COLLEGE OF FORESTRY

PROPOSAL

Elliott State Research Forest

Oregon State University

Table of Contents

SECTION 1

Executive Summary

In December 2018, the State Land Board requested that Oregon State University explore with the Oregon Department of State Lands the potential transformation of the Elliott State Forest into a state research forest managed by OSU and its College of Forestry. This exploratory work has been ongoing since early 2019 and has included the engagement of advisory committees at the state and college level and the solicitation of input from stakeholders. This document outlines OSU's initial proposal in response to the state's request.

THE OPPORTUNITY FOR OREGON

The world faces growing climate and sustainability crises. Forestry as a profession has a responsibility and the potential to contribute to a more sustainable future. Oregon State University believes forests should be managed to support human needs, foster economic opportunity, and not only sustain but advance the environment. In order to accomplish those objectives, it is imperative that sustainable forestry practices be developed through careful scientific inquiry. Of particular importance is research that will inform how forests can help achieve broad-scale conservation goals and alleviate climate change while producing traditional and alternative forest products for a growing global population.

It is possible to accelerate high impact research that meaningfully guides and informs sustainable forest management, yielding substantial benefits for Oregon's environment, economy and communities, if that work can be conducted on a landscape of sufficient scale and diversity. An Elliott State Research Forest (ESRF) could be that landscape and opportunity.

In addition to being a platform for this critical research, an ESRF would provide Oregonians with access to forest education and recreation, as well as jobs in forest products, forestry and forest research. Together, these elements would make the ESRF a global model for holistic management and best practice in environmental and natural resources policy.

OSU College of Forestry's proposal for an Elliott State Research Forest is a collaboratively developed research design, including a structure for governing the forest, and a financial framework. These components are designed to enable an ESRF not only to meet the State Land Board's vision of providing a forest that shares Oregonians' values, but also provide world-class scientific research aimed at addressing policy and information needs of crucial importance to Oregonians and the world.

MANAGEMENT PLATFORM TO SUPPORT PUBLIC VALUES

The State Land Board and Oregonians have been clear that the ESRF must always be a public forest. Accordingly, this enclosed proposal includes specific commitments to ensure that key public values always are honored. These include commitments to recreation and public access, partnerships to promote education programs, a transparent governance structure, adherence to strong and enduring conservation ethics, and plans for a working research forest infrastructure that will support local rural and Tribal communities.

RESEARCH TO INFORM FUTURE DECISIONS

Practical, relevant and collaborative scientific research conducted at the Elliott State Research Forest will yield critical insights into sustainable forest management. We aim to tackle the fundamental question: What is the best landscape-scale approach to providing society with sustainable wood resources without compromising biodiversity, ecosystem function, climate resilience, and social benefits? For decades, a wide range of approaches have been proposed but to our knowledge, a quantitative comparison of these potential practices has not yet been conducted anywhere in the world. We therefore plan to employ the first replicated landscape-scale experimental assessment of the best way to manage forests to integrate the needs of humans and nature. Is it best to conserve nature in reserves, and intensify production in tree plantations? Or is a better strategy to reduce harvest impacts using extensive (e.g., ecological forestry), but spread out harvests across the landscape? We will test a range of intermediate strategies too, that include differing proportions reserve, plantations and extensive forestry. In these experiments, scientists at OSU and other universities will measure water quality (and flow), carbon storage, endangered species (e.g., murrelets, owls, and salmon) and a host of other plants and animals, landslides, fire risk, climate resilience, as well as social values such as employment, recreation and education. Importantly, this approach will also allow us to test the most effective ways to conduct a range of climate adaptive silvicultural practices. For instance, we know little about how to conduct ecological forestry in this region, because the focus on most landownerships to date has been on intensive production. This framework will also afford the implementation of a range of nested experiments within the larger platform allowing researchers to conduct a host of short-term and site specific experiments.

The research platform outlined in this proposal provides a landscape-scale approach to projecting how long-term sustainable forestry research could be conducted at this scale in a manner that is adaptive, dynamic and flexible. Results gleaned from this research platform will inform future policy and decision making in state, federal, indigenous and private forest landscapes throughout the Pacific Northwest, the Nation, and globally.

In this research plan, over 65% of the forest will be in reserve with approximately 34,000 contiguous acres in the Northwest portion of the forest set aside, creating one of the largest forests in reserve in the Oregon Coast range. The remaining 15,000 acres of reserve are smaller units protecting older trees and critical species habitat and distributed throughout subwatersheds that also receive smaller units of intensive forest management. In 50 years, about 73% of the forest will be 100 years old or older – nearly a 50% increase from today. See 'Summary of the Research Platform' and 'Appendix 4' for details.

With 17% of the forest assigned intensive treatments and 16% assigned extensive treatments, harvests conducted within the Elliott as a part of the research design will be relatively small. The proposal includes a harvest of approximately 1% (about 735 acres) of the forest per year. The harvest acres are higher initially given they include time-sensitive restoration-oriented thinning treatments conducted in former plantations of trees in the first 20 years. After thinning treatments are complete, less than 1% of the forest will be harvested annually as a part of the research design. See 'Financing Management, Operations and Research' section for details.

The research design allows for transformative landscape scale research on a variety of forest management issues that will no doubt evolve with time. Holding operational management constant over time creates certainty for researchers and the public and allows for long-term studies essential for long-lived forests, something impossible to accomplish using private or other public lands that are not designated as research forests. A few key issues include:

- climate adaptation of forests and carbon sequestration
- conservation of biodiversity and at-risk species dependent upon forested landscapes
- economics and technology of sustainable timber production
- recreation and public education opportunities in relation to forest management activities
- implications of fire and other forest disturbances on long-term health of forested landscapes

TRANSPARENCY AND ACCOUNTABILITY TO THE PUBLIC INTEREST

An OSU-managed ESRF will be open and accessible to Oregonians. As proposed by the OSU College of Forestry—and subject to approval by the OSU President and the OSU Board of Trustees—OSU will make decisions regarding the management and operations of the Elliott according to an adaptive forest research plan and with the advice of a stakeholder advisory committee that will provide input on planning and management decisions, and the assessment of the effectiveness of the management plan that flows from the research activities. This approach will enable OSU to exercise appropriate forest ownership while holding the property in the name of the State of Oregon and with continued public access, engagement, and accountability. OSU will operate with transparency, legislative oversight and accountability through an administrative review process currently under development. See 'Governance Structure' for details.

FINANCIAL OVERVIEW

Total net annual revenue for a 50-year forecast of timber harvests that are aligned with the research and conservation goals of the proposal is estimated at $5.7 million, which is insufficient to support projected core annual forest management and operations expenses (including personnel, equipment, fire management and recreation management) and core annual research management and operations expenses (including personnel, monitoring, maintenance, and administrative overhead) of approximately $7.8 million. See 'Financing Management, Operations, and Research on the ESRF' for details. OSU requires an additional $2.1 million annually from the state to operate the forest under the current proposed plan.

There is potential that an ESRF would create opportunity to enter into a carbon credit market to yield revenues that could help the state offset some of its costs of achieving one or more of the following: decoupling from the Common School Fund; funding OSU's working capital and start-up costs (estimated at $35 million); funding OSU's annual operating costs in excess of net harvest revenues (estimated $2.1 million annually). The research design does not preclude the potential sale of carbon to help the state's expenses. However, meeting OSU's costs cannot be directly contingent upon carbon credit offset revenues, given the high level of uncertainty in the carbon credit market and the potential risk it would place on the university's mission and increasing dependence on tuition and fees.

While sophisticated in its design, this financial modeling analysis will need to be refined as on-the-ground surveys of tree stands are conducted, additional OSU review of operational and start-up costs is completed, and a forest management plan is developed.

KEY ISSUES REQUIRING ADDITIONAL WORK

While the research proposal submitted here is comprehensive in scope and detail, additional work remains to be completed before a final decision can be reached on the vision developed by the College of Forestry, including:

- Approval by the OSU President and the OSU Board of Trustees;
- Decoupling of the Elliott State Forest from the Common School Fund prior to transfer to OSU as the Elliott State Research Forest, with recognition that OSU cannot financially assume compensatory obligations to the State or the Common School Fund;
- Development and adoption by OSU, with transparency and input from an ESRF Advisory Committee, of a forest management plan; OSU would subsequently implement and revise that plan, as appropriate, with advice of the Advisory Committee;
- Assurance provided to OSU that adequate resources will be available to the university to cover working capital, research start-up costs, and annual operating costs, including the costs to complete a forest inventory and

draft and adopt a research-based forest management plan prior to transfer of the forest to OSU;

- Arrival by the State Land Board, OSU and other engaged parties to terms that, prior to the transfer, will protect and promote the financial viability of the research forest without creating reliance or liability, or unreasonable risk of same, on other OSU resources;
- An investigation by OSU and DSL of the opportunity of entering the carbon credit market as a means of offsetting costs of decoupling the forest from the Common School Fund and/or recovering start-up, operating and research costs;
- Agreement reached on an administrative review hearing process that is structured to be similar to that used by Oregon state agencies to resolve disputes related to the management and operations of the research forest. Consistent with the principle of financial viability above, OSU's strong preference is that the university will continue to be exempt from existing APA statutes regarding attorney fees stemming from disputes over the research forest.
- Collaboration by OSU and the Department of State Lands on the finalization of the Habitat Conservation Plan to protect endangered species.

In this next phase of planning, should the State Land Board advance OSU's proposal for the Elliott State Research Forest, OSU remains committed to full transparency and to seeking—via the advisory committee and public engagement—continuing guidance from research scientists, interested members of the public, and stakeholders.

SECTION 2

Introduction to an Elliott State Research Forest

A MESSAGE FROM T. H. DeLUCA

Dean of the Oregon State University College of Forestry

Oregon forests have sustained life for millennia. By merely closing our eyes, we can imagine rolling hills and rising mountains, deep green forests and pastel meadows; salmon runs churning rivers and birds making the most extraordinary sounds. With some careful effort, we can find a patchwork of spaces that provide this experience in the first person. As European presence occurred across the western United States, and the expansion of populations and cities, the ability to grow trees for timber became a critical component of Oregon's rural communities and of expanding economies across the region.

In seeking to create an Elliott State Research Forest, we are reflecting on the immense capacity that exists for forests of Oregon, and beyond, to provide the values we need to sustain ecosystems and economies. We believe that carefully crafted research and scientific inquiry in a dedicated area can inform the conservation and management decisions required to protect endangered species that ultimately lead to their delisting; to sequester carbon in above-ground and below-ground systems for mitigating climate change; and to engage the public in science, recreation, and education that supports an informed democracy. With broad engagement in designing such a process, economic growth in a genuinely sustainable manner could stabilize and revitalize communities that have been flailing for decades and are always at risk to the boom and bust of policy changes.

We cannot do this with our eyes closed or an unwillingness to dialogue and listen to the voices, calls, and sounds of nature. We must all recognize that this is a unique time for Oregon, the Pacific Northwest (PNW) and the world. We are experiencing the fruits of our unbridled consumption of fossil fuels in the form of human-induced climatic change. The impacts of these changes are evident in the increasing occurrence of extreme weather events, increased scale and effects of wildfire, and an accelerated loss of species. During the 'Anthropocene' we have witnessed a startling decline in species diversity at the hands of large scale land management and development. Thoughtful forest management has a significant role in helping to bring back balance to the PNW and once again take a front seat in the environmental movement, but this remains to be seen. Science and discovery must lead in informing forestry's future.

Forestry must accept its role and responsibility in managing forests for the good of people and the environments upon which they depend. The responsibility is not a small task; people demand many values of their forests, including clean water and air, habitat for species to thrive and survive, climate regulation, places to recreate and gain the benefits of time in nature, and yes, fiber production. The Elliott State Research Forest represents an enormous and unique opportunity to apply science to sustainably provide its myriad values and guide and inform forest management everywhere in an ethical, and life-sustaining manner. The opportunity includes the study of innovative practices, investigating climate resilience of these practices, demonstrating the forest is far more than timber to be logged, and maximize the value and sustainability of ecosystem goods and services provided by the coastal slopes of western Oregon. The efforts will be for the betterment of people and society, whether they are aware of them or not.

Over a century ago, the discipline of forestry was introduced to the western US as a response to the cut-out-get-out logging of the 1800s that only viewed forests as stumpage value. Forestry as a discipline was radical, and it was the first environmental science put into practice on the landscapes of the western United States. The framing of American forestry through millennia of indigenous management that led to the development of the dramatic and beautiful forests. The condition that we often hold up as 'natural,' was actually a construct of indigenous human design, expert use of fire and conservative, yet broad scope utilization of forest resources. Importantly, it was managed for sustainability and as a part of their community identity. The establishment of American forestry was to address the scars left by wasteful, hasty logging practices and to ensure forests for future generations – to protect ourselves from ourselves.

A century later, economic demands shifted the focus of forestry from conservation and correcting past inadequacies to centering on net present value and financial returns. Environmental values often associated with sustainable forest management were frequently cast in a subordinate role to efficient fiber production and addressed within that context—not quite as bad as the cut-out-get-out principles of the 1800s. The listing of at-risk species sharpened this contrast and led to increasingly polarized views of appropriate goals for active forest management and healthy working landscapes. Fast forward to today, and this history defines the forestry profession. More recently, areas of active management on federal lands greatly diminished without consideration of the impacts of a rapid shift from managed to unmanaged. Today, forestry is often categorized and perceived as one of several extractive industries that are struggling (and failing) to adapt to a changing world. This characterization must change, but at the same time, forestry must change.

In the future, forestry must conserve biological diversity, minimize fragmentation and enhance habitat for species of concern, optimize carbon storage, and provide for recreation activities while still meeting fiber demands of a growing population. Forestry and its science should draw upon the wisdom, knowledge and history of indigenous partners to learn how to ethically approach and apply management so that nature and people may thrive. Forestry needs to support and sustain rural economies with skilled jobs that support families and livelihoods. Forestry needs to protect and promote the health and well-being of rural communities through ecosystem services and places to recreate. The practice of forestry must maximize its contributions to societies to offset global warming. Forestry can accomplish this by yielding sustainable, renewable and value-added timber for homes and cost-effective mass timber products for commercial wood buildings that displace carbon-emitting steel and concrete construction with carbon-sequestering wood products. To ensure we practice forestry in a manner that provides these multiple values on a sustainable basis will require operational scale research in representative settings that can seed enhanced methods and practices that can be implemented on forest lands across the Pacific Northwest and beyond.

Can we create such a path forward for a forestry's future? Yes, absolutely, and the size, location, and multiple values that define the Elliott State Forest present a singular opportunity to study, develop science, and demonstrate how to attain this future.

To transform the Elliott State Forest into the "Elliott State Research Forest" will require forethought and adherence to a platform that will support research initiatives today and into the future with the controls and replication that define the rigorous expectations for thoughtful science. As others in this process suggest, we must be capable of undertaking science that helps address how we can achieve broad-scale conservation goals and ameliorate climate change on forest landscapes while also producing fiber for a growing world population and public access for recreation and education. Undertaking science of this scale is the central challenge that the Elliott State Research Forest must meet to fulfill its potential. While there are many issues to address before the ongoing conversations narrow to a recommendation to the Land Board, I believe there are five pillars essential to accomplishing the vision for the OSU College of Forestry to oversee an Elliott State Research Forest:

1 The primary purpose of an Elliott State Research Forest is research; however, the values people hold for it and forests everywhere drive its management. The prime motivation is the sustainable and ethical provision of all of the values. We base decisions on the principles of diversity, equity, and inclusion of all values and the people that hold them.

2 A cross-section of management strategies that represent a spectrum of operational settings from reserves and conservation-oriented thinning to more intensive management must support the research design. The Triad research design currently being considered has excellent potential for creating a platform capable of supporting a variety of research over an extended time. The challenge is to align these different strategies with stand attributes and species concerns without introducing bias that will compromise that research.

3 While the forest must be financially self-supporting, harvests will not take place for the sole purpose of generating revenue. Only when there is certainty and transparency that revenue from harvests is a derivative of maintaining and implementing the research design platform can stakeholders and the public be assured that OSU management reflects public expectations for what the research forest is supposed to represent.

4 Triad treatments need to maximize the values of older forests by minimizing impacts to the structure, composition (including species of concern) and function of older forest stands. The research design should generally protect past unmanaged, naturally regenerated stands. However, this has to be accomplished without limiting the scope of future research to test the relationship of management actions in different age classes to a variety of response variables.

5 The structure and values associated with how we make decisions relating to the management of the Elliott into the future are as important as the research design we agree to implement. We aim to achieve a transparent structure, collaborate with a cross section of stakeholders, and create clear lines of decision-making authority and accountability to ensure the development and execution of a forest management plan is always supportive of the research goals for the forest.

We stand at the edge of a new frontier with a choice to make. We can move forward into as-yet uncharted territory and work together to place forestry at the forefront of a sustainable future, or accept the status quo. As we know, forestry as a practice is far more than just a means of acquiring timber. Forestry, in its essence, is a conservation science and an adaptive practice that considers ecosystems holistically and seeks to meet multiple objectives and provide for future generations. Being adaptive means being able to evolve to meet challenges and opportunities. The evolution of the forestry profession requires thorough scientific inquiry, application and evaluation. The Elliott State Research Forest represents our path into this new frontier. It will require that those who care deeply for this forest, forested landscapes across the Pacific Northwest, and for the practice of forestry, remain committed partners to our College well into the future.

Thomas H. DeLuca
Cheryl Ramberg-Ford and Allyn C. Ford Dean of the Oregon State University College of Forestry

ACKNOWLEDGEMENTS

This proposal was developed, reviewed, and revised through nearly two years of work by a number of individuals and committees. OSU would like to acknowledge their many contributions to this process and the development of a comprehensive proposal for an Elliott State Research Forest.

First and foremost we would like to acknowledge and thank the many members of the community who directly reached out to us to provide their thoughts, opinions, and reactions to the proposal.

We also thank the University leadership and the Board of Trustees for their support of the College during the exploratory process.

