ONRC.

All these developments pushed DNR to set aside more land without active management than envisioned in the 1997 HCP. According to the tactical model for the OESF Forest Land Plan, the deferred areas (areas unavailable for harvest either permanently or temporarily) currently account for approximately 110,832 acres of state trust lands in the OESF (DNR 2016a; Figure 1 and Appendix 1).

Deferring more areas led to decreased management options, which decreased the revenue and likely limited the community benefits from the OESF. Another consequence of more deferrals is that the remaining areas would need to be harvested more heavily and with shorter rotations compared to an un-zoned approach in order to provide similar revenue to trust beneficiaries. The resulting bifurcated landscape departs from the vision for OESF integrated management and risks undesirable interactions with natural disturbances and habitat fragmentation including edge effects and connectivity.

The recently-adopted OESF Forest Land Plan (DNR 2016b) is one of multiple ways to implement integrated management. Given current forest conditions, arising largely from the past intensive-management history (45% of state trust lands in the OESF are between 20 and 39 years of age (DNR 2016b)) and the recent science on forest ecology and restoration (e.g. Carey 2003, Franklin and Johnson 2012), it appears that more or less integrated management approaches, that seek to improve revenue and ecological and community benefits all at the same time, can be implemented. However, these management approaches have not been tried or tested over long time and/or at large scale. Immediate risks may include harming rather than helping late-seral forest and riparian habitat, diminished economic returns and operational feasibility issues. Trying and comparing different management strategies in an experimental framework is the only way we know to truly reduce the uncertainties and risks.

Purpose of the Proposed Study

The purpose of this study is to evaluate the effectiveness of different landscape-level integrated-management strategies to provide revenues and ecological and community well-being benefits that are sustainable over time. Since one of the proposed management strategies is the OESF Forest Land Plan (DNR 2016b), the study will also help assess the effectiveness of the plan, thus meeting DNR obligations for effectiveness monitoring under the state lands HCP (DNR 1997). We propose a collaborative, scientifically-vetted, replicated management experiment to compare the integrated strategy of the OESF Forest Land Plan to alternative management strategies with higher and lower levels of integration at landscape scale. The data and conclusions from this study would help guide future management decisions, perhaps with large implications on future sustainable harvest levels and conservation strategies not only in the OESF but on other state trust and federal lands.

Core Questions

The learning design of this experiment follows from the goal of the OESF adaptive management program to continually improve land management by finding better ways to integrate revenue production and ecological values (DNR 2016b). The development of the experiment begins by identifying an overarching set of core questions that, when answered, can aid in making future critical decisions about managing the forest. Framing the questions properly goes a long way to determining the success of any learning effort.

The central overarching question is:

> ***Will a higher sustainable level of both ecological and community wellbeing (including revenue for beneficiaries) emerge from an array of land management strategies implemented and compared across the OESF landscape?***

A series of related strategy questions will be addressed:

1. How well does integrated management, described in the OESF Forest Land Plan (DNR 2016b), perform compared to a zoned, conservation-biology-based strategy?
2. Can integrated-management be expanded beyond the option described in the OESF Forest Land Plan by applying a strategy with higher potential risk and return, without falling short of the overall HCP conservation and trust revenue objectives?
3. How well do various integrated management strategies perform relative to a temporary (10 year) no-action control? The control is included to help understand the interactions with natural background variation such as wind, landslides and other natural disturbances.

Many more specific and detailed technical questions may be answered, for example:

- Can management strategies include innovations in scheduling, logging systems, and road maintenance, as a way to better meet DNR goals, including extending management into riparian and upland habitat areas currently differed from management?
- What are the best indicators for cost effectiveness of the tested management strategies?
- Will increasing deciduous hardwoods in riparian zones increase food supply to young salmon?
- Can standard thinnings be made more economically feasible with limited markets?
- Can forest edges of thinnings be managed to avoid undesired wind damage?

Testable hypotheses

The proposed landscape-scale management strategies include multiple elements: silviculture, habitat conservation, unstable slopes management, road management and use, operational feasibility, and revenue. Specific testable hypotheses can be formed around these elements. An example of a silviculture hypothesis: "Traditional early-seral management (including site preparation and vegetation management) in small variable-retention harvest (VRH) units with high edge density is not economically feasible because of reduced growing space." An example of a habitat conservation hypothesis: "The implementation of integrated management strategy, described in the OESF Forest Land Plan, allows recovery of riparian and aquatic habitat conditions in Type-3 watersheds."

The hypotheses will be formulated during the development of a formal study plan through interactions with different experts, perhaps as part of workshop sponsored by ONRC's rural ecosystem innovation network.

Study Area

The OESF consists of 270,000 acres of state trust lands on the western Olympic Peninsula in Jefferson and Clallam Counties (Figure 1). The set aside land that currently is in temporary or permanent deferral status make up a sizable proportion of the OESF, with large blocks in the Clearwater drainage and more distributed blocks elsewhere (Figure 1). The experimental treatments proposed for this study are in Jefferson County, primarily in the Clearwater River basin, where DNR manages a large contiguous block of land with large portion of it in temporal deferral status.

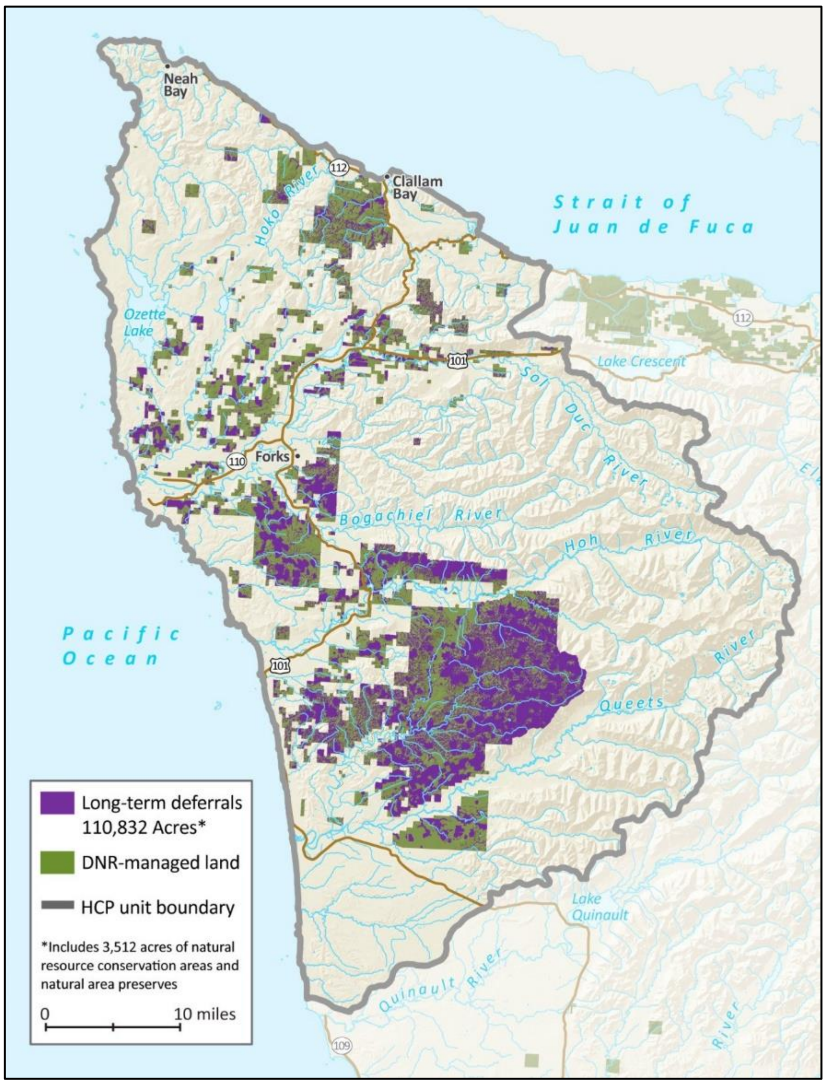

Figure 1. The Olympic Experimental State Forest with approximate deferred areas (DNR 2016a).

Study Design

The comparison of management strategies will be done in a scientific framework where each strategy is represented by a series of replicated experimental treatments applied at a watershed (landscape) scale. Three landscape management strategies and a no-action control will be compared across a population of Type-3 watersheds (these are basins that drain into the smallest fish bearing streams). The strategies should be sufficiently different in order to statistically detect contrast in the ecological and economic responses. We expect that at least 15% differences in major outcomes (including total decadal harvest volume) will be required. Along with treatment design, the sustainable harvest level and other factors including staffing and markets will determine how much volume will actually be harvested in the experimental units during the first decade.

Experimental treatments (strategies)

The proposed study elements and specific treatments following each strategy are summarized in Tables 1 and 2 and then described further. Treatments will be further discussed with experts and stakeholders and through the ONRC Rural Ecosystem Innovation Network effort on silviculture innovation and then presented in detail in the study plan.

Table 1. The four proposed strategies to be compared in a management experiment

	Experimental Strategies			
Expected when implemented:	**Zoned Management[1]**	**OESF Forest Land Plan**	**Accelerated Integration**	**No-Action Control**
Revenue	Less	Planned	More	None
Harvest acres	Less	Planned	More	None
Thinning:VRH[2]	Low	Medium	High	None
Riparian entry	None	Planned	More	None
Old-growth entry	None	None	None	None
Old-forest[3] entry	None	Later	Some	None
Integration	Less	Planned	More	None
Innovation	Low	Medium	High	None

[1] As predominantly practiced by DNR outside of the OESF.
[2] Ratio of thinning to variable-retention harvest (see table 2 for definitions).
[3] Old forest in the study area is mostly 1921-blow origin stands with minimal owl habitat structure

Table 2. Initial ideas on the silviculture toolbox to be used to implement each individual strategy treatment

Silviculture treatment	Description
VRH_{std}	Variable retention harvest is a type of stand-replacement harvest in which key structural elements of the existing stand (e.g. snags, structurally unique and other leave trees, down wood) are maintained while the commercial forest stand cohort is re-initiated. Harvests to be followed by later pre-commercial thinning to improve growth and composition to meet specific objectives
VRH_{es}	VRH_{std} is modified to bring in and extend early seral elements through alder retention and pre-commercial thinning of hemlock
VRH_{alder}	Planted red alder in 25 to 30 year rotations following VRH_{std} mainly in stream-influence areas to increase nutrients and energy into food chains for young salmon and possibly increase revenue
$Thin_{std}$	Commercial thinning, often implemented on the OESF as variable density thinning, which includes objectives for revenue and habitat complexity. It may be followed later by wider thinning or VRH depending on specified objectives
$Thin_{wide}$	Commercial thinning, typically leaving less trees/acre than $Thin_{std}$ and adding silvicultural treatments for increasing the wind firmness such as edge feathering and favoring certain tree species and shapes. Predominantly conifer regeneration left to develop into replacement old-forest habitat without further entry in most cases
$Thin_{es}$	$Thin_{wide}$ with alder under-planting to provide early-seral habitat (neotropical birds, ungulates, fish, and others) followed variably depending on objectives
$Thin_{owl}$	Thinning mainly to reduce density quickly to achieve owl habitat status and achieve the 40% landscape threshold
$Thin_{specialty}$	Highly limited selective product harvests for revenue and habitat objectives
PCT	Pre-commercial thinning on existing stands less than 20 years old to set up older stand treatments (above) to variably alter stand density and composition