PROJECT TEAMS

We thank the following project teams and their members for the countless contributions to this process:

Oregon Consensus

Peter Harkema	Director
Brett Brownscombe	Senior Project Manager
Amy Delahanty	Project Manager
Jennah Stillman	Project Associate

Oregon Department of State Lands

Vicki Walker	Director
Geoff Huntington	Project Advisor
Meliah Masiba	Senior Policy and Legislative Analyst
Ryan Singleton	Forester
Bill Ryan	Operations Deputy Director
Ali Hansen	Communications Manager
Robert Underwood	Project Manager

OSU's College of Forestry Elliott Project Team

Tom DeLuca	Dean of the College of Forestry
Katy Kavanagh	Associate Dean of Research (Exploratory Committee Chair)
Randy Rosenberger	Associate Dean of Student Success and Special Projects
Michael Collins	Director of External Relations
Caitlyn Reilley	Project Coordinator
Anthony Davis	Former Interim Dean of the College of Forestry

COMMITTEES

This process and the enclosed proposal benefited greatly from the expertise and guidance provided by members of the following committees:

OSU Exploratory Committee

Meg Krawchuk	Landscape Ecologist
Ben Leschinsky	Geotechnical Engineer
John Sessions	Forest Engineer
Ashley D'Antonio	Recreation Ecologist
Klaus Puettmann	Silviculturist
Matt Betts	Landscape Ecologist
Clark Binkley	Managing Director Institute for Working Forest Landscapes
Shannon Murray	Continuing Education Program Coordinator
Jenniffer Bakke	Wildlife Biologist
Gordie Reeves	Aquatic Biologist
Deanne Carlson	Graduate Researcher, Forest Ecosystems and Society

Department of State Lands Advisory Committee

Asha Aiello	Oregon Outdoor Council
Steve Andringa	Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians
Paul Beck	Douglas Timber Operators
Jen Clark	Reedsport School District
Melissa Cribbins	Coos County
Eric Farm	Barnes & Associates
Geoff Huntington	Oregon Department of State Lands
Michael Kennedy	Confederated Tribes of Siletz Indians
Michael Langley	Confederated Tribes of Grand Ronde
Ken McCall	Oregon Hunters Association
Mary Paulson	Oregon School Boards Association
Bob Sallinger	The Audubon Society of Portland
Mark Stern	The Nature Conservancy (retired)
Keith Tymchuk	Other
Bob Van Dyk	Wild Salmon Center

External Science Advisory Panel

Jennifer Allen, Chair	Environmental/natural resource public policy, Portland State University
Cassandra Moseley	Community-based forestry, rural development, University of Oregon
Eric White	Forest recreation and economic development, USDA Forest Service
Gwen Busby	Natural resource economics, GreenWood Resources Inc.
Linda Nagel	Silviculture, climate change, Colorado State University
Mark Swanson	Landscape ecology, early seral forest development, Washington State University
Matt Sloat	Ecology of pacific salmon watersheds, Wild Salmon Center
Ryan Haugo	Conservation science, The Nature Conservancy
Serra Hoagland	Tribal relations, biologists, USDA Forest Service, Salish Kootenai College

ADDITIONAL CONTRIBUTERS

University Faculty, Staff, and Students

We thank the numerous University faculty, staff, and students who contributed to the development of this proposal:

Stephen Fitzgerald	Professor and Extension Specialist and Director of College of Forestry Research Forests
Dana Warren	Associate Professor, Forest Ecosystems and Society and Fisheries and Wildlife
Kevin Bladon	Associate Professor, Forest Engineering, Resources and Management
Catalina Segura	Associate Professor, Forest Engineering, Resources and Management
Ariel Muldoon	Senior Faculty Research Assistant, Forest Ecosystems and Society
Jim Rivers	Assistant Professor, Forest Engineering, Resources and Management
Jennifer Elston	Executive Assistant to the Dean of the College of Forestry
Adrienne Wonhof	Director of Administration and Operations, College of Forestry Dean's Office
Scott Harris	Graduate Research Fellow, Forest Ecosystems and Society
Lauren Rennan	Art Director, College of Forestry
Taal Levi	Associate Professor, Department of Fisheries and Wildlife
Mark Harmon	Professor Emeritus, Forest Ecosystems and Society
Chris Wolf	Research Associate (Post-doc), Forest Ecosystems and Society
Kim Nelson	Senior Faculty Research Assistant, Department of Fisheries and Wildlife
Zhiqiang Yang	Courtesy Faculty, Forest Ecosystems and Society
Dan Roby	Professor Emeritus, Department of Fisheries and Wildlife

Scientists

We thank the following scientists for their honest feedback on the research design and ESRF proposal:

David Lindenmayer	Fenner School of Environment and Society, Australian National University
John M. Marzluff	School of Environmental and Forest Sciences, University of Washington
Bernard T. Bormann	School of Environmental and Forest Sciences, College of the Environment, University of Washington
Christian Messier	Center of Forest Research, University of Quebec in Montreal and in Outaouais
Andrew Balmford	Department of Zoology, University of Cambridge
Jerry Franklin	Emeritus Professor of Forest Ecology, University of Washington
Sue Baker	School of Natural Sciences, University of Tasmania, Australia

Experts

Lastly, we thank the experts from Mason, Bruce & Girard Inc and US Forest Capital LLC for their consultation.

SECTION 3

Guiding Principles and College of Forestry Commitments

GUIDING PRINCIPLES

Recognizing that the Elliott State Forest (ESF) is incredibly important to the people of Oregon, the state Land Board voted to keep the forest in public ownership in 2017. The Land Board's collective vision, as articulated at the May 2017 Land Board meeting, was a future forest that *"maintains public ownership and access, is decoupled from the Common School Fund, and has a habitat conservation plan."*

This collective vision initiated an assessment by Oregon Consensus (OC) in 2018 for the purpose of gathering perspectives and informing a process for finding a path forward for the Elliott State Forest. Following this assessment, at the December 2018 Land Board meeting, the Land Board directed the Department of State Lands (DSL) to work with Oregon State University (OSU) to explore the feasibility of OSU's management of the Elliott State Forest as a research forest.

In early 2019, OSU agreed to develop a plan in collaboration with DSL that engaged local tribal nations, local governments, and other stakeholders and is consistent with the Land Board's vision.

- Keeping the forest publicly owned with public access
- Decoupling the forest from the Common School Fund, compensating the school fund for the forest and releasing the forest from its obligation to generate revenue for schools
- Continuing habitat conservation planning to protect species and allow for harvest
- Providing for multiple forest benefits, including recreation, education, and working forest research

OSU began an exploratory process in early 2019 that included public listening sessions, outreach to stakeholders, and engagement with local tribes around a potential research forest concept. During public listening sessions, attendees were divided into discussion groups that roughly aligned with public values the Land Board had articulated as important to consider in the design and management of a research forest. Listening session discussion groups included: Recreation and Public Access; Research and Education; Timber, Economy and Forest Management; and Conservation.

As OSU was conducting its exploratory work, holding public listening sessions, and investigating aspects of transforming the Elliott State Forest for research, DSL formed an Advisory Committee composed of community leaders and stakeholders to provide insight and input on key elements of an Elliott State Research Forest (ESRF) proposal.

With the initial Land Board vision and data from the Oregon Consensus assessment report as the foundation, the DSL Advisory Committee and OSU Elliott project team collaboratively reviewed the input from the OSU led outreach to develop guiding principles also known as public values.

Throughout 2019, guiding principles were developed for the following areas:

- Forest Governance
- Recreation
- Educational Partnerships
- Local and Regional Economies
- Conservation

Each set of principles is a reflection of stakeholder input synthesized and reconciled to provide overarching statements of suggested direction for management of the Elliott State Research Forest in the context of the primary research mission.

COLLEGE OF FORESTRY COMMITMENTS

The public, including all of the people it represents, hold multiple values and perspectives for the Elliott State Forest (ESF) and genuinely care about its future. Currently, the ESF provides various types of ecosystem goods and services, such as wood production, species habitat, and recreational opportunities to varying degrees. As one might expect, members of the public carry a variety of expectations regarding how to manage the ESF and which of the ecosystem goods and services of the ESF are most important to them.

The proposed research framework for an Elliott State Research Forest (ESRF) is multifaceted, and is designed to provide opportunities for the provision and expression of many of the public's interests. The research theme, discussed more fully in the research section of this proposal, is a systems-level understanding of synergies and trade-offs for conservation, production, and the livelihood objectives on a forested landscape within a changing world. The goal of the ESRF is to conduct research that provides a science-based understanding of how to sustainably deliver ecosystem goods and services, delivering on multiple values important to the public, while maintaining the Land Boards vision of a publicly owned and accessible working forest. However, first and foremost, the ESRF needs to be a viable research forest. In this context it is not a preserve or park (although it supports the same or similar ecological, social, and economic values), but rather it is a working forest—working to achieve multiple values through a combination of active and passive research-based management approaches.

Recognizing that the success of such a research forest will require broad public support, the College of Forestry has articulated a set of commitments to the diverse public values expressed in each of the five sets of guiding principles developed by OSU and the DSL Advisory Committee in the process outlined above. These guiding principles align with the Land Board's vision and will aid decision-making as the research design is implemented and management actions are undertaken on the forest. These commitments will shape future ESRF planning and management, but they cannot be carried out by the College or Oregon State University alone. The College will rely upon an external ESRF Advisory Committee to remain in alignment with its primary goals, objectives, and commitments, upon public and private partnerships and collaborations to secure adequate resources and funding, as well as assistance in meeting many of these commitments.

The following subsections list the DSL Advisory Committee's guiding principles followed by the College of Forestry's commitments to the public and the forest based on, and in response to these guiding principles.

FOREST GOVERNANCE

DSL Advisory Committee's Guiding Principles

1. **Accountability.** The history and unique public nature of the Elliott Forest requires placing a premium on establishing a governance structure that will provide clear lines of accountability for forest management decisions that support research programs and articulated public values into the future. This structure should include formal and informal mechanisms that ensure commitments and principles are honored in the context of fiscal and operational management of the forest over time.

2. **Transparency.** Management of the Elliott Forest requires a commitment to transparent operations and decision making that will maintain and enhance public support for the research forest over time. This includes clear and defined processes for governance and oversight, clearly defined pathways for public inquiry and input, and accessible information related to forest operations.

3. **Representation.** An Elliott State Research Forest governance structure should engage and incorporate multiple interests and partnerships that reflect key public values the forest will represent over time. Representation of these values in governance of the forest should be balanced, accountable, and transparent with regard to fiscal and operational management of the forest to support research programs over time.

4. **Decision Making.** Regardless of governance structure, decision-making processes directing the fiscal and operational management of the Elliott State Research Forest must be accountable, transparent, and open to input while also empowered to operate the forest efficiently and effectively to meet identified objectives.

College of Forestry Commitments

OSU's proposed governance structure for the ESRF is described in detail in the governance section of this proposal. It clearly articulates ownership rights, responsibilities, and accountability, as well as a role for representatives of public interests in the decision-making process.

The College of Forestry is committed to:

1. **Transparency and accountability** in the management and use of the ESRF through a governance structure that includes meaningful engagement with public interest groups, local communities, the private sector, Tribes, and others, primarily through a stakeholder committee that advises on ESRF management. The **publicly-represented committee** will address issues such as revenue generation and economic outcomes, conservation, Tribal interests and traditional cultural uses, research and monitoring, recreation and education, and the other myriad ecosystem services benefits provided by the ESRF.

2. Owning and managing the ESRF **as a public forest and guarantee public access** for recreation, education, and foraging in ways consistent with research objectives and activities.

3. **Engaging, coordinating, and promoting research and management partnerships** with local watershed councils and associations, Tribes, conservation NGO's and other public and private entities.

4. **Collaborating with scientists and researchers** from other institutions in Oregon, the USA and globally.

RECREATION

DSL Advisory Committee's Guiding Principles

1. **Ensure Public Access Into the Future.** The Elliott State Research Forest ("forest") will remain accessible to the public for a variety of uses from multiple established entry points, by both motorized and non-motorized transportation, but not all places at all times.

2. **Promote Recreational Access and Use that is Compatible with Research and Ecological Integrity.** Public use of the forest will be supported and managed for different recreational opportunities consistent with a management plan reflecting stakeholder interests and historical activities in concert with public safety, ongoing research, harvest, and conservation of at-risk and historically present species.

3. **Support and Promote Diverse Recreational Experiences.** The Elliott State Research Forest recreational program will leverage partnerships within the local community and others to accommodate multiple and diverse recreational

uses to provide a range of user experiences within the context of a working forest landscape. Recreational planning will not favor one recreational type over another, but will seek to ensure high-quality experiences on the forest by managing to minimize the potential for conflict between users while safeguarding research and management objectives, and conservation values.

4 **Partner with Stakeholders and Manage Locally.** Elliott State Research Forest recreation programs will be managed by local staff who live in the community and work with stakeholders to enhance and protect the identified values of Elliott recreationists.

5 **Conduct Research on Sustainable Recreation Practices.** An Elliott State Research Forest recreation program will support relevant research on recreation and eco-based tourism, with the goal to advance scientific knowledge and inform the general public on the opportunities and impacts of balancing multiple interests within forested landscapes.

6 **Cultivate Multi-Generational Respect for the Forest.** Utilizing a collaborative approach to partner with schools, organizations, and volunteer groups recreation planning and management will seek to create more opportunities for engagement and a more widely informed forest-user community that is vested in the future of the Elliott State Research Forest.

College of Forestry Commitments

The ESRF will remain a publicly owned forest and will continue to be accessible for recreational uses. Through a direct, transparent and engaging governance structure, we will be held accountable to the public for their access and use that is consistent and does not conflict with research activities and outcomes.

The College of Forestry is committed to:

1 Providing and enhancing **public recreation access and use** of the Elliott, including **building upon existing partnerships and developing new ones**.

2 **Collaborating with local stakeholders** in developing and implementing a **recreation management plan** for the ESRF. The work may build on or integrate with existing efforts, such as Oregon's Websites and Watersheds, Southwest Oregon Community College (SWOCC), hunting organizations, motorized and non-motorized interests, trail groups, and the amenity sector.

3 **Conducting research on sustainable recreation management practices** that **advance knowledge and inform the general public** about forested landscapes represented by the ESRF and as used by locals and visitors.

4 **Principles of diversity, equity, and inclusion** associated with recreational access and use of the ESRF.

EDUCATIONAL PARTNERSHIP

DSL Advisory Committee's Guiding Principles

1 **Seek and Incorporate New Educational Partnerships.** An Elliott State Research Forest will offer opportunities to leverage and integrate existing local and state educational programs and institutions that support and generate forest-based research and knowledge.

2 **Expand Accessibility to Forestry Education.** An Elliott State Research Forest will provide and promote a diversity of values, and in doing so will leverage efforts by OSU's College of Forestry to engage students with diverse social, economic, ethnic, and cultural backgrounds in forestry education programs.

3 **Serve Students at All Levels of Education Through Programs on the Forest.** OSU will seek to foster and establish a programmatic link with K-12, community colleges, informal collaborative educational initiatives, and educational programs at other universities so that the forest becomes a resource for students at all educational levels.

4 **Integrate and Demonstrate Elements of Traditional Knowledge in Educational Programs on the Forest.** Through active partnerships with local Tribal Governments, the Elliott State Research Forest will seek to provide demonstration areas that use traditional forest management practices and focus on Traditional Ecological Knowledge outcomes for use in educational programs.

5 **Foster Public Awareness and Understanding of Sustainable Forest Management.** Management and research actions on the Elliott State Research Forest will seek to promote broader understanding and awareness of the role of healthy working forest landscapes to local economies, resilient ecosystems, innovative competitive products, and healthy communities.

6 **Develop an Educational Partnerships Plan.** The Elliott State Research Forest will work with stakeholders to develop a plan to foster and implement educational partnerships consistent with the foregoing principles and will implement it pending available resources.

College of Forestry Commitments

The ESRF will remain a publicly owned forest and will continue to be accessible for educational uses. Through a direct, transparent and engaging governance structure, we will be held accountable to the public for their access and use that is consistent and does not conflict with research activities and outcomes.

The College of Forestry is committed to:

1 Providing and enhancing **educational access and use** of the ESRF, including building upon existing partnerships and developing new ones. For example, we will work to integrate

and build on existing efforts and partnerships, such as historical research and data from Oregon's Websites and Watersheds, and partnerships with SWOCC, local school districts, Tribes, and OSU's Outreach and Extension.

2 **Collaborating with stakeholders** in developing and implementing an education/outreach plan for the ESRF, including its human and natural history as well as social and economic research opportunities (in addition to other research relevant to ecological and management issues). Collaborations will ensure the forest provides professional and educational benefits to Oregonians, in particular, and to the broader public and scientific communities in general.

3 The ESRF being a showcase and place of **learning about the role of healthy working forest landscapes** to local economies, resilient ecosystems, innovative competitive products, and healthy communities.

4 **Principles of diversity, equity, and inclusion** associated with educational access and use of the ESRF for students of all backgrounds, ages, and levels.

LOCAL AND REGIONAL ECONOMIES

DSL Advisory Committee's Guiding Principles

1 **Operate as a Working Forest While Managing for Research.** The Elliott State Research Forest will be owned and managed as a working forest that produces wood supply as a by-product of research, consistent with the mission of the Institute for Working Forests Landscapes at Oregon State University College of Forestry.

2 **Be Financially Self-Sustaining.** The financial model of the forest should incorporate traditional and innovative options for generating revenue to support forest management, and research programs without requiring continued funding support from outside sources.

3 **Generate Consistent and High-Quality Timber Harvest.** A sustainable supply of wood volume will be produced over time as a by-product of the research program on the Elliott State Research Forest. Quality should be prioritized over the quantity of harvest.

4 **Support Employment Opportunities for Local Communities.** The Elliott State Research Forest should not be managed from a remote location. Management and operation of the forest should be located in proximity to the forest and promote local partnerships that provide opportunities to local businesses and residents of Coos and Douglas counties.

5 **Study and report on the Relationship between the Research Forest and Local Economies.** The connections between OSU, the Elliott State Research Forest, and local economies should be documented and reported with transparency over time.

College of Forestry Commitments

The ESRF, as a working forest, will provide benefits to the economies and communities surrounding it. There is great potential for positive impacts on local economic sectors as we grow capacities associated with timber and other forest products, research, forest management, infrastructure building, maintenance, restoration, education, and recreation activities on or related to the ESRF. We also anticipate that the ESRF will generate spillover workforce and economic benefits to the broader region, state, and elsewhere.

The College of Forestry is committed to:

1 Operating the ESRF as a research forest that is financially **self-sustaining** based on revenue generated directly and indirectly from the forest through timber harvesting and other revenue-generating activities, gifts, grants, and contracts.

2 **Providing local jobs and other economic values** associated with activities on the ESRF. These include jobs in support of timber production, supplying timber to local mills, managing and monitoring the forest, recreation, education, and other activities on the ESRF whenever possible. In addition, recreation and education opportunities may draw people from outside the local economy who spend money as they recreate and learn.

3 **Sustainable production of timber products and growing high-quality trees** by maintaining approximately 33% of the forest in some level of timber harvesting. Harvesting provides wood products and research opportunities relevant to advancing market opportunities tied to high-quality wood products. Harvesting supports traditional and new wood products pertinent to the health of Oregon's forest products sector in the future.

4 **Managing the ESRF locally**, including key personnel living in the surrounding communities as well as building the infrastructure necessary to house researchers, students, and other stakeholders. Over time, OSU envisions the forest will attract researchers from around the region, the nation, and the world to conduct research that brings significant investments in housing, food, and research infrastructure to Coos and Douglas counties.

5 **Advancing financial partnerships** tied to recreation, education, research, forest management, and habitat restoration that individually and collectively improve local economic and workforce benefits both on and off the forest. While timber harvest revenue will directly support forest research and management, it will be insufficient to fund all opportunities or needs on the forest, thus making partnerships and related external funding critical to achievement of broad public values on an ESRF (e.g., Cougar

Pass fire tower restoration, habitat restoration, road removal, recreation infrastructure development and maintenance, and educational programming).

CONSERVATION

DSL Advisory Committee's Guiding Principles

1 **Improve Conservation Status of At-Risk Species.** The Elliott State Research Forest will undertake studies, research, and associated forest management activities that seek to change the way forests are managed throughout the region and beyond to ultimately promote the recovery of at-risk species and the ecosystems upon which they depend.

2 **Implement Science-Based Conservation Efforts to Enhance the Productivity and Conservation Values of the Research Forest.** In adhering to the academic mission of Oregon State University, and to ensure the sustainability of any management or activity that occurs on the landscape, all conservation decisions or proposed projects on the Elliott State Research Forest will be rooted in the best available science.

3 **Manage for Multiple Conservation Values to Maintain and Enhance Essential Elements of a Forest Ecosystem.** With a holistic, ecological approach, management of the Elliott State Research Forest will support the protection and enhancement of at-risk species and preservation of biodiversity, along with promoting improved natural hydrologic function and opportunities of carbon sequestration.

4 **Preserve and Proactively Steward a Diversity of Forest Structures.** Management of the Elliott State Research Forest will emphasize key ecological areas ranging from early seral to late-successional forest structure in the context of the greater landscape. The future growth of the forest should encompass diverse objectives of biological quality and resilience for future adaptability.

5 **Collaborate with Local Partners for Monitoring and Restoration of Habitat.** Management planning for the Elliott State Research Forest will partner with local conservation stakeholders to maintain transparency and mutual trust that protection of sensitive natural values will be prioritized.

6 **Management Decisions Will Not Be Driven by Potential Financial Returns.** The integrity of the research objectives and conservation values on the Elliott State Research Forest will not be compromised by the presence of active management and economic influences on the forest.

7 **Conduct Innovative Research on the Intersection of Forest Ecosystems Functions and Climate Change.** The Elliott State Research Forest will provide a unique opportunity to conduct innovative research on the role that native, mature, and managed forests can play in ameliorating the impacts of climate change for sensitive species, water quality/retention, and carbon sequestration.

College of Forestry Commitments

The ESRF will make meaningful contributions to species persistence and recovery through its research platform, specific research programs on habitat restoration and enhancement, and broader commitments below. As a result of a research design that promotes older forests, complex early seral, and other valuable habitats, and the functions of resilience and resistance in riparian, aquatic, and terrestrial systems, conservation and biodiversity outcomes and values will be enhanced. The ESRF research design and commitments outlined below support a goal of conserving and recovering species including coastal coho salmon, marbled murrelet, the northern spotted owl, and other species of concern; while species recovery is dependent upon actions and actors across a broader landscape, the ESRF can positively contribute to the achievement of this aspirational goal.

The College of Forestry is committed to:

1 **Conserving, enhancing, and sustaining high-quality habitats for endangered species and other wildlife** through actions such as placing approximately 66% of the ESRF into reserves where recurring timber harvests will cease and habitat restoration and protection would be their primary focus. Doing so creates the largest contiguous reserve networks in the Oregon Coast Range (detail in Appendix 5). We also will foster the growth of older forest stands in the ESRF well beyond current levels, which will be a significant gain of older complex forests relative to today.

2 **Providing and enhancing other habitats**, in particular for complex early seral forests diminished through plantation practices and the focus on late seral conservation.

3 **Conserving, enhancing, and sustaining native riparian conditions and vital ecological processes** that influence the aquatic system of the ESRF and connected aquatic networks. This commitment includes recruitment of instream wood, shading for water quality and thermal refugia, and active restoration projects related to these and other aquatic system attributes.

4 **Conserving, enhancing, and sustaining ecosystem processes including carbon storage and soil productivity** on the forest by increasing rotation ages in intensively managed stands, retaining older trees in extensively managed stands, and designating reserves.

5 **Reducing the current road network density** and known related adverse impacts on the ESRF (in particular in the Conservation Research Watersheds), while maintaining and balancing for necessary access for research, harvesting, management, education, fire protection, and recreation.

6 **No salvage harvests in reserves** (CRW and other reserve watersheds) when tree mortality is due to natural disturbances (drought, disease, wind, insects, and fire).

7 Helping advance a **Habitat Conservation Plan** that improves the certainty around OSU's ability to advance research, while conserving endangered species over an extended timeframe.

8 **Working forest approach** that, through research and applied project work, is intentional about better understanding and highlighting the role of coastal pacific forests in carbon sequestration and climate adaptation, and the impacts of climate change on the diverse public interests associated with forests.

TRIBAL ENGAGEMENT

Oregon currently has nine federally-recognized Indian Tribes. These Tribes are sovereign nations and Oregon has recognized this relationship through various statutes, Executive Orders and policy statements. Thus, this unique status will require the establishment of formal Government-to-Government agreements that guide future partnerships and collaboration. Sustained involvement of Tribes is essential to the future management and potential of a public forest. Therefore, the guiding principles for Tribal engagement will revolve around:

- Respect for Tribal sovereignty and Government-to-Government relationships.
- Develop sustainable partnerships with Tribes.
- Promote shared generation of knowledge from activities on and related to the ESRF.
- Understand and appreciate the unique values of individual Tribes and their respective connections to the ESRF.
- Honor Tribal Ecological Knowledge (TEK).
- Ensure accessibility by Tribes to OSU's educational programs, research, and information resources.

A necessary first-step in expressing our commitments to Tribes, we intend to establish government-to-government MOUs between College of Forestry / Oregon State University and local Tribal governments that set standards and expectations for sustaining meaningful and productive partnerships in research, education, and outreach that directly co-benefit Tribal communities, individuals, and businesses, and OSU.

The DSL Advisory Committee and sub-committees, including Research Platform and Governance, have included representatives from various Tribes. As the new governance structure of the ESRF evolves, we anticipate continued involvement from Tribal representatives on committees in an advisory capacity.

The College of Forestry's commitments express our desire to own and manage the ESRF for the good of science, the land, and the people it sustains. Our commitments to the public values are enduring in that they are long-term, enabling research to be conducted over large spatial and temporal scales addressing ecological, social, and economic questions in the context of sustainable forest management, including natural disturbances, changing climates, and social pressures on these forested systems. We also acknowledge that not all commitments can be honored simultaneously in the same spaces, which will require a balanced and sustainable approach to forest research and management. The following section provides information on the research objectives for an ESRF.

SECTION 4

Summary of the Research Platform

Forests are integral for the health and wellbeing of humanity and the conservation of biodiversity and ecosystem functions and services. With increasing global demand for forest products and influences from a changing climate, it will be critical to find ways to provide these essential resources without compromising global forest biodiversity, carbon sequestration, and ecosystem health. We propose the Elliott State Research Forest (ESRF) be a center – both in Oregon and worldwide – for sustainable forestry using the scientific method.

The research platform consists of a series of documents drafted collaboratively over the past two years that establish the experimental design, goals, and outcomes for an ESRF. The primary research platform documents are the Research Charter (Appendix 1), presented to the Land Board in 2019, and a set of appendices describing elements of the research design and implementation (Appendices 2-11), developed primarily by members of the OSU Exploratory Committee and College of Forestry faculty.

The research platform incorporates input from local citizens and a diverse group of stakeholders through public listening sessions, focus groups, the Department of State Lands Advisory Committee (DSL AC), and local tribes. The research platform documents went under review by the DSL Research Platform subcommittee, members of the OSU College of Forestry, and an external Science Advisory Panel (SAP). Additionally, research concepts in the platform were reviewed by several scientists external to OSU from the Pacific Northwest and beyond (a summary of these reviews are in Appendix 13). Together, the research platform, DSL AC guiding principles, and governance structure outlined in this proposal will guide decision-making and research well into the future.

The following guiding principles serve as the foundation for establishing a long-term research program that remains focused and relevant to the overarching vision set forth by the Oregon State Land Board for a publicly owned and accessible forest. Research initiatives executed on the forest must collectively support a unifying question. The collective work of different research program initiatives will contribute to a greater body of work over time. As such, the following guiding principles are established and detailed more fully in the Research Charter in Appendix 1.

1 **Principle 1: Research:** The ESRF will advance and sustain science-based research. We will accomplish all management objectives related to fulfilling other public values and revenue generation within a 'research first' context.

Figure 1. Conceptualizing the Elliott State Research Forest as a social-ecological system

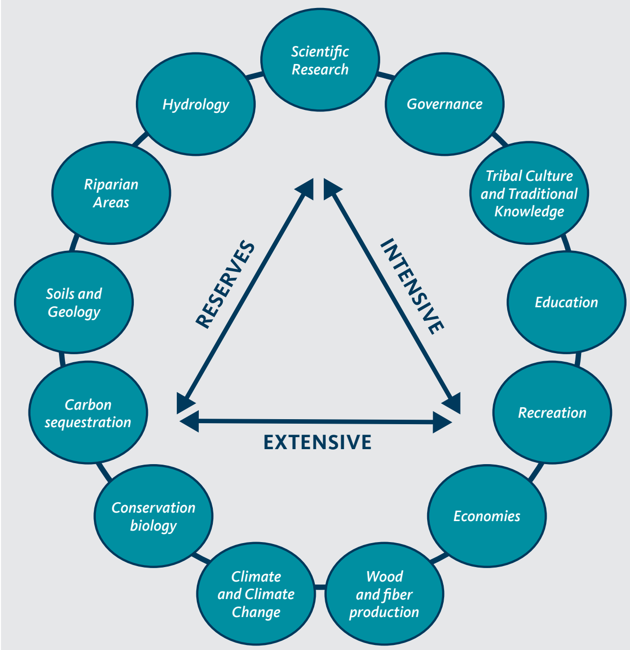


Figure 1. *Conceptualizing the Elliott State Research Forest as a dynamic system with an array of interconnected elements. Note that our research is embedded within the ecological and social systems.*

2 **Principle 2: Enduring:** Research on the ESRF should aim to remain relevant across many years, generations, and social, economic, and environmental contexts.

3 **Principle 3: At Scale:** An overarching research question, research design, and long-term monitoring on the ESRF should leverage the unique opportunity to quantify the synergies and tradeoffs associated with different amounts and arrangements of treatments at a landscape scale through time.

4 **Principle 4: Tailored to the Landscape:** The overarching research question will guide a research design that is tailored to existing and potential future biological, physical, social, and economic conditions on the ESRF.

5 **Principle 5: Practical, Relevant, and Collaborative:** The Land Grant mission of Oregon State University and the history of the ESRF as a public forest require that research on the forest be relevant to forest management issues and challenges facing Oregonians.

The goal of research on the Elliott State Research Forest (ESRF) is to advance more sustainable forest management practices through the application of a systems-based approach to investigating the integration of intensively managed forests, forest reserves, dynamically managed complex forests, and the aquatic and riparian ecosystems that flow within them (Figure 1). Notably, the ESRF's size will enable us to explore and quantify the synergies and tradeoffs associated with these land management practices at a landscape scale through time. We will be able to quantify the complex relationships among the multiple ecological, economic, and social values in response to landscape-scale research treatments (intensively managed forests, forest reserves, dynamically managed complex forests). To honor the rich legacy of this land, an ESRF should do nothing less than attempt to reimagine the future of forestry. We have chosen to use a Triad theme as a framework for the research to be conducted on the Elliott. This framework facilitates our ability to broadly ask fundamental questions about tradeoffs in conservation and provide a general layout of treatment applications, but in no way does this limit us to one set of questions. Rather, we envision conducting a variety of parallel and nested experiments that push the limits of knowledge and practice in forestry and a sense of the range of those questions can be found below and in Appendix 3.

CONTEXT TO THE TRIAD FRAMEWORK

The United Nations has reported our planet is facing unprecedented threats to biodiversity and ecosystem services (e.g., clean water, wood, food). Meanwhile, livelihoods in resource-dependent communities have been declining for some time – particularly in Oregon. Indeed, according to the Food and Agriculture Organization, over 1.6 billion people globally depend on the forest for their livelihoods. The number is much larger than that if you include how many of us rely on wood products in our daily lives. **Therefore, a fundamental question for humanity is whether it is possible to support the forest product needs of 8 billion people without further eroding nature's life support system.**

Four approaches have been suggested to achieve this balance. First, society could reduce its dependency on wood. Although this is the most palatable strategy for many, our consumption habits indicate little progress. Wood consumption is up – in lock-step with population growth. Second, a regional option is to import wood, or wood alternatives, from elsewhere. This option exports environmental consequences of our behavior, and is unappealing to many because it harms developing, highly biodiverse regions that cannot afford strong environmental laws.

Third, we could manage landscapes using ecological approaches to forestry. This strategy reduces per acre wood production, so more of our planet would need to be logged to meet demands. Already, more than 2/3 of the Earth's productive surface is used for agriculture or timber.

Fourth, we could intensify production – via technology – to generate higher wood yields. With concentrated production, it becomes possible to set aside more wildlands for nature. The downside is that this intensification often uses fertilizers and pesticides may have unforeseen consequences to human and ecosystem health.

Unfortunately, to our knowledge, there are no experimental landscape-scale tests of which of these strategies would be best for the conservation of forest biodiversity along with a suite of forest products, services and other values. This leaves the unanswered question: "how can we best manage our forests to meet biodiversity, timber, and economic needs in the face of global change?"

Figure 2

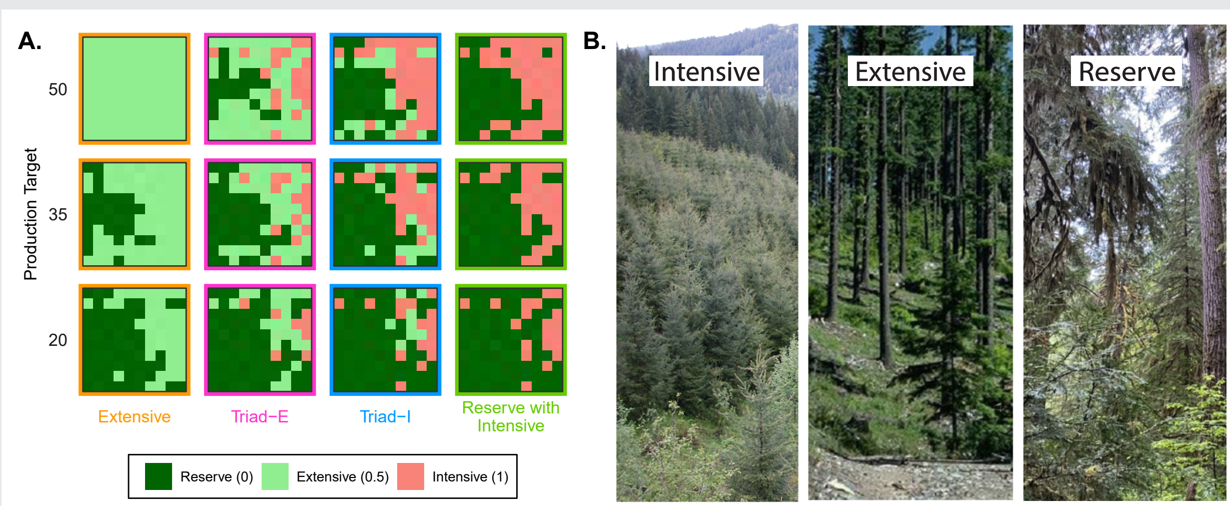
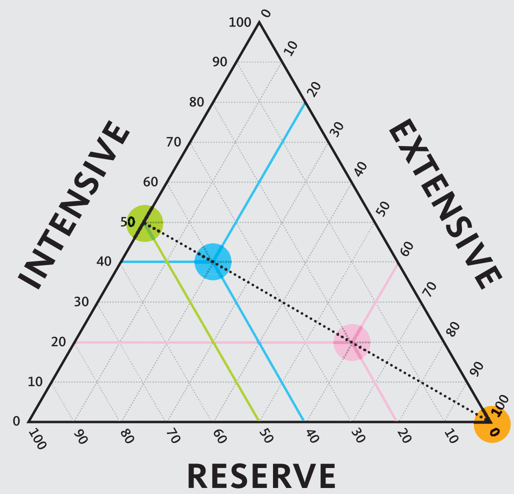


Figure 2. *Conceptual illustration of contrasting approaches to managing landscapes for timber production and biodiversity conservation in mixed-wood yield landscapes along a continuum from where extensive (ecological) forestry dominates to landscapes comprised of reserves and intensive management. In (A), each of the nine panels is a schematic map of a region with unmanaged habitat (also termed 'reserve', dark green; 0 units of production per pixel), ecological forestry (also termed 'extensive management', light green; 0.5 units/pixel), and high-yield forestry (also termed 'intensive management', coral; 1 unit/pixel). Region maps in the same row all produce the same quantity of wood, but use different proportions of forest management approaches to provide the production target. The three rows show results from low (20) to higher production targets (50). Note that even the highest production target depicted here is still only ½ of the total production possible. Due to the reduced per acre production afforded by extensive forestry, 'Extensive' landscapes (left column) necessarily have reduced reserve compared to the 'Reserve with Intensive' landscapes. Intermediate options (Triad-E and Triad-I) will also be examined and represent balanced options where reserves, extensive and intensive management occur in the same landscapes. At the ESRF, we will test the 50% production target (top row). In (B), examples of each type of management are shown: intensive management (Douglas-fir plantation), ecological forestry (variable retention harvesting in native forest), and unmanaged, protected old growth.*

Oregon State University's College of Forestry aims to answer this question by applying the first experimental test of the "Triad" approach. The plan – the first of its kind globally – would employ a large-scale long-term experiment to determine how to manage forests to balance human's and nature's needs. Is the best strategy to conserve nature in reserves and supply wood by intensifying production in tree plantations? Is it better to reduce harvest impacts using ecological forestry but expand harvests across the landscape to meet wood demand? Or are intermediate strategies that utilize reserves, intensive management and ecological forestry – called the "Triad" approach – best? In these experiments, scientists will measure water quality, carbon storage, endangered species, biodiversity, landslides, fire risk, and socioeconomic values like timber production, recreation and hunting. This framework allows for a great deal of flexibility in terms of where and to what scale different treatments are placed on the landscape. And the design affords flexibility in terms of nesting a range of experiments within the larger platform allowing researchers to test a range of hypotheses from climate resilience to issues surrounding social acceptance of forest practices to facilitation of recreational opportunities.