1. Zoned Management

This is designed as a low risk/return strategy of keeping intact the areas currently deferred from management. The experimental treatment will reflect, as close as possible, what DNR does outside of the OESF. The strategy includes the following elements:

- Keep the late-seral habitat deferrals for spotted owls and murrelets in place (no active management in older forest) indefinitely;
- Implement fixed riparian buffers per the riparian forest restoration strategy (Bigley and Deisenhofer 2006)

- Apply VRH_{std} on remaining areas (up to 60%) to partially compensate for the deferred areas to meet a decadal volume targets set by the sustainable harvest calculation and described in the OESf Forest Land Plan (see table 2 for prescription details, and how they are applied in table 3). The ratio of thinning to VRH is lowest in this approach. Over time, this short-rotation/deferral strategy would best support regional small-diameter log dimensional lumber mills but runs the risk of a late-seral habitat deficit if intense windthrow or other disturbance (perhaps climate related) destroys the structure of older deferred stands.
- Implement changes to VRH_{std} to better account for early-seral processes of N_2 fixation, weathering, mineral-soil organic matter accrual, and improved neotropical bird and ungulate habitat by managing for increased early-seral species and processes (VRH_{es}), for example through mixed planting of conifers and red alder.

This strategy can be described to be "risk-averse" in relation to owls, murrelets, and steeper modeled unstable slopes; and to provide low to moderate levels of ecologic and community benefit. About 15% decrease in the total decadal volume, projected to be extracted under the tactical model of the OESF Forest Land Plan, will be realized.

2. The OESF Forest Land Plan

This is designed as a moderate risk/return strategy. The experimental treatments represent the management pathway for the OESF Clearwater landscape planning unit (DNR 2016b):

- Restoration of late-seral habitat through active and passive management until the threshold of 40% spotted owl habitat (including at least 20% old-forest habitat) per landscape planning units is exceeded. The active management includes "owl thinnings" – thinning of non-habitat stands to accelerate the development of early-seral spotted owl habitat (Young Forest Habitat as defined in the HCP). A typical example is stands that have many habitat attributes but have too many trees per acre to meet the habitat definition.
- No management in late-seral spotted owl habitat and currently deferred marbled murrelet habitat until the threshold of 40% (including at least 20% old-forest habitat) per landscape planning units is exceeded. After this threshold is met, limited variable retention harvest as practiced by DNR (VRH_{std}), will begin in deferrals to provide revenue for beneficiaries while at least 40% habitat is maintained per LPU at any time.
- The management of marbled murrelet habitat will follow the HCP long-term conservation strategy (currently under development).

- Some of the operable upland areas (outside of the habitat deferrals) and modeled unstable slope areas[1], deemed suitable by geological assessment, will also receive VRH_{std} and some will be thinned using the standard thinning techniques practiced by DNR which are designed with low initial windthrow risk ($Thin_{std}$;). Pre-commercial thinning and other non-commercial activities are included.
- Both $Thin_{std}$ and VRH_{std} are allowed in stream riparian areas, their amount and location was modeled during the EIS process for the OESF Forest Land Plan (DNR 2016b).
- The field operations will follow the riparian, spotted owl and other implementation procedures and silvicultural guidance, developed by DNR staff. Areas with $Thin_{std}$ will have to be fairly extensive given higher costs of operations, but will contribute to potential replacement owl-habitat in the event of major wind damage to older forest areas.

This strategy is expected to have moderate ecological risks in relation to owls, murrelets, and steeper modeled unstable slopes and moderate revenue and community benefit.100% of the total decadal volume projected to be extracted under the tactical model of the OESF Forest Land Plan will be realized.

3. Accelerated Integration

This is designed to be a high risk/return strategy that more fully adopts the concept of integrated management while maintaining DNR goals. The strategy includes the following elements:

- Manage some of the younger commercial-thin-size stands with thinnings wider than $Thin_{std}$ combined with edge management to minimize propagation of wind damage ($Thin_{wide}$). $Thin_{wide}$ aims to speed up the development of habitat and to provide more revenue.
- Actively manage stream riparian areas to either increase large log delivery or to improve the productivity in food chains important to resident fish while increasing tree harvest and revenue. The type of activities and/or amount of managed riparian areas exceed the treatment representing the OESF Forest Land Plan.
- Entry for increasing the productivity in food chains will consider creating openings where alder can be planted and subsequently managed on a 30-year basis (VRH_{alder}) especially near intermittent streams. Managing alder rotations in riparian areas, like other species will include planting and tending as well as harvest.

[1] Areas identified as Forest Practices Class IV Special due to rule identified landforms.