Figure 3. Percentage of reserve, intensive and extensive treatments in the TRIAD framework



Triad TREATMENTS

Extensive
0% Reserve, 100% Extensive

TRIAD-E
20% Reserve, 20% Intensive, 60% Extensive

TRIAD-I
40% Reserve, 40% Intensive, 20% Extensive

Reserve with Intensive
50% Reserve, 50% Intensive

Equal wood supply

Figure 3. *Conceptualizing the four different Triad Treatments. Each colored dot represents a subwatershed level Triad treatment. The text below specifies the proportions of stand level research treatments (intensive, extensive, reserve).*

TRIAD RESEARCH FRAMEWORK

Our goal is to investigate promoting biodiversity, ecosystem processes, and ecosystem services while achieving a given wood supply using existing and novel land management strategies. Expansion of high-yielding tree plantations could free up forest land for conservation provided the implementation is in tandem with more robust policies for conserving native forests. However, because plantations and other intensively managed forests often support less biodiversity than native forests, a second approach argues for widespread adoption of extensive management, or 'ecological forestry', which better conserves key forest structural elements and emulates a broad range of disturbance regimes. Extensive management often reduces wood yields, and hence there is a need to harvest over a larger area to maintain an equivalent supply of wood. A third, hybrid suggestion involves 'Triad' zoning where we divide the landscape among reserves, extensive management, and intensive management in varying proportions.

We will utilize a "Triad" design, which will experimentally vary these three general land management approaches at the scale of whole landscapes:

1. Reserves with Intensive (hereafter "Intensive") forestry,
2. Extensive ("ecological") forestry (hereafter "Extensive"), and
3. the combination of reserves, ecological forestry, and intensive forestry (hereafter "Triad").

We will test two Triad options that vary in the proportions of each forestry type (intensive, extensive, and reserve - see Figures 2 and 4). We can visualize this approach as a triangle with its endpoints being reserve, intensive, and extensive stand management practices applied in varying proportions (Figure 3). To reflect society's demand for wood products, each Triad treatment will produce the same wood supply (illustrated by the dashed line in Figure 3), but using very different approaches. We structure the endpoints for the Triad design ('Reserve with Intensive' and 'Extensive,' green and orange circles respectively in Figure 3) under the premise that you can increase the amount of land in reserve as you intensify management while maintaining a stable output of wood products. On one end of the spectrum, the larger amount of intensively managed land would result in a greater amount of land in reserves (due to the high production in plantations, less land areas needs to be under management). On the other, Extensive (ecological) management, where multiple ecosystem service objectives are likely to be provided simultaneously, is only likely to provide a fraction of the timber per acre, and thus less area can be set aside in reserves. Within the Triad design, we will also explore riparian strategies (e.g., Riparian Conservation Areas, wood delivery potential, and restoration thinning) with terrestrial ecosystem management strategies to ensure the conservation of aquatic and terrestrial ecosystems as an integrated system. The four treatments that we will allocate across the landscape are depicted in Figures 3 and 4 and described below.

The experimental unit for the research design are subwatersheds 400 to 2,000 acres in size. The 66 subwatersheds are designated to be in either the Conservation Research Watersheds (CRW) shown in green or Management Research Watersheds (MRW) shown as a mosaic of orange, pink, light blue, and lime green in Figure 5.

Over 9,000 acres of the forest are in partial watersheds (MRW Partial) that are either less than 400 acres or not fully contained within the ESRF's boundaries, resulting in multiple ownership. The forty watersheds that are wholly contained within the MRW will receive the varying Triad treatments (Extensive, Triad-E, Triad-I, Reserves + Intensive) outlined below and illustrated in Figures 2 and 4. We chose subwatersheds to define boundaries (ridges) to give us the ability to use water as an integrator of the effects of the different Triad Treatments. We have approximately 10 replicates per subwatershed Triad treatment, which gives us sufficient statistical power to detect treatment differences for several variables, as is more fully described in Appendix 10. The initial subwatershed and stand level treatment allocation processes are more fully described in Appendix 4.

TREATMENTS

1. Extensive Treatments would be 100% extensive stand management across the entire subwatershed, outside of the RCA.
2. Triad-E Treatments would have 60% of the subwatershed acreage, outside of the RCA, in extensive, 20% intensive, and 20% reserve stand management.
3. Triad-I Treatments would have 20% of the subwatershed acreage, outside of the RCA, in extensive, 40% intensive, and 40% reserve stand management.
4. Reserves with Intensive Treatments would have 50% of the subwatershed acreage, outside of the RCA, in intensive and 50% reserve stand management.

We assessed the level of prior forest management in each subwatershed by evaluating stand age (Figure 6). Given that logging commenced in earnest (approximately) in 1955, we concluded that any stand that originated after this date (based on revised inventory data) resulted from harvest, including disturbance and salvage. Stands older than this are assumed to have originated from stand-replacing wildfires. Overall, about 50% of the Elliott State Forest has been clearcut in the past 65 years. The percentage of area within the individual subwatersheds in the MRW that are younger than 65 years of age ranges from 19% to 98%. Details about assigning the initial draft allocation of subwatersheds to Triad treatments are in Appendix 4.

STAND-LEVEL RESEARCH TREATMENTS

The ESRF is well-positioned to support the proposed integrated Triad research design. Currently, 42,000 acres of the forest are Douglas-fir plantations, established primarily between 1955 and 2015. These stands reflect conventional even-aged forestry practices over the past six decades. Intensive (production-oriented) stand-level research treatments in these forests will allow us to investigate management options that primarily emphasize wood fiber production at rotations of 60 years or longer. We aim to examine various intensive management treatment options, including those that do not utilize herbicides. Simultaneously, we can assess methods to reduce this harvest regime's impact on other attributes such as biodiversity, habitat, carbon cycling, recreation, and rural well-being.

Reserve stand-level research treatments primarily from unlogged, naturally regenerated stands that comprise 35-40,000 acres (or up to 49%) of the landscape. The reserve treatments include former plantations, recognizing the need for a focused effort to recruit future old stands. Such treatments will have two starting points: a) Exploring treatments to restore and enhance conservation value in established plantations that will transition to reserves; and b) Conserving unmanaged mature forests as they move through natural successional processes. These unlogged forests are ideal for monitoring ecosystem attributes such as biodiversity, recreation, carbon cycling, and water in the absence of any timber harvest. Thus, they serve as benchmarks for research treatments and managed habitat.

While intensive and reserve treatments provide opportunities to study management extremes, a third research treatment, extensive research treatments, will strive to increase forest complexity to help achieve multiple values across the landscape. The purpose of these widespread dynamically managed forests will be to explore the implementation of a new set of alternatives in a continuum between intensive plantation management and unlogged reserves. The research design on this continuum of extensive options will enhance diverse forest characteristics and better integrate them with riparian areas to meet a broad set of objectives and values in any stand. We can accomplish this goal by retaining (or creating) structural complexity while ensuring conditions exist to obtain regeneration and sustain the complex forest structure through time. Extensive alternatives represent the most significant opportunity for learning and expanding timber management's frontiers by aiming to simultaneously achieve biodiversity objectives and timber demand at the stand scale. The extensive treatments are where we will test a vision for a genuinely sustainable approach to land management - reflecting social values, needs, and ecosystem function. The Oregon Department of Forestry and Bureau of Land Management are implementing similar alternative approaches making the scientific findings from the ESRF on how species and ecological processes, such as carbon sequestration, respond to extensive treatments especially relevant. Detailed descriptions of intensive, extensive, and reserve stand level research treatments are available in Appendix 5.

We envision a robust experimental design consisting of integrated plantations, unlogged reserves, streams, riparian forests, and dynamically managed forests for the complexity of species and canopy layers (Figure 7 and Figure 8). As the ESRF ages and research progresses, we will see at-scale results that quantify combined effects and tradeoffs among ecological, economic, and social values. The research treatments applied to the CRW and MRW will deliver the knowledge needed to support forestry's next evolution.

'NESTED' (STAND-SCALE) RESEARCH AT THE ELLIOTT STATE RESEARCH FOREST

Although the unifying 'grand vision' for the ESRF is how to meet society's wood demands while maintaining biodiversity, carbon

Figure 4. Triad Landscape-level (Subwatershed) Treatments

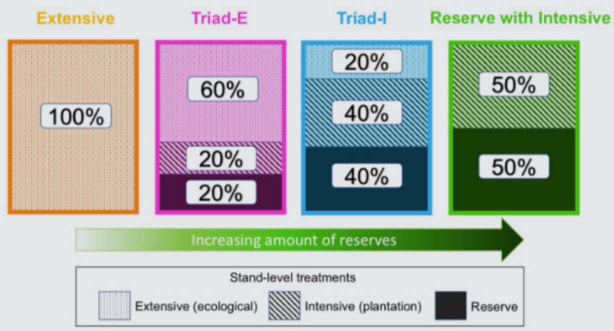


Figure 4. *The four Triad treatments that we will apply at the subwatershed scale at the ESRF. All of the subwatersheds (400-2000 ac) in the Management Research Watersheds will receive one of these four treatments. Treatments are designed to produce approximately equivalent wood yields using different combinations of stand-level treatments: reserves, extensive (ecological forestry) and intensive management (plantations). The 'Extensive' Triad treatment (orange) will be 100% ecological forestry, the 'Reserve with Intensive' Triad treatment (light green) will comprise 50% intensive forestry and 50% reserve. 'Triad-E' and 'Triad-I' contain differing proportions of reserve, ecological and intensive forestry.*

Figure 5. Potential Subwatershed Triad Treatment Assignments

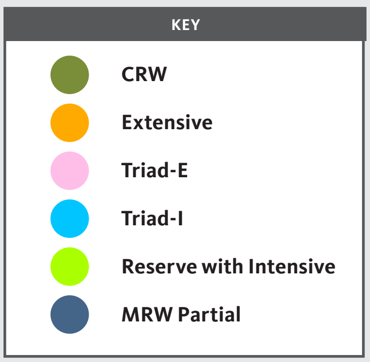


Figure 5. *Map illustrating the proposed western reserve area (Conservation Research Watershed; CRW, in dark green) and the potential allocation of subwatershed-scale Triad treatments in the ESRF's eastern part. Partial watersheds (dark blue) are only partly contained in the ESRF, so they will not have a formal subwatershed Triad treatment assigned. Map is based on August 2020 allocation.*

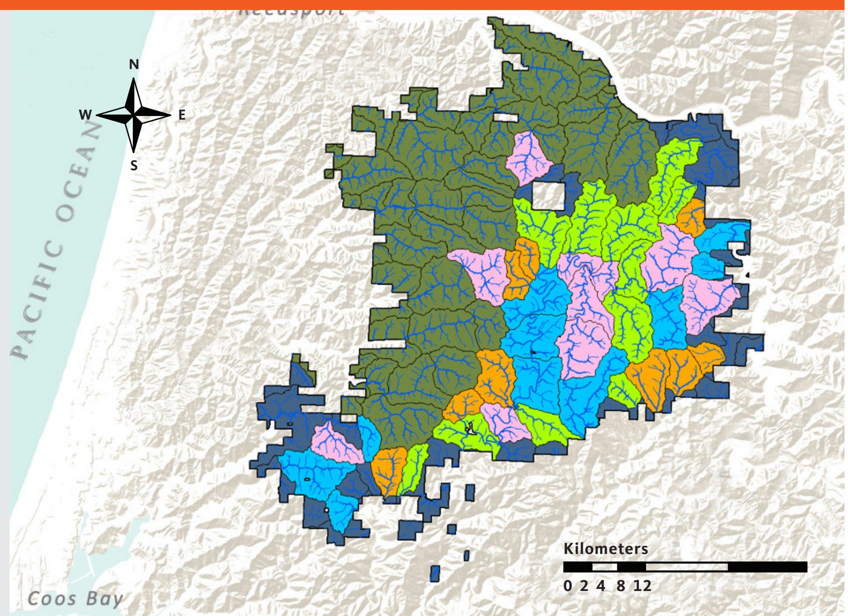
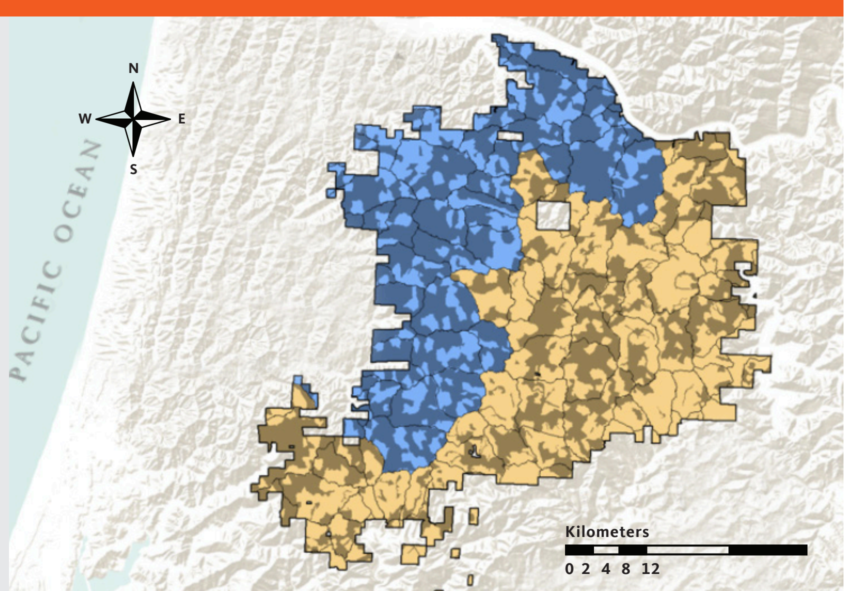


Figure 6. Age class distribution in the Conservation Research Watershed and the Management Research Watershed

KEY

	LTE65	GT65
CRW	36%	
MRW	60%	%
ALL ELLIOTT	50%	50%

Figure 6. *Subwatersheds of the Elliott State Research Forest color coded by classification into the Conservation Research Watersheds (CRW) and Management Research Watersheds (MRW) and color coded by stand age greater than 65 years (GT65) and less than 65 years (LTE65). Uncolored regions indicate this portion of watershed is not part of the proposed Elliott State Research Forest.*



sequestration, and other social and ecological objectives, there are numerous opportunities for research and collaborations to nest within the Triad framework. Potential vital areas of research include biodiversity and conservation (Marbled Murrelet, Spotted Owl, Coho salmon), climate change adaptation, disturbances such as landslides and fires, water quality, fragmentation and connectivity issues, and socio-economic and cultural impacts. A list of potential research projects and collaborations is available in Appendices 2 and 3. These projects can be 'nested' within the landscape-level Triad framework. The idea is to conduct rigorously designed stand-scale studies on, for example, (1) different approaches to conducting ecological forestry, (2) how to do intensive forest management with minimal use of herbicides, and (3) whether mixed-species plantations can increase yields and show greater resilience in the face of changing environmental conditions (see Appendix 13, Figures 13a & 13b). Studies at these finer spatial scales will have a full random allocation of treatments across a gradient of conditions, which will enable inference to forests beyond the Elliott.

The research performed on the ESRF will achieve several outcomes (listed more fully in the Research Charter in Appendix 1); and, hopefully, increase public trust in active management on public and private forest lands. Using a landscape approach to research, the proposed work will improve the health of rural economies, communities, and citizens; increase the competitiveness of Oregon's private landowners and businesses, and enhance ecosystem health while leading to long-term improvements in the sustainability of forest management throughout the region. The research conducted on the ESRF will provide long-standing and emerging solutions to forest management issues and allow us to pursue future research questions we can't even imagine today.

With novel and increasingly uncertain future environmental and social conditions, landscape-level research provides a chance to test alternative forestry practices. We must research alternatives to specified rotation lengths, stem density, species diversity, age diversity, configurations of riparian buffers, and assess how these choices the systems within and outside of the forest through time. We need to explore all options and tradeoffs – not just those with which we are most familiar. Exploration is the essence and function of a research forest and will not happen through

Figure 7. Percentage of ESRF allocated to stand level research treatments as of August 2020 draft allocation*

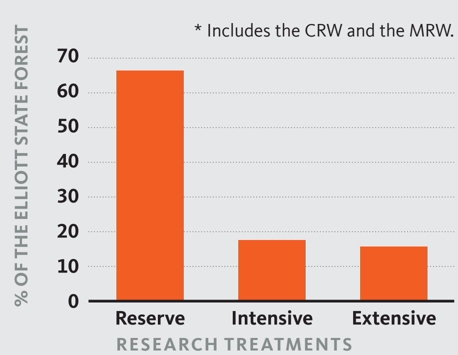


Figure 8. Proposed stand level allocation of extensive, instensive and reserve treatments

KEY

- MRW Reserve
- Intensive
- Extensive
- CRW
- Extensive Reserve (GT152)
- GRCA

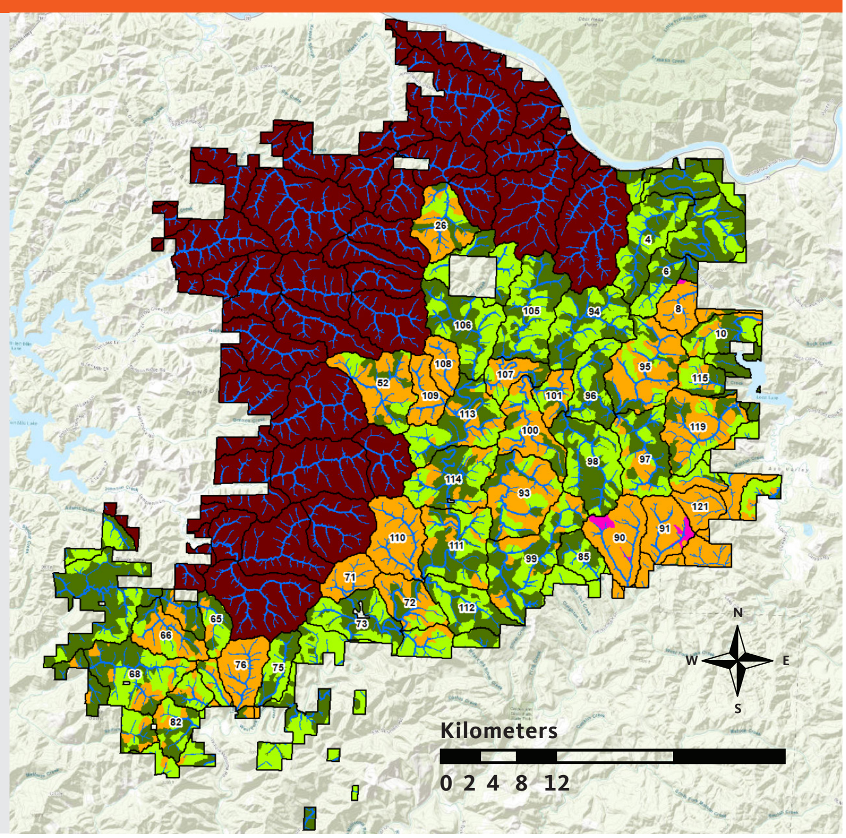


Figure 8. *Map showing proposed stand level allocation of MRW reserves, intensive, extensive, extensive reserve and GRCA (Generic Riparian Conservation Areas). GRCA is Generic Riparian Conservation Area and was estimated by buffer widths of 100ft and 50ft on fish bearing and non fish bearing streams respectively to achieve potential ~70% wood recruitment in the MRW. Extensive Reserve are areas of extensive stand treatments that are greater than 152 years old and will be placed in reserve status within those extensive allocations. Map based on August 2020 allocation.*

merely establishing isolated reserves in a landscape of traditionally managed forests.

ADAPTIVE SILVICULTURE FOR CLIMATE CHANGE

Projected increases in temperatures and summer moisture deficits in Pacific Northwest forests are expected to promote increased drought stress, more frequent insect outbreaks, increased risk of large wildfires, increased frequencies of severe winter storm events, reduced summer streamflows, and increased water temperatures (Dalton et al. 2013, May et al. 2018). These changes pose significant risk to the region's timber economy, outdoor recreation economy, indigenous livelihoods, and habitat quality for threatened and endangered populations of salmon, northern spotted owls, and marbled murrelets. The proposed treatment design framework for the Elliott State Research Forest (ESRF) offers a unique opportunity to evaluate the effectiveness of a range of climate change adaptation strategies within a landscape where all of these resource concerns overlap.

The flexibility of the proposed ESRF treatment themes, and the interspersion of intensive management, extensive management, and reserve areas within the triad treatment subwatersheds provides an exceptional foundation to develop and test climate change adaptation treatments within the framework of an existing, multi-region climate change adaptation experiment known as the Adaptive Silviculture for Climate Change project (ASCC, Nagel et al. 2017). For instance, climate change adaptation strategies designed to increase ecosystem resilience to wildfire, insect outbreaks, and drought by increasing forest compositional diversity, structural heterogeneity, and age-class diversity at stand to landscape scales fit naturally within the goals of the extensive treatment theme. Alternatively, adaptation strategies such as reforesting with climate-adapted genotypes, managing on shorter rotations to provide more frequent opportunities to adjust to changing conditions, installing fuel reduction treatments and/or fuelbreaks to facilitate fire suppression efforts, and controlling competing vegetation or managing stand densities to reduce drought stress and associated synergies with some insect pests all fit under the umbrella of the intensive management approach. Leveraging the existing resources and treatment design processes of the ASCC project will facilitate the development of an array of site-specific climate change adaptation treatments on the ESRF within the context of regional climate change vulnerabilities and resource concerns. Unlike existing sites in the ASCC network and other manipulative climate change adaptation experiments, however, the ESRF offers an opportunity to compare the effectiveness of different climate change adaptation strategies at management-relevant spatial and temporal scales due to the size of the ESRF, the proposed funding mechanisms to support multi-decadal research initiatives, and the flexibility of the existing extensive and intensive treatment themes to accommodate several common climate change adaptation strategies. Ultimately, the ESRF would offer a globally-unique opportunity to address climate change adaptation questions at management-relevant scales, within the context several regionally-specific natural resource management concerns.

The ESRF represents an enormous and unique opportunity to study novel practices and the climate resilience and resistance of ecosystems managed under these practices. The ESRF will also attempt to honor the millennia of stewardship these forests experienced from generations of Indigenous peoples by demonstrating the forest is far more than timber to be logged and maximizing the value and sustainability of wood products.

LITERATURE CITED

Dalton, M., Mote, PW, Snover, AK. 2013. Climate Change in the Northwest: Implications for our Landscapes, Waters, and Communities. Island Press, Washington, DC. 271 pp.

May C., Luce, C, Casola, J, Chang, M, Cuhaciyan, J, Dalton, M, Lowe, S, Morishima, G, Mote, P, Petersen, A, Roesch-McNally, G, and York, E. 2018: Northwest. In: Reidmiller, D.R., Avery, CW, Easterling, DR, Kunkel, KE, Lewis, KLM, Maycock, TK, and Stewart, BC (eds.). Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. U.S. Global Change Research Program, Washington, DC, USA, pp. 1036–1100. doi: 10.7930/NCA4.2018.CH2

Nagel, LM, Palik, BJ, Battaglia, MA, D'Amato, AW, Guldin, JM, Swanston, CW, Janowiak, MK, Powers, MD, Joyce, LA, Millar, CI, Peterson, DL, Ganio, LM, Kirschbaum, C, and Roske, MR. Adaptive silviculture for climate change: a national experiment in manager-scientist partnerships to apply an adaptation framework. Journal of Forestry. 115(3): 167-178.

SECTION 5

Adaptive Management and Phased Research Implementation

Undertaking the design and implementation of a research program of this magnitude and complexity is daunting. Accordingly, we have explicitly chosen to use a combination of a phased research implementation plan coupled with adaptive management protocols, modeling, ecosystem assessment and monitoring, and stakeholder input to reduce uncertainty and ensure the viability of the research through time. The phased approach (progressive increase in research activity across the ESRF over time) will include selecting a suite of watersheds from the Management Research Watersheds (MRWs) to conduct trial treatments and then utilize data analysis, modeling, and stakeholder input to adapt and refine the research plan. The length of time that this adaptive process will take is difficult to predict at this time. At first glance, it makes sense to estimate somewhere between 10-20 years, given the slow rate that trees grow. However, we intend to be highly responsive in the early years (1 - 5) when treatments are initially put on the ground. If concerns or problems arise during this stage, we will adjust accordingly. The adaptive approach (increasing depth of activity within the first phase of the ESRF over time) is briefly envisioned as follows (Figure 9):

A Conduct an in-depth landscape analysis of the ESRF.

B Identify and test the criteria for selection of 16 subwatersheds (4 replicates of the 4 treatment categories) plus up to 4 watersheds to serve as no-harvest controls.

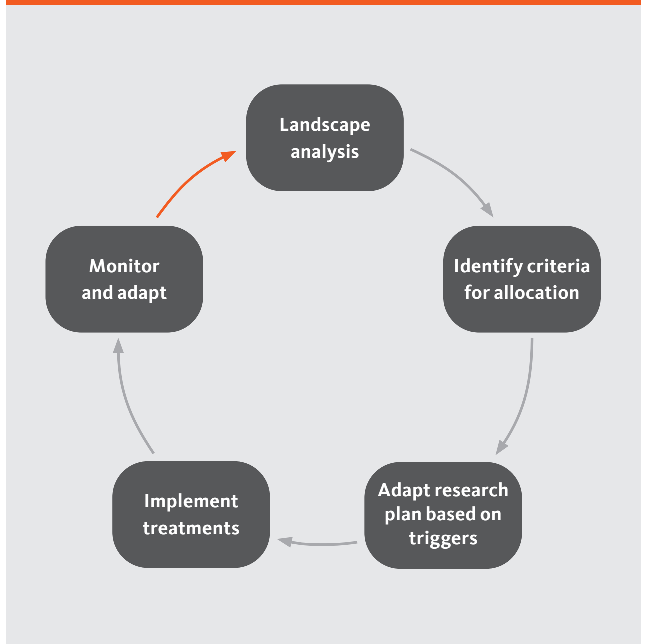
C Based on these data, allocate treatments to each stand within the subwatershed in proportion to the initial experimental design.

D Develop a list of criteria or outcomes that would trigger changes in experimental protocols.

E Explore what changes are experimentally and socially acceptable if triggers are met. (Both D and E should be an open and transparent discussion, i.e., with external peer and public input).

F Design and implement monitoring protocols that include previously established triggers in initial subwatersheds and several untreated watersheds.

Figure 9. Illustrating the iterative process of adaptive management



G Initiate treatments and monitoring within the first 16 subwatersheds and monitoring in controls.

H Monitor criteria that trigger changes in experimental protocols; revisit E.

I Adapt treatments for remaining watersheds as needed based on monitoring results, analysis, and stakeholder input.

There are numerous benefits to a stepwise implementation plan. These include:

- Increase in input from the broader research community and local and regional public entities with each progressive step.
- Collection of multiple years of pre-treatment monitoring data on up to 4 control subwatershed replicates to inform future applications of treatments.
- Development of a better understanding of the system we are experimenting within and the ability to design a study that is adaptive and flexible enough to withstand changes in social, economic, and ecological conditions over the very long life of a forest.

Over time, as we add more watersheds to the matrix of experiments, the phasing will continue. We anticipate a similar process and outcome for the former plantations in the Conservation Research Watershed experimental treatments. Since there is only one phase of active management planned (thinning plantations), the timeline may not be as long. We will describe other attributes of timing and implementation of activities on the ESRF in governance documents.

SECTION 6

Governance Structure

Note: Details of the governance structure are still under consideration. The content included in this section is unchanged from the December 2020 proposal. An updated proposed governance structure will be available soon.

~~Governance of the Elliott State Research Forest (ESRF) is important for the effective management of the forest by OSU, for ensuring State Land Board expectations for the forest, and for accountability to the public, stakeholder groups, and other interested parties. OSU anticipates that more work will be conducted after, and conditional on, the December 8, 2020, State Land Board meeting and decision regarding OSU's proposal for an ESRF. The following is offered as a potential governance framework; the final governance structure, including the terms of authority and accountability within Oregon State University, are subject to the approval of the OSU Board of Trustees. This governance structure enables OSU to exercise all of the attributes of forest ownership while holding the property in the name of the State of Oregon and with continued public access, engagement, and accountability. OSU supports the establishment of an ESRF Advisory Committee whose purpose is to provide advice and recommendations to OSU on ESRF planning/management decisions and public dispute resolution, and to provide input on assessments of the effectiveness of OSU's implementation of its public commitments and forest management planning.~~

~~OREGON STATE UNIVERSITY~~

~~Oregon State University, through a successful transfer and subject to approval by OSU's Board of Trustees, President, and Provost and the State Land Board, will accept ownership of the Elliott State Forest. The Elliott State Forest must be decoupled from the Common School Fund (CSF) and with no debt obligation to the CSF by OSU. As the effective owner of the ESRF, OSU will make all final decisions regarding the management and operations of the ESRF with the primary purpose of maintaining the integrity of all research and management activities on or associated with the forest in a manner that is generally consistent with the conceptual framework proposed to and accepted by the State Land Board on December 8, 2020 (Figure 10). This will include any refinements through management plans, and with respect to relevant state and federal laws (e.g., the Endangered Species Act through a Habitat Conservation Plan approved by federal listing agencies) prior to transfer from the CSF.~~

~~COLLEGE OF FORESTRY DEAN~~

~~The COF Dean will seek authority from the OSU President, OSU Provost, and OSU Board of Trustees to make all ESRF management and operations decisions, subject to compliance with the research design, commitments to the public, management plans, and with relevant and applicable state and federal laws, including the federal Endangered Species Act through a Habitat Conservation Plan approved by federal listing agencies. Accountability to these plans and commitments are as described below in the Accountability and Restrictions section. The Dean's additional authority and responsibilities are for oversight of forest management, research, and HR and budgets. The Dean may delegate these functions and responsibilities but maintains accountability for the outcomes.~~

1. ~~The COF Dean appoints and oversees an Executive Director for the ESRF.~~

2. ~~The COF Dean, on behalf of OSU, will decide what scientific research projects are conducted on the ESRF and nested within the research design. As such, the COF Dean appoints a Science Advisory Committee (ala the Science Advisory Panel; terms and membership yet to be determined) that is composed of scientific experts representing a variety of disciplines internal and external to OSU. An internal to OSU Research Advisory Committee (terms and membership yet to be determined) may also be established by the COF Dean to provide guidance and advice on research projects to be undertaken on the ESRF, and to support research autonomy and academic freedom for scientific investigations on the ESRF. The external and internal science/research advisory committees will review all proposed research on the ESRF and provide feedback to the COF Dean, including their integration with other research projects or landscape treatments, feasibility, and propensity to generate new knowledge.~~

3. ~~The COF Dean charges each advisory committee (including the ESRF Advisory Committee detailed below) to interact with each other in order to ensure the integration of science, economics, and social issues and to effectively communicate across disciplines and stakeholders.~~

~~ESRF EXECUTIVE DIRECTOR~~

~~The ESRF Executive Director reports to and is overseen by the COF Dean, and is responsible for delegated duties including long-term planning, implementing research, maintaining and restoring the ecological health of the forest, harvesting, and access for recreation and education, overseeing forest management and operations (including facilities, staff, and contractor management), performing fiscal accountability duties (budget development and fundraising), assisting ESRF associated advisory committees, advancing partnership opportunities, and engaging the public.~~

1. ~~The Executive Director is an OSU employee who is hired/appointed by and reports directly to the Dean of the College of Forestry.~~

2. ~~The Executive Director is stationed at the ESRF (i.e., lives in the surrounding community).~~

3. ~~The Executive Director directly supervises management/operations staff (Figure 11) who are also stationed at the ESRF (number and type yet to be determined; does not include research scientists, FRAs, and Graduate Assistants or others engaged in active research and teaching).~~

4. ~~The Executive Director submits and posts on the ESRF website an Annual Forest Management Report (AFMR). This annual report will address activities associated with restoration, harvest and forest operations, finances, research initiatives conducted on the forest, recreation and public access, and community outreach and education (examples are included below in Public Input and Dispute Review section, 1.B.).~~

5. ~~The Executive Director seeks input from the ESRF Advisory Committee, OSU staff, and relevant parties and publics in developing management plans, including forest management, restoration, wildlife management and protection, recreation, education and outreach (process yet to be determined).~~

6. ~~The Executive Director regularly engages the public and communicates about proposed actions and intended outcomes on the ESRF. While the process is yet to be defined, it will include notice of public meetings, posting of materials and minutes, and public comment (oral and written) that will be considered in substantial management actions undertaken on the forest.~~

~~ESRF ADVISORY COMMITTEE~~

~~The ESRF Advisory Committee is established as part of OSU's proposed governance structure and is appointed by the Director of the Department of State Lands in consultation with OSU and the Governor's Office to ensure a level of independence in its representation and function. The ESRF Advisory Committee is integral to the sustainability and success of an ESRF. The ESRF Advisory Committee provides an active, diverse forum for input and advice on ESRF planning and management, on effectiveness of past implementation of the forest management plan, and on compliance with foundational documents and codified allowable activities and public dispute resolution. As such, reasonable staffing and administrative support for the ESRF Advisory Committee is part of the core ESRF expenditures (Figure 11). The ESRF Advisory Committee is not responsible for day to day or project specific management or operations of the forest and serves OSU in an advisory capacity.~~

~~Given the ESRF Advisory Committee fosters public dialogue, accountability, and communication on matters relating to the management of the forest, and to surface issues for constructive discussion with OSU concerning management of operations in the forest, the Committee members must broadly represent the various interests concerned with the ESRF, including local governments, recreation groups, environmental/conservation groups, underrepresented local community members, educational interests, timber/forest product sector interests, Tribal governments, and a state agency representative with expertise relevant to management considerations.~~

Figure 10. Governance structure for the Elliott State Research Forest

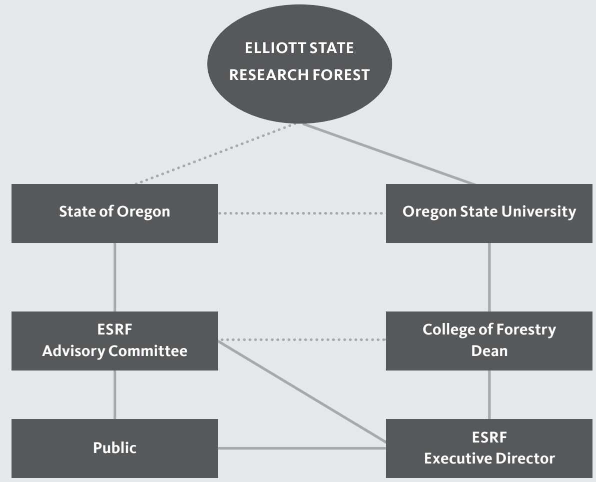


Figure 10. *Governance structure for the ESRF. Solid lines show direct relationships and the dashed lines show indirect relationships.*