- Entering late-seral habitat deferrals (specifically old forest NSO habitat) using, where possible and feasible, single tree or small-clump removals ($Thin_{specialty}$) targeted to removing high-value products and at the same time improving habitat, for example, extending life of high-quality live trees (e.g., w/defects). Entry into older stands will be limited and focused on generating net ecological benefit as well as being economically feasible (net revenue generation not mandatory but the revenue from the activity should at least pay for the cost of the activity).
- A proposed treatment in unstable slopes may be thinning in recharge areas of deep-seated landslides and assessing the effects of tree removal on groundwater levels (particularly in areas with glacial deposits). Manipulations of inner gorges, which DNR models identify as risky for mass wasting, may also be considered.

This strategy is expected to have higher ecological risks in relation to owls, murrelets, and steeper modeled unstable slopes and potentially achieves higher revenue and community benefit. About 15% increase of the total decadal volume, projected to be extracted under the tactical model of the OESF Forest Land Plan, will be realized.

4. No-Action Control (with 10-year sunset)

The DNR cannot implement a permanent no-action control without a broad consensus that the information it might provide will offset losses in revenue and possibly habitat that will likely result. The DNR, however, does not have the resources to manage all areas of the OESF in a decadal period. Including a few watersheds in the experiment where no harvest will occur is therefore possible. This treatment would be established with the clear expectation that an active treatment could be applied after a full decade of monitoring and no action. The scientific reasoning for including this treatment is that it will both help to better understand changes that result from natural disturbances and serve as a high-contrast treatment, which improves the ability to detect management-related environmental changes. If an outcome is observed in both managed and control treatments, then management should not be falsely blamed or credited. For example, extreme rain and or wind events may trigger increased slides or windthrow. If results were the same in controls as other treatments, then management interactions are not supported. Such interpretations are possible only if the control is randomly selected, i.e. not placed in an area deferred for some other reason.

This treatment is not a management strategy and averts a risk to reduced revenue solely because there are insufficient resources to manage all lands in a decade. Its risks to wildlife are varied.

Table 3. Potential application of silvicultural toolbox to landscape elements by treatment, applied using sustainable harvest schedule

	Experimental treatments			
Landscape elements	**Zoned management**	**The OESF land plan**	**Accelerated integration**	**No-action control**
Operable uplands	VRH_{es} VRH_{std}	$Thin_{std}$ VRH_{std} $Thin_{owl}$	$Thin_{wide}$ VRH_{es}	None
Riparian areas	None inside fixed-width buffers	$Thin_{std}$ VRH_{std}	$Thin_{std,}$ $Thin_{wide,}$ VRH_{alder}	None
Modeled unstable slopes	None	$Thin_{std}$ pending geo-assessment	VRH_{alder} $Thin_{wide}$ pending geo- assessment	None
Roads (building and maintenance)	Standard as needed	Standard as needed	Trials of new approaches	Standard
Old forest habitat deferrals	None	VRH_{std} or $Thin_{std}$ only after 40% threshold	$Thin_{specialty}$	None
Old growth deferrals	None	None	None	None

Spatial Study Design

To address the key questions, we expect to use a simple randomized block design with at least 4 blocks (3 minimum) each including the 4 experimental treatments. This results in total of 16 experimental units, each being a Type-3 watershed. Using DNR data, we identified a pool of 33 potential experimental units in 15 townships including DNR lands in western Jefferson County ranging in size from 640 to 3750 acres (Appendix 2). Each experimental unit is a type-3 watershed that includes deferrals and operational areas (Figure 2). Blocks of four experimental units each will be formed from this population, combining units that are most similar to one another, using similarity analysis techniques (Bormann et al. 2008) and field reconnaissance. Within blocks, the 3 treatments and control will be randomly allocated, so each unit has to be able to accommodate any treatment. The experimental design will be peer-reviewed during the development of the study plan to assure scientific validity.

The experimental design should allow us to make the following contrasts:

- Integrated Management vs. Control
- Accelerated Integrated Management vs. Control
- Zoned Management vs. Control
- Integrated Management vs. Accelerated Integrated Management
- Integrated Management vs. Zoned Management
- Accelerated Integrated Management vs. Zoned Management