~~ESRF ADVISORY COMMITTEE'S RESPONSIBILITIES:~~

1. ~~Provide timely and constructive input and advice on decisions impacting the long-term management trajectory of the forest and operations consistent with forest management, restoration and conservation, recreation, and education/outreach plans adopted by OSU.~~

2. ~~As a condition of appointment, each member will work to support the ESRF vision and foundational documents, including its research design, public commitments, and related foundational elements captured in the State Land Board decision or statutory framework establishing the ESRF.~~

3. ~~Receive public input and, if called upon by the COF Dean, assist as an initial layer of review and feedback on resolving formal disputes in accordance with the administrative review process detailed below.~~

4. ~~The ESRF Advisory Committee is charged with substantively participating in the following activities associated with the ESRF in an advisory capacity to the COF Dean and Executive Director:~~
   - ~~Participate in development, review, and comment on forest management, recreation, and education planning activities conducted by the College before those plans are adopted and implemented, including participation in any revision process (yet to be determined).~~
   - ~~Review and comment on biennial plans stating activities to be conducted by the College pursuant to the adopted Forest Management Plan. The biennial plan will address activities associated with harvest and forest operations, restoration, wildlife management,~~

~~recreation, public access, and community outreach.~~
- ~~Review biennial budget planning documents prior to the start of the relevant fiscal year.~~
- ~~Review and provide comments on reports to federal and/or state agencies associated with implementation of HCP terms and conditions.~~
- ~~Receive annual updates on financial matters associated with forest operations.~~
- ~~Review and provide comments on the AFMR.~~
- ~~Take comments from the public at meetings.~~

~~ESRF ADVISORY COMMITTEE APPOINTMENTS AND MEMBERSHIP CRITERIA INCLUDE:~~

1. ~~Composition - the size and composition of this committee will be a continuation of or patterned after the DSL Advisory Committee that is in place to guide the creation of an ESRF (up to 20 members).~~
   - ~~The committee will consider expanding its current membership to include one additional recreation representative, and one youth natural resource/environmental education representative.~~
2. ~~Bylaws are yet to be developed and adopted by OSU, and will include a specific charge to the committee and include the following items:~~
   - ~~Terms and conditions; e.g., four-year staggered terms with option for renewal.~~
   - ~~Nomination, including self-nominations, and vetting (e.g., attributes such as solutions-oriented, collegial, service-oriented) processes for open positions on the committee.~~
   - ~~Selection process for filling open positions on the committee.~~
   - ~~Removal for cause procedures.~~

~~PUBLIC~~

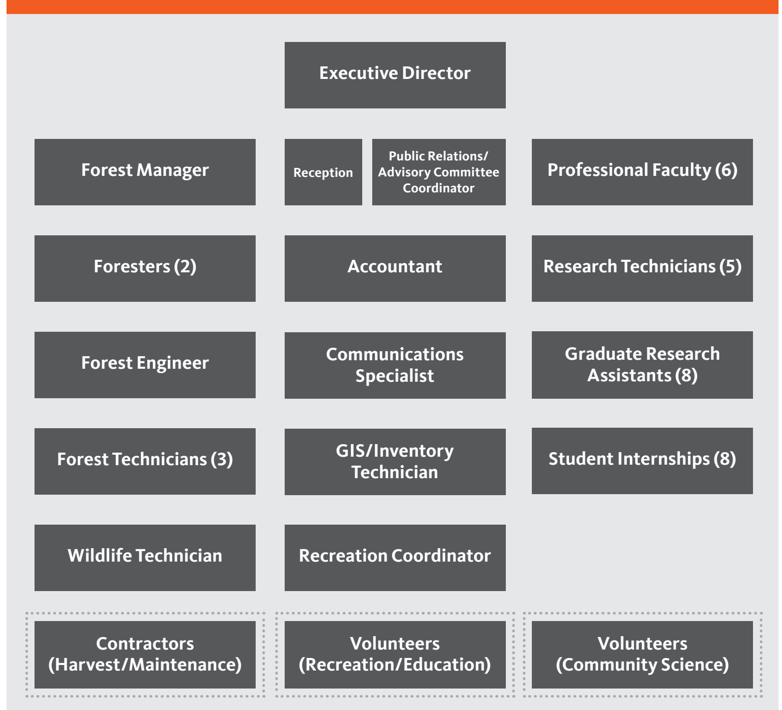
~~The ESRF remains in public ownership. Therefore, the public must be empowered to provide input and influence on the ESRF's overall operations in a transparent and meaningful way. Transparency provides an effective strategy to proactively avoid or resolve potential conflicts with stakeholders or other public parties, including the provision of adequate information and the opportunity to comment in order to effectively identify where conflicts may be anticipated to occur. The following are part of OSU's approach to meeting its commitment to transparency:~~

1. ~~The public is represented through membership on the ESRF Advisory Committee, its ability to have notice and comment on decisions related to the ESRF, its ability to access ESRF public records and to attend meetings convened by OSU, and its elected representatives.~~
2. ~~The Executive Director regularly engages and informs the public about decisions related to the ESRF.~~
3. ~~OSU communications regarding the ESRF are subject to the Oregon Public Records Act unless otherwise subject to non-disclosure under State law.~~
4. ~~ESRF Advisory Committee and any subcommittee meetings will honor the spirit of Oregon statutes relating to meetings laws, regardless of whether they are deemed to be applicable to OSU.~~
5. ~~Formal processes and structures for advance public review and comment are to be developed, including public notices, comment periods, a website that provides the management plans and updates, and annual local open public meetings.~~
6. ~~Individuals may also engage in forest activities that contribute to its overall goals and objectives, including volunteering in research (community science), recreation, education, and contractors in harvesting activities and vehicle/facilities maintenance (Figure 11).~~

~~ACCOUNTABILITY AND RESTRICTIONS~~

~~OSU commits to ensuring accountability to the integrity and transparency of the ESRF's management and operations. A set of ESRF foundational documents will be completed and ratified by OSU and DSL that will be used as the framework for OSU's implementation of the ESRF research design and management activities after the transfer from the CSF[1]. These foundational documents include:~~

Figure 11. Organization Chart for the ESRF



1. ~~The ESRF Proposal advanced by OSU that contains specific, citable content including:~~
   - A ~~The ESRF Research Design, containing related maps and description of research and management treatment approaches.~~
   - B ~~OSU's Commitments to the Public, describing OSU's commitments to actions, approaches and outcomes relevant to conservation, local community and economic development, recreation, education, and tribal engagement.~~
   - C ~~OSU's commitments to the framework for providing transparent and accountable forest management decisions after transfer from the CSF.~~
   - D ~~OSU's commitment to managing a financially self-supporting research forest upon transfer from the CSF and contingent upon the provision of working capital and startup costs that is based on sources of revenue associated with the operation and management of the ESRF.~~

2. ~~Habitat Conservation Plan and related Incidental Take Permit covering federal Endangered Species Act compliance approved by relevant federal regulatory agencies and included in the transfer of the forest from DSL to OSU.~~

3. ~~A Forest Management Plan (FMP) with terms and provisions consistent with the other documents in this section and that binds and guides annual ESRF operations planning.~~

4. ~~A forest conservation easement, deed restriction or other protective covenant that attaches to the ESRF when transferred from the CSF, and reflects key attributes of the ESRF Proposal, including but not limited to the following (subject to approval by the OSU Board of Trustees and DSL):~~
   - A ~~OSU cannot sell, partition, trade or otherwise transfer any portion of the Elliott State Forest/ESRF real property to a third party other than the State of Oregon as part of exercising terms of a reversion right (terms yet to be determined and agreed upon by OSU and DSL). While this document would not prohibit additional acreage from being added to the ESRF over time, it would ensure the ESRF is not reduced from its status subsequent to CSF transfer of the forest to OSU.~~
   - B ~~The ESRF cannot be used as direct collateral for a loan (although the ESRF would be part of OSU's asset base and available for purposes of supporting bond capacity).~~
   - C ~~Prohibition of lease or sale of any mineral resources (including hardrock minerals such as gold or fluid minerals such as oil, gas, geothermal resources), except for rock quarry activity to support the road system or for direct use in the operations of the forest.~~
   - D ~~Prohibition of commercial-scale energy development, including, but not limited to, wind, solar, or hydro, with potential exception for on-site use (including sale of energy to the grid) or for approved research purposes.~~

~~PUBLIC INPUT AND DISPUTE REVIEW~~

~~If members of the public allege that the ESRF is not being managed in compliance with its goals, commitments, terms of transfer, management plans, or applicable laws – and substantiate such allegation in writing in a manner that (1) specifies the connection between asserted facts and the goals, commitments, transfer terms, plans or laws being violated, (2) demonstrates that the alleged non-compliance is substantial and consequential, and (3) establishes that the alleged non-compliance actually harms the person's use and enjoyment of the ESRF – then OSU will provide an administrative review hearing process. Should OSU not respond to a complaint, not recognize the complaint as valid, or rules against the complaint in the hearing, then the complainant will have a pathway to appeal before the Oregon Court of Appeals to address those allegations.~~

~~OSU management activities that are consistent with the foundational documents and/or any revised forest management plan cannot be the subject of an administrative mechanism complaint (examples include but are not limited to intensive management practices in pre-approved locations, harvest of large trees or trees that were eligible for harvest in 2020 but have since aged to be over 65 years, choice of logging systems, or miscellaneous matters related to forest health, timber volume, or employment related issues attached to the ESRF). Should OSU receive a notice showing irreparable harm, and the complainant is likely to prevail, OSU shall provide an expedited hearing (as discussed below). While the specific details governing public input and review/hearing procedures/restrictions are to be developed, the following are examples of potential documentation of and limitations to such actions:~~

1. ~~As part of its accountability and transparency, OSU produces and makes publicly available on the ESRF website:~~
   - A ~~A biennial Forest Operations Plan (FOP) that delineates active forest management actions to be conducted on the ESRF in the 2-year period following the FOP's finalization. FOP development includes public review~~

---

[1] ~~The intent of OSU, DSL, and the ESRF Advisory Committee is that a Forest Management Plan will be collaboratively crafted and adopted by OSU prior to the transfer of the ESRF to OSU unless DSL and OSU agree otherwise after consultation with the ESRF Advisory Committee. Pending transfer to OSU the following limitations on forest management activities will apply:~~

- ~~Management activities undertaken prior to final transfer of the Elliott Forest from the Common School Fund will be the responsibility of DSL and will be undertaken in collaboration with the ESRF Advisory Committee and OSU consistent with preserving the integrity of the research design, terms outlined above, and the financial integrity of the CSF~~
- ~~Forest management activities would be subject to review and comment by the ESRF Advisory Committee~~
- ~~Management activities involving harvests would be limited to partial watersheds identified in the ESRF Proposal outside of the ESRF research watershed replicates, unless otherwise agreed to by OSU and DSL after consultation with the ESRF Advisory Committee~~

~~and comment, as well as input and advice from the ESRF Advisory Committee. Once a FOP is finalized, it will be made public for a period of time (yet to be determined) prior to the first FOP-scheduled activity in order to allow adequate opportunity for comment and response by OSU. The FOP includes:~~

- ~~Description of overall management activities planned to be undertaken during the period of the FOP.~~
- ~~Nature and purpose of on-the-ground activity (harvest, road/trail work, herbicide use, mountain beaver, etc.), including the type of silvicultural prescription to be implemented, if any .~~
- ~~Size and location of individual project areas–reference ESRF Research Design/map.~~
- ~~Description of any significant construction-related activities, including road or trail building/removal or additions/subtractions from existing infrastructure.~~
- ~~Anticipated restrictions (type and duration), if any, to public access from any activity.~~
- ~~Current condition of area to be impacted (including forest age) as well as expected condition and outcomes of implementation (not just research or ecological objectives but anticipated jobs, harvest volume, etc.).~~
- ~~Whether the activity is likely to impact (positively or negatively) threatened or endangered species, water sources, steep or landslide-prone slopes, recreational or educational opportunities, public access (e.g., restrictions during the project or after), tribal partnerships, local community partnerships, workforce and jobs.~~
- ~~A budget reflecting projected revenue and expenses associated with operations, administration, and research treatments and related projects on the ESRF over the relevant FOP period.~~
- ~~Any other information reasonably necessary that demonstrates whether proposed forest management activities are consistent with the FMP and HCP.~~

B ~~An Annual Forest Management Report (AFMR) that documents FOP implementation over its covered period of time, including the following:~~

- ~~Location and particulars of forest management undertaken.~~
- ~~Description of any activity undertaken that was not covered in the FOP and reasons for deviations, if any.~~
- ~~Restrictions on public access, and whether those restrictions were observed.~~
- ~~Primary outcomes from the annual work, including conservation, jobs/economy, recreation, education, partnership objectives.~~
- ~~Financial components related to costs, expenses, revenue generated (from harvest or otherwise) related to ESRF operational viability.~~
- ~~Any other activities associated with advancing public accountability, engagement, and transparency objectives.~~

2 ~~The subject matter for a hearing conducted or authorized by OSU is available in the following limited circumstances:~~

A ~~Alteration of or changes to the foundational documents without prior public engagement and review, ESRF Advisory Committee input and recommendations that the changes are consistent with the intent of the ESRF Research Proposal approved by the State Land Board (a process for revising foundational documents is yet to be determined).~~

B ~~Adoption of an FMP or amendments thereto with provisions contrary to the foundational documents.~~

C ~~Planned (e.g., as set forth in the FOP) or actual (e.g., revealed in the AFMR or otherwise discovered) implementation of actions that are, by clear and convincing evidence, in substantial non-compliance with the FMP and/or foundational documents. The administrative review hearing process would attach only to non-compliance resulting from matters within OSU's knowledge and responsibility (i.e., not force majeure), as opposed to disagreements over the degree or manner in which an otherwise allowable activity is conducted. The following situations are examples of some, but not all, actions that can trigger the hearing:~~

- ~~Harvest treatments or other activities (e.g., road work, herbicide use, etc.) of a nature and type inconsistent with the designation of the watershed within which the treatments occur, or that are contrary to the treatment descriptions contained for that designation in the Research Design or FOP/FMP.~~
- ~~Violation of provisions of the HCP, recorded forest conservation easement, deed restrictions, or other protective covenants.~~
- ~~Harvest in full watershed replicates identified in foundational documents as "Managed Research Watersheds" that is unrelated to a) research, b) maintaining forest conditions in support of future research activities, or c) the funding of research and monitoring-related operational efforts on the ESRF.~~
- ~~Creation of additional reserve acreage (designation or de-facto) beyond what is in the Research Design without the ESRF Advisory Committee's engagement and recommendation.~~
- ~~Creation of harvest volume or financial targets or requirements.~~
- ~~Abandonment of the HCP during its term for reasons other than force majeure.~~
- ~~Failure to implement or adopt elements of the foundational documents, including adoption of recreation and educational plans.~~

SECTION 7

Financing Management, Operations, and Research

Table 1. ESRF Financial Analysis - Annual	
Category	**Estimate**
Total Harvest Revenue (MMBF Harvested)	$5.7M (16.6 MMBF)
Forest Management and Operations Costs	-$2.3M
Net Harvest Revenue	$3.4M
Research Management and Operations Costs	-$5.5M
Subtotal	-$2.1M
Alternative Revenue Needed	$2.1M
Balance	**$0M**

FINANCIAL OVERVIEW

A key foundation for an ESRF is that it will be financially self-sufficient as a research forest based on revenue generated through harvesting operations and other alternative sources of revenue to fund and advance the mission and vision of the ESRF as a research forest Other sources of funding are possible to complement operations revenue sources, such as grants, contracts, gifts, and in-kind contributions from agencies, partners, and collaborators; however, the following financial analysis is based only on harvest revenue, management and operations costs, and research costs.

Financial modeling outputs (i.e., annualized estimated revenue) are averaged to an annualized basis for comparison with annualized estimated costs. Management and operations revenue and costs estimates are based on historic trends–actual revenues and costs will fluctuate both in modeling assumptions and aligning with a forest management plan (yet to be developed). Estimates for research management and operations expenses are included as a direct cost of a research forest.

Based on the current research platform design and allocation of watersheds across the different treatments, preliminary financial analysis demonstrates that the ESRF is not self-sustaining from a financial perspective without an alternative source of revenue to cover the annual deficit, and up front sources of funds to cover contingencies and establishing the ESRF. Currently there is a $2.1 million deficit on an average annual basis for the first 50-years. Given these are estimates and assumptions are conservative, there is flexibility in these estimates if they are close to what is realized over time. Total revenue needed for financial self-support is estimated to be $7.8 million (annualized harvest and alternative sources of revenue, potentially including carbon offsets). This annualized revenue stream would support core annual forest management and operations expenses (including personnel, equipment, fire, and recreation) and core annual research management and operations expenses (including personnel, monitoring (carbon, water, wildlife, and recreation), maintenance, and overhead).

This analysis assumes an even flow of revenue and costs, and does not consider cash flow necessary to implement the research design on the forest, nor does it include an ability to build a financial reserve or endowment to ensure against natural disturbance, market fluctuations, or other factors that could affect revenue generation from the forest. It also is unknown at this time if there will be annual insurance costs beyond OSU's self-insurance policy. Startup investment needs are also identified. These startup costs are associated with purchasing and installing research equipment necessary to measure initial conditions and long-term monitoring for carbon, water, wildlife, and recreation research, as well as other monitoring costs. In addition, investments in building the infrastructure and facilities necessary for a world-class research center are included as startup costs. Startup costs are estimated to be $24.8 million. In addition, OSU will need working capital during the transfer and initial implementation phases before a steady revenue stream is realized from the forest, estimated at $3.3 million per year for three years, or $10 million. Therefore, total startup and working capital costs are equal to $34.8 million.