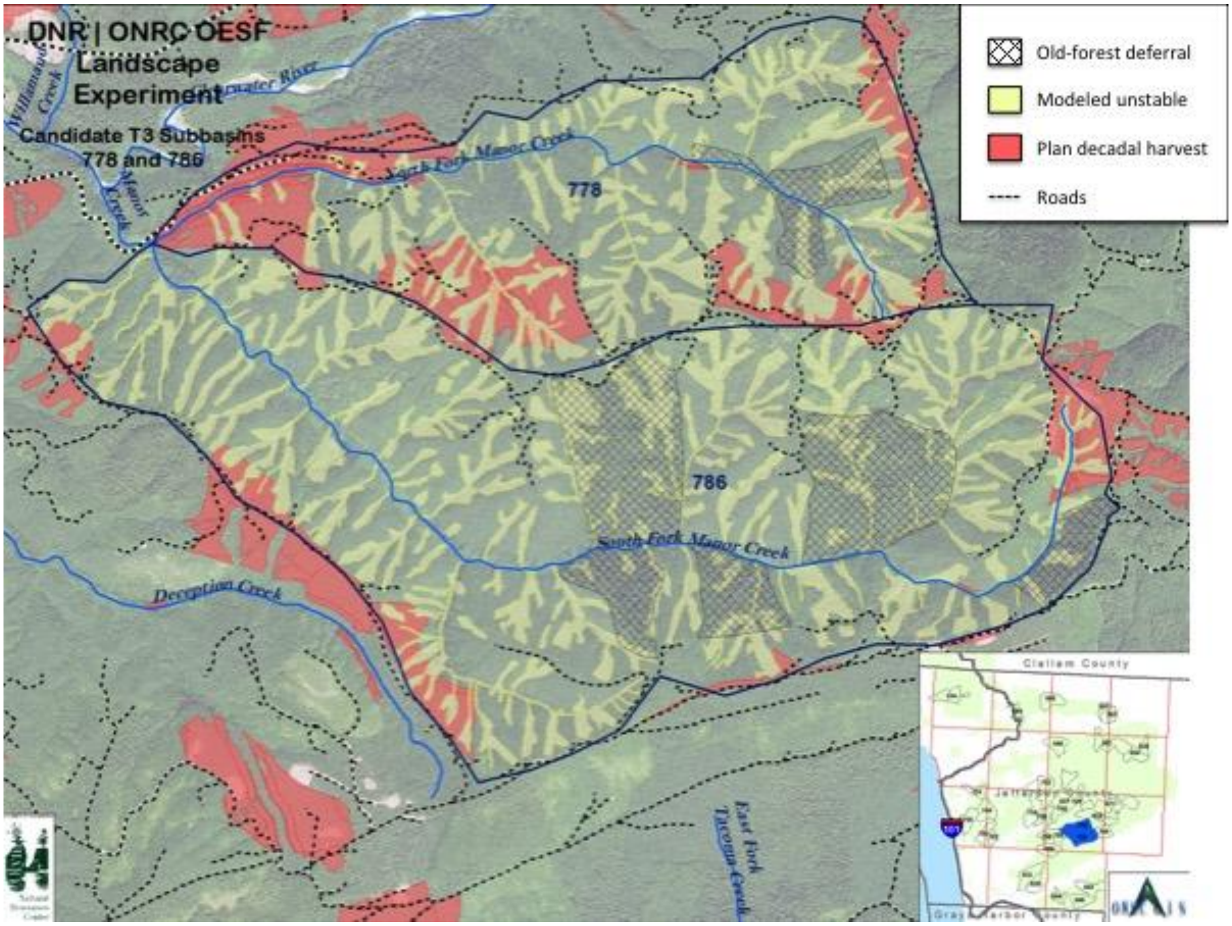

Figure 2. Two example experimental units (watersheds) under consideration. Decadal harvest is tentative to show degree of harvest over a full decade.

We realize that the previously managed lands in the eastern, upper Clearwater landscape are too young for commercial harvest, so we lose several townships because of this. We need extra units also because of other reasons why specific areas may be removed from availability, for example after murrelet long-term conservation strategy is finalized. The current conclusion is that we will be able to find at least 20 units—so the design appears feasible.

Assuming the average size of the initial pool of Type-3 watersheds (1,500 acres), the entire study of 16 units will be about 24,000 acres. This represents about 10% of the trust lands in the OESF (not counting the natural resource conservation areas and natural area preserves).

Response variables

This is an operational-scale experiment, which primarily is focused on improving future management decisions. As such, key response variables are derived from considerations part of past and potential future decisions. For example, response variables could be the net return of wide thinnings, the time to achieve habitat structures in owl thinnings, and the cost of maintaining roads in each experimental unit. Monitoring variables that cannot be clearly tied to management decisions or that are too expensive will be avoided. To do this, measures of strategy effectiveness or success tie to the core and specific questions (listed earlier), and then are balanced across the range of integrated objectives. That is, monitoring resources will be focused on how management is directly affecting the bases for deferrals (for example, evidence of accelerated development of spotted owl, murrelet, or riparian habitat) but also evidence of changes in other measures of ecological and community wellbeing (for example, distribution of seral stages, jobs, and accounting of relative management costs and beneficiary revenues). Future decisions can then be based on the entire range of treatment effects.

We propose to use detailed activity accounting and remote sensing (repeat LiDAR and aerial photos) as the backbone of the monitoring system. LiDAR can be linked to limited ground measures to evaluate outcomes on a wall-to-wall basis.

Retrospective analysis and modeling

We will consider adding retrospective analyses to extract knowledge from past actions and modeling to guide the study design and implementation. The ecological and economic outcomes of implementing the OESF Forest Land Plan treatment have already been modeled as part of the EIS analyses. Modeled the outcomes of the other two strategies can give us a treatment schedule for each of the experimental units based on an optimal model run. The empirical data collected post-treatment will be used to assess the model projections.

Adaptive Management Context

Learning about forests and communities is probably the single most important process that determines long-term sustainability that considers people as an integral part of the ecosystem (Olsen et al. In prep.). How learning is accomplished and lessons are applied is undergoing major changes that began with the conceptualization of adaptive management in the 1970s (Holling 1978, Walters 1986, Lee 1993). These changes stem from a realization that learning—previously limited to researchers, with technology transferred to managers without stakeholder participation—has not been: (1) linked well enough to management uncertainties and future decisions (2) fast enough to provide timely guidance for alternative direction, or (3) site-specific enough to address diversity found in landscapes. New, science-based adaptive management concepts include question-driven monitoring, operational-scale "management experiments," stakeholder participation in learning, and feedback for future decisions (Bormann et al. in press).

The DNR recognizes that integrated management includes number of uncertainties. The agency has committed to research, monitoring, and adaptive management to reduce these uncertainties and to continuously improve forest management (DNR 1997). The DNR developed a structured adaptive management process for the OESF and institutionalized it through adaptive management procedure (described in the Forest Land Plan; DNR 2016b). The implementation of this project will follow the adaptive management process in all its steps: identifying research questions relevant to business needs, budget approvals, reporting, interpretation of scientific results, considering stakeholder's input, and recommendations for forest management adjustments.

Stakeholder Involvement

The ONRC and DNR understand the importance of involving a broad base of interested stakeholders in this study. Without effective communication and participation, stakeholders may remain skeptical to the point that even well designed, relevant study with scientifically credible results may have little positive effect on public perception. We expect that stakeholders will weigh elements of sustainability differently (variably focused on ecologic and community wellbeing) and are willing to work through this challenge aiming for learning together and building trust.

The proposed approach for stakeholder's participation includes the following opportunities for involvement:

- Review and discuss the study proposal in order to build shared vision for the study and to achieve complementarity through ideas and resources;
- Review and improve the management treatments proposed by the study research team (we expect that different stakeholder groups will align with different management strategies and knowledge bases);
- Review and improve the response variables (we expect a debate to achieve consensus among stakeholders on economically feasible set of monitoring variables necessary to distinguish success between treatments);
- Solicit state funding for the study and other support such as support letters for grants;
- Help collect data;
- Discuss study results;
- Review study reports and recommendations for management adjustments; and
- Participate in presentations, publications, blogs, and other forms of disseminating information about and from the study.

The following stakeholders are expected to be interested in the study:

- Local land managers and land trusts such as Olympic National Forest, Olympic National Park, Rayonier, Green Crow Corporation, Fruit Growers Supply Company, Merrill & Ring, The Nature Conservancy, Hoh River Land Trust, and Jefferson Land Trust;
- Nearby Tribal governments: Quinault, Hoh, Quileute, and Makah;
- Environmental groups such as Olympic Forest Coalition, Forterra, and Audubon;
- Beneficiaries (Common School Fund and the University of Washington) and local governments such as Clallam and Jefferson Counties and City of Forks;
- Forest Industry such as American Forest Resources Council, Interfor, Sierra Pacific Industries; and
- Professional organizations such as Society for American Foresters and The Wildlife Society.

Details on stakeholders' involvement will be determined later and will be described in the study plan for the management experiment.

Research Partnerships

Because DNR and ONRC have limited resources to dedicate to this study, its successful implementation relies on partnerships with other research institutions, organizations, and individuals who have relevant areas of expertise. These partnerships are expected to bring additional scientific expertise, attract external funding, increase the visibility of OESF, and help disseminate the new knowledge gained through this project.

The DNR and ONRC will capitalize on already existing formal partnerships such as the Four-Party MOU for research coordination signed by DNR, ONRC, Olympic National Forest, and Forest Service Pacific Northwest Research Station (PNW) and the MOU signed between DNR and PNW for OESF participation in the national Experimental Forests and Ranges Network. DNR participates in two research cooperatives based at UW - the Stand Management Coop and the Precision Forestry Coop - and will look into utilizing these structures.

Potential Research Partners:

- University of Washington entities other than the ONRC;
- Federal agencies such as USDA Forest Service, Pacific Northwest Research Station (PNW RS), National Oceanic and Atmospheric Agency (NOAA), and US Geological Survey (USGS);
- State agencies such as Department of Ecology and Department of Fish and Wildlife
- Education institutions such as Evergreen State College and Peninsula College;
- Silvicultural Research Cooperatives such as the Stand Management Cooperative;
- Northwest Indian Fisheries Commission; and
- Non-profit organizations such as Wild Salmon Center.

Project Implementation

The project implementation includes 6 steps:

- Field reconnaissance of the experimental units
- Study plan, stakeholder and expert feedback, and scientific peer review
- Pre-treatment measurements
- Experimental treatments
- Post-treatment measurements
- Analyses and reporting

Field reconnaissance

The field reconnaissance includes several weeks of fieldwork to visit each of the 16 experimental units identified through GIS. The field reconnaissance will validate the remote sensing data and will assess on the ground the ecological similarity across the units, the road and hiking access, and will recommend potential replacement of units.

Study plan, stakeholder and expert feedback, and scientific peer review

This proposal will be refined based on field reconnaissance and through discussion with research and management participants and key stakeholders (described earlier). The study plan will receive full independent peer review and include a letter that reconciles comments and changes.

Pre-treatment measurements

Measurements of the ecological response variables, as identified in this proposal and in more details later in the study plan, will take place in all 16 experimental treatments. The measurements will be done using a combination of traditional field methods and remote sensing. Additional time and resources should be considered for cases when the timber sales planned for these units are not sold and new experimental units or different areas within the same unit has to be measured. Data on economic variables such as road network extent and road costs will be collected from DNR operational records and GIS databases.

Experimental treatments

The experimental strategy treatments will be organized as timber sales, prepared and administered by DNR Olympic Region. Contract logging is preferred over the traditional timber sale because it gives DNR more control over the operations thus ensuring that the experimental design is followed and takes advantage of innovations already being implemented by loggers in other areas (e.g., small, perpendicular-pull cable systems being used in thinning plantations in coastal Oregon).