HARVEST MODELING ASSUMPTIONS

Timber harvests occur on the ESRF to implement the research platform design in allowable harvest areas. One of six treatments were applied to each of the 119 sub-basins. This results in the following acreage allocations:

1. 51,560 acres are in reserve or no harvest classifications (does not include thinning).
2. 30,981 acres are in harvest classifications
   - 15,335 acres in extensive
   - 15,646 acres in intensive

Table 2. Average Annual Harvest Volumes and Acreage				
Category	**Harvests in Intensive**	**Harvests in Extensive**	**Harvests in Reserve***	**Total**
Average Annual Harvest (MMBF)	10.6	3.9	2.1	**16.6**
Range Over First 50-years (Annual MMBF)	1.4-17.2	0-10.7	0-6.6	**N/A**
Average Annual Harvest (Acres)	349	216	171	**736**
Range Over First 50-years (Annual Acres)	64-489	0-747	0-548	**N/A**

**Harvests in Reserves are for restoration thinning and are scheduled to be completed within the first 20-years.*

Harvest revenue is maximized subject to the constraints of standards and guidelines, including Habitat Conservation Plan expectations, riparian prescriptions, reserves, and stand harvest prescriptions. Additional assumptions in the model include:

1. Non-declining, sustained yield flow.
2. OSU Experimental Design treatments were tailored to fit with the existing landscape. Therefore, Intensive management was assigned to young stands, extensive to intermediate and older stands, and Reserves to older stands.
3. Once established, average rotation ages are 60-years for intensive (non-reserve status) and 100-years for extensive
4. Assumed no log exports.
5. Log prices based on current market prices – similar to long term average.
6. No harvest in existing stands >160 years old.
7. Habitat restoration thinning harvests in the reserve areas of the Conservation Research Watershed and the Managed Research Watersheds would occur within 20 years of initial management.

The harvesting model results in approximately 17 MMBF per year while maintaining a consistent revenue stream over time. The average number of acres per year in active harvests (regeneration and thinning) are 736. The initial periods will be higher than this as restoration harvests are conducted in the reserves to set them on their future trajectory as older forests with natural variations, and the latter periods will likely drop to below 600 acres per year in active harvests. These average annual harvest acreages and volumes may change given they are based on even flow assumptions in a financial feasibility analysis, and may not reflect actual operations on the forest over time.

ALTERNATIVE REVENUE

Financial analysis shows a $2.1 million annual revenue deficit for which alternative revenue sources would need to be secured external to OSU. A significant potential source of revenue from the ESRF is through the sale of carbon offset credits certified by the California Air Resource Board (CARB) program based on the current stock and future flow (i.e., tree growth) of sequestered carbon in the forest. A forest carbon offset credit is one metric ton of carbon dioxide equivalent (CO2e) sequestered through management actions and externally validated and registered by CARB. These credits can then be sold on the open market to organizations either required by law to compensate for their own carbon emissions, or that seek to voluntarily offset their emissions.

A detailed analysis was conducted by an independent contractor for OSU and DSL based upon baseline carbon accounting estimates from the forest modeling conducted in 2019, and a draft governance structure. While acreage allocations on the ESRF and California compliance market prices have changed since the modeling work was completed in 2019, values reported here are based on the low range of past and current carbon prices, and do not account for a general increase in sequestered carbon potential that the newer research design is anticipated to provide based on an increase number of acres held in reserve status. It is anticipated that DSL would access the carbon sequestered on the forest (initial period value) for the purpose of paying toward the State's compensatory obligation to the Common School Fund, while the annual payments (yearly vintage value) could be used to recover some of the upfront and alternative revenue needed to ensure the forest is financially viable and sustainable. The yearly vintage value would nearly close the $2.1 million financial gap between annual timber revenue and annual research forest costs. And the initial period value would cover upfront costs needed, but only under a private protocol market.

FOREST MANAGEMENT AND OPERATION EXPENSES

Forest management and operations costs vary based on the number of acres managed/harvest volume. These costs include personnel such as forest manager, foresters, forest engineer, forest technicians, GIS/Inventory technician, wildlife technician, business/log accountant, and recreation coordinator (Figure 11) are estimated to be $1 million. Annual

Table 3. Estimated Carbon Credit Value

Program Type	Initial Credit Period (tonnes)[a]	Initial Period Value	Average Annual Metric Tons of Credit per Year[b]	Yearly Vintage Value
Private Protocol, Compliance Market	4.9M	$49M	105,000	$1.7M
Public Protocol, Compliance Market	0.9M	$9.5M	145,000	$1.7M

[a]*Establishes % of gross credits to be contributed to buffer pool* [b]*Estimated for years 2-10, but will continue for the length of the contract period*

Table 4. Annual Forest Management and Operations Costs

Category	Cost	Notes
Personnel - annual and ongoing	$1.0M	Includes forest manager, foresters, forest engineer, forest technicians, recreation coordinator, GIS/inventory technician, accountant, wildlife technician
Annual maintenance and expenses	$1.3M	Includes fire management, HCP monitoring, business/legal support, vehicle replacement/maintenance, computer/software support, road maintenance, recreation program expenses, rent/supplies
Total Annual Costs	**$2.3M**	

Table 5. Annual Research Management and Operation Costs		
Category	**Cost**	**Notes**
Research Personnel	$2.3M	Includes executive director, communication specialist, public relations/advisory committee coordinator, secretary/receptionist, professorial faculty, technicians, graduate students, student interns
Variable Research Backbone Monitoring Cost	$0.9M	$300K (10%) for inventory, re-measurement, equipment updates $146K (10%) for C, $129K (10%) for aquatic, 200K (20%) for wildlife. Social Science ($100K) or 20%. Misc $25K
Vehicle and Facility Maintenance	$0.1M	Estimated $9 per sq/ft for a 5,000 sq/ft building on an ESRF, maintenance of vehicles $5k per year
IT/Data Storage/Software/QA/QC includes personnel to manage data analysis	$1.0M	Patterned after HJ Andrews annual IT/data costs
Research Equipment Maintenance	$0.2M	Estimate by Katy Kavanagh
OSU Overhead for administrative services (payroll, accounting, etc)	$1.0M	13% of total forest revenue (carbon and harvest) this assumes $7.6 million in revenue per year at 10%
Total Annual Research Expenses	**$5.5M**	

maintenance and expenses associated with forest operations, including HCP monitoring, IT/legal support, vehicle/road maintenance, recreation program, fire management, and miscellaneous rent/supplies are estimated to be $1.3 million. Total annual forest management and operations costs, as detailed below, are estimated to be $2.3 million.

RESEARCH MANAGEMENT AND OPERATION EXPENSES

Research management and operations costs are also estimated and included here as fixed annual costs to oversee and manage research activities in the forest. Annual research personnel costs include an executive director, communication specialist, public relations/advisory committee coordinator, secretary/receptionist, professorial faculty, research technicians, graduate students, and student interns (Figure 11) are estimated at $2.3 million. Annual variable research monitoring and equipment upagerades are estimated at $0.9 million. Annual maintenance of vehicles and facilities are important, and are estimated at $0.1 million. Active large-scale research such as that proposed for the ESRF, as well as inventory and monitoring data, requires significant annual investments in IT, software, and data storage, and are estimated at $1 million. Research equipment is anticipated to be placed throughout the forest to collect carbon, wildlife, water, and recreation data; annual maintenance costs of this research equipment is estimated at $0.2 million. Some support services will be accessed through OSU, and compensation of these resources is anticipated to be approximately 13% of total annual revenue, or $1 million. Total annual research management and operations costs are estimated to be $5.5 million.

WORKING CAPITAL AND BUILDING RESEARCH CAPACITY AND INSTRUMENTATION EXPENSES

It is anticipated that it will take approximately three years for transfer of the property to OSU and before a revenue stream is generated from the forest. However, inventory, monitoring, and wildlife surveying must be conducted in a timely manner to expedite transfer and begin revenue generation. It is estimated that $3.3 million per year for three years is needed in working capital, or $10 million.

Implementing the research design and meeting the goals and objectives of the ESRF will require major investments in facilities and infrastructure, and instrumentation for research and monitoring. While these startup investments are not part of the financial analysis, they are related. If debt is incurred by the ESRF in order to cover these expenses, then annual debt payments will be assessed against the annualized net revenue generated from the forest. Many of these foundational expenses would accrue at the beginning of the enterprise, e.g., capital construction of the ESRF Research Station or installing research instruments to capture baseline data prior to any landscape or resource changes.

Four primary categories of startup costs are identified, including:

1. **Infrastructure / Research Station -** this includes facilities that would house research labs; bunkhouses for scientists, students and others actively engaged in research and educational activities where onsite lodging is needed; workshop; climate-controlled storage; classrooms; and an event/visitor center. Comparable research stations cost $17 million to construct.

2. **Vehicles / Accessories -** an estimated 15 vehicles dedicated to research activities would be needed to ensure access to research sites and are estimated to cost $0.5 million. These vehicles would be in addition to those needed for the operations side of the forest, although some dual purpose of them could occur.

3. **Research Plots and Inventory -** an integral part of a research project is the development of permanent and temporary research plots. Inventory would be a combination of lidar and aerial photography. The development of a forest management plan is prefaced on having good inventory data. While it is not possible to conduct an inventory on all acres simultaneously, the staged implementation of the research design enables this work to be done over time. However, ensuring that funds are available to complete this work in an ongoing manner is critical to the success of an ESRF. Research plot and inventory costs are estimated to be $3 million.

4 **Priority Research Areas -** four research areas were identified as being high priority and that require baseline data collection and long-term monitoring. These four areas align with public values for the forest, and will help to assess the College's success at meeting its commitments as well as sustaining them over time.

A **Carbon / Climate Monitoring -** carbon measurement and monitoring meets several objectives of the forest, including aligning with carbon offset credit tracking. Needed equipment includes carbon soil pits, C/N analyzers, drying ovens, etc., to measure carbon concentration and decomposition rates in live and dead wood, forest floor, and soil. Climate measurement and monitoring equipment and labor includes climate and soil stations for measuring temperature, precipitation, relative humidity, soil moisture, and radiation. Equipment and labor costs are estimated to be $1.5 million.

B **Aquatic / Riparian Monitoring -** measurement and monitoring includes conducting fish surveys and assessing and tracking stream morphology. Equipment and labor would be needed for weir construction; sensors for water temperature monitoring (longitudinal stream and air), flow, and turbidity; autosamplers for measuring suspended sediment/solutes/dissolved oxygen; and data loggers for automated data collection. Equipment and labor costs are estimated to be $1.3 million.

C **Wildlife Monitoring -**various equipment and labor is needed to measure and monitor a variety of wildlife that are important indicators of ecological quality and resilience. These include the establishment of vegetation plots, wildlife cameras (primarily for mammals), and arthropod/bee/salamander monitoring. Also important is instrumentation of the forest for measuring and monitoring marbled murrelet and spotted owl (as well as songbirds) through wildlife surveys (complements community science efforts) and bioacoustic technology. In addition, some eDNA sampling and analysis may be conducted. Equipment and labor costs are estimated to be $1 million.

D **Social Science / Recreation Monitoring -** measuring and monitoring how people, both on and off the forest, are affected by landscape changes and recreation infrastructure development is an important aspect of learning from the forest. Equipment and labor needs include infrared trail counters, recreation cameras, permanent and portable roadway traffic counters, and surveys of recreation users and surrounding communities (or regional/statewide). An assessment of biophysical locations for the development of trail systems/networks would be important to developing a recreation management plan. In addition, the establishment of permanent photo plots for illustrating and tracking landscape changes for use in evaluating public perceptions and values of these changes. Equipment and labor costs are estimated to be $0.5 million.

Table 6. Estimated Working Capital and Startup Research Costs

Category	ESRF	Notes
Working capital	$10M	Working capital for three years during transfer phase
Infrastructure/Research Station	$17.0M	Research facility that includes labs, bunkhouses, classrooms, shop, climate-controlled storage, event center
Vehicles & Accessories	$0.5M	Estimated 15 vehicles at $34,000 ea. for vehicle and accessories
Research Plots & Inventory	$3.0M	Aerial and ground based LiDAR, aerial photography and permanent or temporary plot installation
Carbon/Climate Monitoring Equipment	$1.5M	Carbon soil pits, lab equipment for analysis, climate/weather stations
Aquatic/Riparian Monitoring Equipment	$1.3M	Fish surveys, stream morphology, sensors for temperature, discharge, suspended sediment, stream and air temperature
Wildlife Monitoring Equipment	$1.0M	Vegetation plots, bioacoustics, wildlife surveys, cameras, eDNA sampling and analysis
Social Science / Recreation Monitoring Equipment	$0.5M	Infrared trail counters, recreation cameras, traffic counters, community surveys and assessments, photo plots
Total Start Up Expenses	**$34.8M**	

SECTION 8

Appendices

The following appendices are included to provide additional context and detail on the research platform.

Appendix 1	Research Charter
Appendix 2	Research Opportunities Within the Triad Research Design
Appendix 3	Example Research Projects
Appendix 4	Draft Research Treatment Allocation Process
Appendix 5	Descriptions of Research Treatments (intensive, extensive, reserve)
Appendix 6	Aquatic and Riparian Area Research Strategy
Appendix 7	Riparian Area Research and Conservation Treatments
Appendix 8	Integrating Riparian Areas with Adjacent Research Treatments
Appendix 9	Figures, Tables, and Photos
Appendix 10	Power Analysis of the Elliott State Forest Research Design
Appendix 11	Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest
Appendix 12	Summary of the Research Design for Peer Review
Appendix 13	Summary of Peer Reviews
Appendix 14	Summary of Science Advisory Panel Engagement and Feedback

APPENDIX 1

Research Charter

NOTE: This document was originally delivered to DSL director Vicki Walker in Dec. 2019. Minor updates have been made to ensure this document is consistent and integrated with the full ESRF proposal. The revised version is included below.

Prepared by the Exploratory Committee for the Elliott State Research Forest. The committee consists of ten members from College faculty, staff, and outside the University representing a variety of scientific fields including forest biological, physical, and social sciences. By bracketing perspectives on the committee such as; thought leaders and appliers, those with global and local experiences, focused researchers and educators we are maximizing participation and broadening the dialogue in the College and beyond.

FOREWORD

Forests are integral for the health and wellbeing of humanity, as well as to the conservation of biodiversity and ecosystem functions and services. With increasing global demand for forest products and with influences from a changing climate, it will be critical to find constructive ways to provide these essential resources without compromising global forest biodiversity, carbon sequestration, and ecosystem health. We propose that the Elliott State Research Forest (ESRF) be a center – both in Oregon and worldwide – for sustainable forestry using the scientific method.

Two major alternatives have been put forth to minimize tradeoffs between timber production and ecosystem health. First, extensive management attempts to mimic natural disturbances using adaptive silviculture regeneration techniques such as retention harvests. However, such ecological approaches tend to have less timber production per unit area, and thus require a higher proportion of the landscape to meet fiber demand.

Alternatively, others suggest conserving portions of the forest in strict reserves, while using intensive forest management, such as even-age regeneration harvests and plantations, to generate the necessary wood supply on a smaller area in comparison to extensive management. There are a variety of intermediate options that vary the proportions of reserve, intensive management and extensive management in the landscape and can be encompassed into a Triad design. The overarching objective of the ESRF will be to provide the first landscape-scale experimental tests of such strategies for producing timber products while minimizing risk to forest ecosystem services.

ESRF Exploratory Committee Members		
Member	**Expertise**	**Affiliation**
Katy Kavanagh (Chair)	Associate Dean of Research	College of Forestry
Matt Betts	Landscape Ecologist; emphasis on biodiversity	College of Forestry
Ashley D'Antonio	Recreation Ecologist	College of Forestry
Shannon Murray	Continuing Education Program Coordinator	College of Forestry
Klaus Puettmann	Silviculture, Forest ecology	College of Forestry
Meg Krawchuk	Landscape Ecologist, fire & conservation science	College of Forestry
John Sessions	Forest Engineer, Forest Operations Planning & Management	College of Forestry
Ben Leshchinsky	Geotechnical Engineer; focus on forest road design, hydrologic process, landslides, and slope stability	College of Forestry
Jenniffer Bakke	Wildlife Biologist, Environmental Services Manager	Hancock Natural Resource Group
Clark Binkley	Managing Director	Institute for Working Forest Landscapes
Gordon Reeves	Aquatic Ecologist	USFS, College of Forestry

RESEARCH CHARTER INTRODUCTION

"The ultimate goal of the research programs at the OSU College of Forestry is to provide innovative approaches to enhancing people's lives while also improving the health of our lands, businesses, and vital ecosystems, and to do so collaboratively with active involvement of multiple partners with different perspectives."
- OSU Institute for Working Forest Landscapes, 2013, page. 1.

The ESRF would become an integral part of realizing this vision. This Research Charter is intended to guide the design and implementation of research on the Elliott forest over time, and in doing so ensures that these important tenets of the Institute are honored. Work on the Charter will progress until all of the components are fully described so that it will guide governance and remain fundamental to management of the forest into the future.

COLLABORATIVE APPROACH

The collaborative component of this research plan to date has incorporated input from local citizens and other stakeholders from public listening sessions, focus groups, the Department of State Lands Advisory Committee, and information received in discussions with the local tribes. We incorporated this information into our overarching research theme, desired outcomes, the selection of a diverse set of treatments and need to have specific research questions that could be tested under these sets of treatments. We are continuing to receive input and as this research plan is still a draft document, we fully expect to incorporate additional input by engaging constituencies in discussions with the Exploratory Committee about key areas for research inquiry into the future. We will have continued collaboration on subsequent drafts of the experimental design, implementation and monitoring.

1 GUIDING PRINCIPLES FOR RESEARCH

Guiding principles are the foundation for establishing a long-term research program that remains focused and relevant to the overarching vision set forth by the Oregon State Land Board. In December 2018, the Oregon State Land Board directed the Oregon Department of State Lands (DSL) to work collaboratively with Oregon State University (OSU) to develop a plan for transforming the Elliott State Forest into a research forest. A successful plan will be consistent with the Land Board vision for the forest, which includes:

- Keeping the forest publicly owned with public access
- Decoupling the forest from the Common School Fund, compensating the school fund for the forest and releasing the forest from its obligation to generate revenue for schools
- Continuing habitat conservation planning to protect species and allow for harvest
- Providing for multiple forest benefits, including recreation, education, and working forest research

An ESRF program must rise to the true potential associated with the size and complexity of the Elliott by ensuring that it fosters research that is enduring across generations, takes advantage of the forest's size, landscape, and habitat characteristics, and is highly relevant to Oregon and beyond. Research initiatives executed on the forest must collectively support a unifying question so that the collective work of different research program initiatives will collectively contribute to a greater body of work over time.