Several factors will likely limit operations and will slow implementation: DNR operates on a low cost to revenue ratio to maintain high revenue flow to Trust beneficiaries; log prices have been depressed since 2008; and the last two mills producing dimensional lumber in the Forks area recently closed. These realities limit the kinds of management practices that operators can include in their bids on DNR sales, and limit their investment in new harvesting or transportation technology. They will be considered during the study plan development.

Post-treatment measurements

The measurement of ecological response variables will take place in all sixteen experimental treatments including the no-action controls. The measurements will be done using a combination of traditional field methods and remote sensing. To the extent possible the field work and remote sensing data collection will take place immediately after the manipulations to avoid changes introduced by natural disturbances such as windthrow and diseases. Data on economic variables such as road use and road costs will be collected from DNR operational records and GIS databases.

Analyses

Ecological and economic analyses will be conducted to compare the effects of different management strategies. The operational feasibility and cost of innovative operations will also be analyzed. Ideally, ONRC would also like to link this study and its commodity output to its planned rural-ecosystem, value-added innovation and start-ups network (UW will be seeking federal funds for this). This network would be part of ONRC's larger, multi-ownership sustainability system effort. The initial focus of this effort has been on CLT production, but it may be too early to link to this proposal. The study results will be shared with stakeholders and DNR managers. Potential implications for forest management will be discusses in adaptive management framework.

Expected results

First results on operational feasibility of experimental treatments, their economic return and compliance with ecological standards for post-harvest conditions are expected 1-3 years after the treatments are completed. The results on the ecological effects of experimental treatments, such as creating and maintaining habitat, increasing stands wind firmness, and increasing primary productivity in streams will take longer. Initial reports are expected 5 years post treatment. More conclusive results on ecological responses are expected by year 10.

Timeline

Preliminary timeline estimate of the project implementation is shown in Table 4.

Table 4. Project implementation timeline

Activity	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
Review of the study proposal; meetings with stakeholders													
Development of study plan; funding requests													
Field recon of experimental units													
Pre-treatment measurements													
Layout of first timber sales and SEPA process													
First harvest operations													
Post-treatment measurements													
Analyses of management effects (economic, ecological, operational)													
Annual meetings with stakeholders and progress reports													
Five-year results report; ten-year report and study assessment													

Accelerated schedule - funding and staff available to implement and monitor the treatments
Prolonged schedule - insufficient funding and staff requires spreading the effort over longer time

Key Project Staff

To implement a complex study most likely involving 20,000 to 30,000 acres over the next decade, that addresses major issues affecting DNR management and its relationship with beneficiaries and citizens, is a serious undertaking. Following is the initial list of project staff necessary to implement the experiment during first and second biennium - FY 15-17 and FY 18-19 (table 5).

Table 5. Staff needed for full project implementation in FY 16-17 and FY 18-19

Position	Name	Organization	Responsibilities
Project lead/principal investigator	Bernard Bormann	UW-ONRC	Experimental oversight
Project lead/principal investigator	Teodora Minkova	DNR	Experimental oversight
Forest ecologist	Dan Donato	DNR	Forest ecology research and reporting
Silviculturist	TBD	DNR	Silviculture research and reporting
Geologist	TBD	TBD	Geology research and reporting
GIS/LiDAR specialist	Keven Bennett	UW-ONRC	Remote sensing recon, data analyses
Forester for experimental implementation	vacant	UW-ONRC	Liaison with OESF foresters, collect additional data on operations
Supervisor of operations	Bill Wells	DNR	Oversees the preparation and implementation of all land management activities
Foresters and contract administrators	OESF foresters	DNR	Lay out and administer timber sales
Monitoring crew lead, and seasonal staff	TBD	TBD	Pre- and post-harvest field measurements
Data manager	Warren Devine	DNR	Data management, quality control and summary
Stakeholder facilitator	TBD	UW	Runs the stakeholder participation effort; advices social science student
Social Scientists	TBD	UW	Advisor and student working with stakeholders and annual check-ins
Forest modeler	TBD	DNR	Modeling the ecological and economic outcomes of treatments
Roads modeler	Shandor Toth	UW	Modeling and analysis of road costs
Economist	TBD	TBD	Economic analyses and reporting
Statistician/ Biometrician/ Remote sensing specialist	TBD	TBD	Expertise and peer-review on the study design, methods, and analytical approach

Budget and funding sources

Both the Department of Natural Resources and the University of Washington intend to initiate this experiment with existing funds. That is, initiation will not be dependent on new funding to either party from the legislature or other sources. That said, the speed at which the experiment can be implemented, the extent of student involvement, and the rate of learning will depend on supplementing existing resources. Especially important will be to increase funding for DNR staff to layout and administer experimental treatments and to establish a supplemental operating budget that will jumpstart the trial of innovative operational techniques (such as for harvesting and road maintenance).

The strategy to get supplemental support is multifaceted. Obtaining a broad consensus of support from stakeholders is central to increasing state and federal public funding. Developing collaboration with The Nature Conservancy, Forest Service, FS Research, other universities and colleges, NGOs, and others will aid in getting grant funding from federal and foundation sources which appear to us as reasonably obtainable. Internal redistribution of funding within DNR and UW will also be explored in particular for sufficient levels of monitoring. This includes the possibility of obtaining a portion of UW trust land fund payments. Stakeholders' ideas will be solicited and budgets will be developed for the full study plan.

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Appendix 1. Areas deferred in the tactical model for the OESF Forest Land Plan

Data from DNR (2016a, Appendix L, p. L-44). Note that there is a high overlap between deferrals in this list, so acres do not add up to 110,832 acres.

Deferral	Acres
Marbled murrelet occupied sites	58,118
Steep and modeled unstable slopes and landforms	49,233
Old-growth forest	43,419
Mapped Old Forest Habitat	39,674
Young Forest Habitat	18,518
Wetlands and their associated buffers	8,822
Natural areas preserves and natural resource conservation areas [1]/	3,512
Research plots	2,259
Low-site stands with no commercial value	1,916
Problem or inoperable stands	726
Upland Wildlife Management Areas	699
Unknown northern spotted owl habitat (at least 50 years old)	665
Seral stage blocks (Old growth research areas)	612
Gene pool reserves	458
Old Forest Habitat (Type A, Type B, and high quality nesting)	373
Protected from harvest (general category)	197
Recreation sites	40
Administrative sites	11

[1] Natural area preserves and natural resource conservation areas are permanent deferrals. The rest of the designations in this table are temporary deferrals which can be released for harvest in the future with a change in policy, forest conditions, or scientific information on how to best integrate revenue production and ecological values.

Appendix 2. Pool of potential experimental units in Jefferson County OESF

We initiated an analysis of type-3 watersheds to explore experiment feasibility. This involved identifying watersheds that had all landscape elements, so they could act as a microcosm of the OESF. We first recognized that we needed to remove watersheds smaller than a section (640 ac) as not useable for landscape-scale experimentation. This left 33 watersheds to evaluate (Figure A2-1). Subsequent analyses will narrow these further as operational issues are identified and watersheds are grouped to form experimental blocks.

T3 Subbasin ID	T3 Acres	DNR Acres	DNR Pct	Bird Defer Acres	Bird Defer Pct	SUSS Acres	SUSS Pct	Harvest1 Acres	Harvest1 Pct	Harvest2 Acres	Harvest2 Pct	Young Acres	Young Pct
759	651	498	76	222	34	75	12	5	1	74	11	51	8
787	704	622	88	282	40	103	15	0	0	11	2	178	25
844	710	701	99	63	9	92	13	0	0	4	1	268	38
551	780	693	89	71	9	39	5	0	0	10	1	213	27
638	780	779	100	206	26	229	29	0	0	67	9	80	10
581	797	557	70	257	32	97	12	0	0	0	0	21	3
587	832	682	82	169	20	71	9	0	0	133	16	21	3
790	849	849	100	105	12	360	42	59	7	112	13	101	12
720	999	999	100	163	16	117	12	1	0	311	31	84	8
784	1139	912	80	255	22	193	17	0	0	85	7	21	2
789	1215	1213	100	132	11	377	31	5	0	141	12	241	20
721	1215	807	66	180	15	111	9	110	9	7	1	366	30
838	1301	752	58	290	22	9	1	0	0	0	0	319	25
778	1335	1335	100	78	6	377	28	76	6	179	13	167	13
702	1409	1092	78	114	8	247	17	0	0	63	4	242	17
654	1504	1504	100	372	25	418	28	0	0	0	0	124	8
748	1524	1524	100	98	6	157	10	122	8	260	17	389	26
780	1530	971	63	146	10	439	29	0	0	136	9	151	10
806	1658	1499	90	350	21	408	25	89	5	83	5	304	18
846	1791	1791	100	452	25	38	2	0	0	201	11	765	43
672	1864	1864	100	822	44	233	12	0	0	145	8	66	4
640	1900	1647	87	98	5	257	14	86	5	216	11	372	20
758	1953	1655	85	353	18	328	17	16	1	85	4	504	26
842	1979	1701	86	139	7	467	24	0	0	133	7	385	19
565	2006	1955	97	489	24	420	21	21	1	275	14	233	12
744	2029	1831	90	695	34	325	16	125	6	63	3	325	16
514	2168	2048	94	537	25	102	5	0	0	49	2	600	28
833	2192	2054	94	153	7	199	9	179	8	15	1	474	22
786	2672	2672	100	463	17	651	24	66	2	89	3	251	9
563	3039	2976	98	773	25	607	20	0	0	139	5	218	7
710	3076	1810	59	332	11	525	17	0	0	116	4	323	11
677	3318	3286	99	876	26	207	6	112	3	514	15	641	19
673	3747	3747	100	1243	33	709	19	0	0	35	1	262	7
Count	**33**												
Avg	**1657**	**1486**	**89**	**333**	**20**	**272**	**17**	**33**	**2**	**114**	**7**	**265**	**16**
Min	**651**	**498**	**58**	**63**	**5**	**9**	**1**	**0**	**0**	**0**	**0**	**21**	**2**
Max	**3747**	**3747**	**100**	**1243**	**44**	**709**	**42**	**179**	**9**	**514**	**31**	**765**	**43**
Sum	**54666**	**49025**	**2929**	**10977**	**649**	**8983**	**549**	**1074**	**63**	**3750**	**241**	**8759**	**543**

10 T3s were deleted from round 1

Which T3s were deleted? **This leaves 33 potential triplet blocks (reps) in 55k acres**

1. Those with less than 640 total acres
2. T3 676 because of 19% planned near-term harvest (1)
3. T3 706 because of 37% DNR percent

Figure A2-1. Initial similarity analysis. Key: **SUSS** is modeled steep and unstable slopes; **Harvest 1** is expected harvest in the 1st decade under the DNR plan; **Harvest 2** is harvests already under contract; and **Young** refers to stands less than 30 years (too young for commercial harvest).