Principle 1: Research

The ESRF will be managed to advance and sustain science-based research that does not introduce statistical bias. All management objectives related to fulfilling other public values as well as revenue generation on the forest will be accomplished within a

Figure 1a. Research Charter Diagram

***Figure 1a.** Diagram of the process and content of the Research Charter for the Elliott State Research Forest.*

research first context. Fundamental to this vision for a research forest is the use of unbiased locations of treatments and controls, adequate unit size to avoid edge-related influences, manipulative experimentation to understand the processes controlling the response, and sufficient longitudinal observations to assess both short- and long-term response. The statistical analysis will attempt to further improve the comparability of treatments, e.g., through analysis of covariance.

Principle 2: Enduring

The overarching research question for the ESRF should aim to remain relevant across many years, generations, and social, economic and environmental contexts. Though research programs and projects on the forest may address more immediate challenges and current needs, the greater arc of the research will take advantage of the University's tenure and consequent stability and mission-based research focus as a Land Grant Institution. Long-term monitoring and adaptation will be incorporated to determine if it is possible to sustain a system-based approach to exploring the integration of plantations, forest reserves, aquatic and riparian ecosystems, and actively managed multiple-strata forests through time. Designed treatment protocols will sustain ecological function and biota by retaining valuable biological legacies that represent complex early successional through late-successional attributes.

Principle 3: At Scale

An overarching research question, research design, and long-term monitoring on the ESRF should leverage the unique opportunity the forest offers for experiments at large spatial and long temporal scales. While different research may be conducted on different areas within the forest, the entirety of the forest should advance knowledge under an overarching research question. **Most importantly, the size of the ESRF will enable us to explore and quantify the synergies and tradeoffs associated with different amounts and arrangements of treatments at a landscape scale through time.** We can experimentally test the ability to emulate the natural range of natural disturbances that were historically typical of the Oregon Coast Range (and natural disturbances that may not have analogs in the past). By maintaining these experimental treatments through time we will observe the full suite of outcomes, including impacts on nutrients, wildlife, fish, aesthetics, and cultural values.

Principle 4: Tailored to the Landscape

The overarching research question will guide the research design and will be tailored to the ESRF based on existing biological, physical, social, and economic conditions. Research treatments will represent and reflect the diverse age class and disturbance history of the forest, and to the maximum extent possible, utilize previously managed stands. The experimental design needs to be tailored to ensure that research on the forest takes full advantage of the forest's capacity to provide knowledge while addressing research themes that are highly relevant beyond the borders of the ESRF, the State of Oregon, or even North America.

Principle 5: Practical, Relevant, and Collaborative

The Land Grant mission of Oregon State University and the history of the Elliott State Forest as a public forest require that research conducted on the forest be relevant to forest management issues and challenges facing Oregonians. Setting the objectives of a research program as it grows over time will require active engagement of a cross-section of stakeholders who work closely with the University to ensure that this publicly owned research forest continues to serve the public with credible, relevant and timely science. We will actively engage and collaborate with the greater research community and a cross-section of stakeholders to ensure the research treatments achieve desired goals of the ESRF and are based on sufficient data to design appropriate experimental protocols.

2 OVERARCHING RESEARCH THEME

Research synergies and tradeoffs for conservation, production, and livelihood objectives on a forested landscape within a changing world.

The overarching research theme is the umbrella under which different research areas and program initiatives reside. Research conducted under this broader inquiry should meet the guiding research principles while addressing the desired outcomes.

3 DESIRED OUTCOMES

These are the outcomes that an ESRF will support and achieve over time as part of the Institute for Working Forest Landscapes. In doing so, these outcomes will set the context for linking together a diverse research program framed around the overarching research question to yield prominent, relevant and rigorous science.

Specific to the Overarching Research Question:

- Successfully install a landscape level research platform on the ESRF that uses a systems-based approach (Figure 1) to investigate the integration of intensively managed forests, forest reserves, dynamically managed complex forests and the aquatic and riparian ecosystems that flow within them.
- Being able to answer a long-standing question; given the societal need for a determined volume of wood supply, what is the best combination, in amount and spatial arrangement, of reserves, intensive and extensive (complex) forestry (at the landscape-level) to supply wood while maintaining water quality, biodiversity, human needs and other forest ecosystem services.
- An experimental design that is robust enough that natural disturbances will not disrupt the long-term goals. We fully expect disturbance to be an integral part of the design.
- A research platform that is capable of incorporating a wide variety of research that varies in spatial and temporal scales.
- A nested set of experiments capable of producing data sufficient in time and space to prove or disprove hypotheses arising from our research question.

Overall

- **Increase Public Trust in Active Management of Public and Private Forest Lands.** Restoring broad scale public understanding and trust entails more than compliance with existing laws. It requires proactive, transparent, and collaborative land management so that multiple interests are vested in the outcomes sought.
- **Improve the Health of Rural Economies, Communities, and People.** The economic base and future opportunities of rural communities can be strengthened by a more diverse economy that is interwoven with a fully functioning working landscape – one that integrates production of merchantable timber with restoration activities, ecosystem services, conservation and recreation/tourism-based markets.
- **Increase the Competitiveness of Oregon's Private Landowners and Businesses.** Capitalizing on the true potential for our westside private forests to compete in expanding world markets for value-added products will require driving innovation at all stages of forest land management from seed stock to harvest methods.
- **Enhance Ecosystem Resiliency.** Implementing and studying a landscape scale approach to forestland management to further forest resilience through changing global environmental and social conditions.

4 EXPERIMENTAL DESIGN INTRODUCTION

Research conducted under this broader inquiry should meet the guiding research principles; science-based, enduring, at scale, tailored, and relevant while addressing the desired outcome of understanding **synergies and tradeoffs of conservation, production and livelihood objectives on a forested landscape within a changing world.**

Approach

Our goal is to investigate promoting biodiversity, ecosystem processes, and ecosystem services while achieving a given fiber supply using existing and novel land management strategies. As our research framework for this investigation, we will use a Triad design. The Triad design is a triangle with its endpoints being reserve, intensive and extensive stand management practices applied in varying proportions. The endpoints are structured under the premise that as you intensify management, you are able to increase the amount of land in reserve, while maintaining a stable output of products or values. Extensive stand management, where multiple ecosystem service objectives are met, with no separate lands set aside as reserves. As contrasted by a dichotomy of intensively managed lands for wood production coupled one to one with reserves. The larger amount of intensively managed land would equate to a larger amount of reserves. Within the Triad design we will integrate a set of riparian conservation areas (RCA) that play a key role in integrating the aquatic and terrestrial ecosystem management.

A **The goal of 'Reserve' research treatments** being very limited intervention and management with initial treatments focused on restoration and enhancing conservation values in the prior plantation areas then transitioning towards no further harvests. In cultivating natural forest successional processes, one-time thinning would be done for ecological purposes in stands that regenerated following clearcut logging. Natural processes would be unmanaged and allowed to create disturbances and seral stages (with the exception of fire). The forests receiving this treatment are located in the western and northern watersheds and the older forests in the remainder of the Elliott.

B **The goal of intensive research treatments** being to maximize wood productivity per acre. Research treatments in these forests will allow us to investigate management options that primarily emphasize the production of wood fiber at rotations of 60 years or longer. At the same time, we can assess methods to reduce the impact of this harvest regime on other attributes such as biodiversity, habitat, carbon cycling, recreation, and rural well-being. These treatments are explicitly applied in areas with younger, previously managed forest stands. The production of wood is an important contribution to society. Intensive treatments will serve as a benchmark for wood production potential and trade offs associated with wood production relative to extensive and reserves.

C **The goal of the 'extensive' research treatments** will be to explore the implementation of a new set of alternatives to intensive plantation management and unmanaged reserves thereby expanding the frontiers of forest management. Research on "extensive" alternatives will aim to accomplish diverse forest characteristics to meet a broad set of objectives and ecosystem services while simultaneously achieving wood production. This will be done by retaining structural complexity while ensuring conditions exist to obtain regeneration and sustain the complex forest structure through time. These treatments are applied across watersheds within stands representing most age classes.

D **The goal of the riparian conservation areas (RCAs)** will be to maintain and restore vital ecological processes that influence the aquatic ecosystem in the intensively managed and extensively managed treatments. The aquatic and riparian conservation component of the system-based research strategy will rely on a set of designated RCAs.

Subwatershed Catchments

The experimental unit of measure will be subwatersheds 400 to 2000 acres in size. The 66 subwatersheds in the ESRF are designated to be in either the Conservation Research Watersheds (CRW) or Management Research Watersheds (MRW), (Figure 5) with over 9,000 acres in partial watersheds that were either less than 400 acres or not fully contained within the ESRF. Subwatersheds were chosen to give us defined boundaries (ridges) and the ability to use water as an integrator of treatment effects. With 40 subwatersheds, we could have approximately 10 replicates per treatment level.

Forty watersheds that are wholly contained within the MRW will receive the varying treatments outlined in Figure 4. The sizes of the individual reserves will range from 80-1000 acres, depending on the percentage of the subwatershed in reserve, the spatial arrangements of the reserves and size of subwatershed. We assessed the level of prior forest management in each subwatershed by looking at stand age. Since the first logging started circa 1955, we concluded any stand younger (based on the 2020 inventory) than this was a result of harvest including disturbance and salvage. Stands older than this are primarily a product of stand replacing fires. Overall, about 50% of the Elliott State Forest has had a regeneration harvest in the 65 years preceding the 2014 inventory. The percentages of the individual subwatersheds in the MRW that are less than 65 years old range from 19% to 98%.

- Extensive or treatment 1 would be 100% extensive stand management across the entire subwatershed.
- Triad-E or treatment 2 would have 60% of the sub basin acreage in extensive, 20% intensive and 20% reserve stand management.
- Triad-I or treatment 3 would have 20% of the sub basin acreage in extensive 40% intensive and 40% reserve stand management.
- Reserves with Intensive or treatment 4 would have 50% of the sub basin acreage in intensive and 50% reserve stand management.

SCOPE OF INFERENCE

In the strictest sense, the scope of inference for any statistical results based on the proposed design will encompass only these particular subwatersheds in the ESRF. However, by using manipulative experiments and conducting scientific research to understand mechanisms controlling responses – the work will be generalizable beyond the scope of the Elliott especially if they are contributing to a process model or other modeling framework. In addition, there is no reason to believe that observed relationships between different forest management approaches and ecosystem processes and services will be relevant only to the conditions that exist in the ESRF. Given this, inference of many results can be extended at least to

Figure 4. Triad Landscape-level (Subwatershed) Treatments

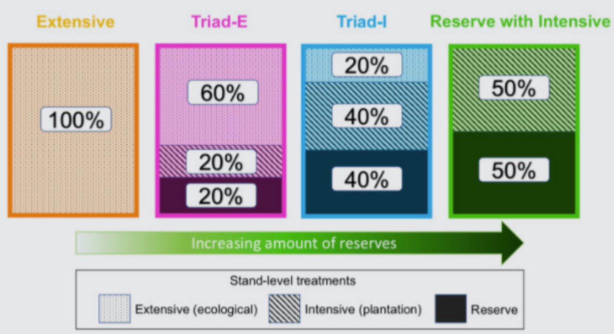
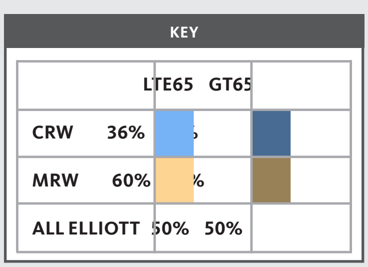


Figure 4. *The four Triad treatments that we will apply at the subwatershed scale at the ESRF. All of the subwatersheds (400-2000 ac) in the Management Research Watersheds will receive one of these four treatments. Treatments are designed to produce approximately equivalent wood yields using different combinations of stand-level treatments: reserves, extensive (ecological forestry) and intensive management (plantations). The 'Extensive' Triad treatment (orange) will be 100% ecological forestry, the 'Reserve with Intensive' Triad treatment (light green) will comprise 50% intensive forestry and 50% reserve. 'Triad-E' and 'Triad-I' contain differing proportions of reserve, ecological and intensive forestry.*

Figure 6. Age class distribution in the Conservation Research Watershed and the Management Research Watershed



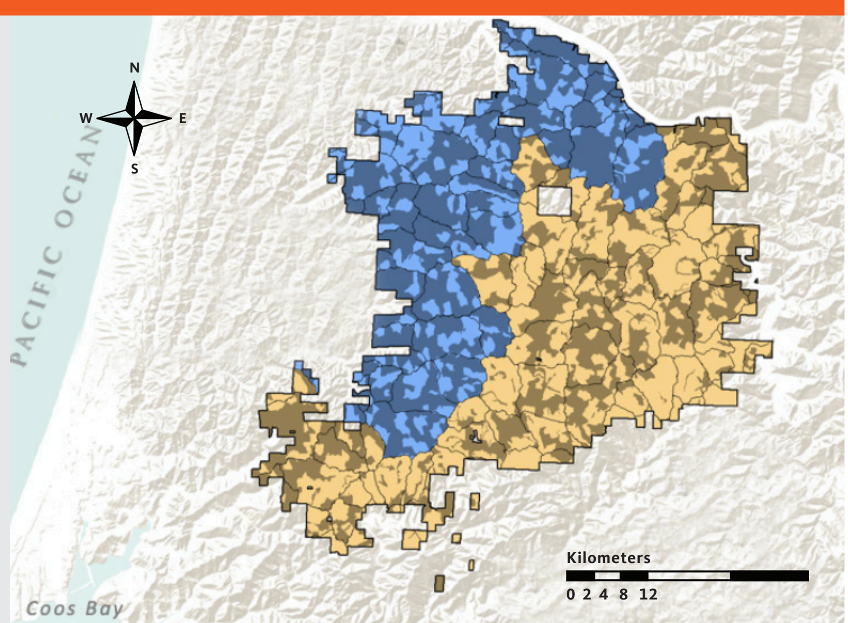


Figure 6. *Subwatersheds of the Elliott State Research Forest color coded by classification into the Conservation Research Watersheds (CRW) and Management Research Watersheds (MRW) and color coded by stand age greater than 65 years (GT65) and less than 65 years (LTE65). Uncolored regions indicate this portion of watershed is not part of the proposed Elliott State Research Forest.*

places with similar forest structure in the same region. Other jurisdictions in tropical and temperate zones have already expressed an interest in mirroring this research design. With this commitment and potential for replicates beyond the Elliott, the scope of inference will broaden significantly.

SUMMARY

Using this approach, future generations can ask and answer what, in times of rapid change, are the most effective means of ensuring biodiversity, ecosystem processes, and ecosystem services are sustained while achieving a sustainable wood supply? The fundamental aspiration for an ESFR is to have an experimental design that is broadly applicable, capable of testing basic knowledge, answering why and how, be based on experimentation, and developing and deploying solutions all while maintaining the capability of addressing the current and next generation of forest-related research and policy questions. We believe we are well positioned to achieve these ideals.

5 THEMATIC RESEARCH AREAS

Thematic areas define the boundaries for which individual research program initiatives can nest within the overall research theme. These areas describe the "playing field" that collectively defines how research on the forest will support the big, overarching research question. While the thematic areas may evolve and change over time, in respects to the context of adaptive capacity and governance, they are intended to function as guideposts to ensure focus and continuity of research programs in service of the long-term goals of the forest. The thematic areas are intended to provide opportunities for nested sets of research activities, including short-term studies of specific research questions that are compatible with the research design.

An initial set of thematic research areas are being identified and developed as the Research Charter is discussed and finalized with input from stakeholders both internal and external to the College of Forestry. The following areas have already been highlighted in initial conversations:

- **Biodiversity and At-Risk Species:** As the Elliott contains a number of potentially at-risk and sensitive species, research needs to address the most pressing of issues associated with sustaining and enhancing terrestrial and aquatic species in the context of managed forested landscapes.
- **Climate Change Adaptation:** Forest and ecosystem health related to climate change impacts; research to identify potential suite of management approaches to help mitigate impacts with a goal of forest resiliency and reduced vulnerability.
- **Natural and Human-Caused Disturbance:** Disturbances such as landslides, debris flows, fires, different types of harvest regimes and recreation all play a crucial role in forested landscapes. The Elliott has and will continue to be the site of significant disturbances – whether natural or human-caused. Research conducted on the forest will be tailored to account for this important opportunity.
- **Structure:** The Elliott has demonstrated inherent potential for older, larger trees to dominate as well as complex early seral that can potentially dominate the northwest forests associated with our region. Research will explore management options that provide for a variety of stand structures, including late-successional conditions, and associated range of biodiversity, wood products and ecosystem services.
- **Socio-economic and cultural impacts.** Opportunities to investigate the human dimensions of a Triad dichotomy. A massive opportunity given to study community engagement and collaborative governance.
- **Water Quantity and Quality in Relation to Forest Management:** The Elliott provides excellent opportunities to develop better scientific understanding of the effects and biological responses of natural and human-caused disturbances in forest landscapes on water quality and quantity.
- **Landscape and Scale Issues.** Opportunities to investigate the role of adjacency, fragmentation (amount and shapes), and connectivity on e.g., source-sink relationships, migration potential (rates and barriers) for plants and animals, habitat area-population size relationships, edge effects.

6 PROJECTS AND PROGRAMS

See Appendices 2 and 3 for lists of nested research opportunities, potential collaborations, and examples of research programs in key areas.

APPENDIX 2

Research Opportunities Within the Triad Research Design

Our vision is to conduct research on a large landscape that leads to science that addresses how forests can help achieve broad-scale conservation goals and alleviate climate change, all while producing fiber for a growing population and meeting various social and economic needs.

The goal of research on the ESRF is to advance more sustainable forest management practices through the application of a systems-based approach to investigating the integration of intensively managed forests, forest reserves, dynamically managed complex forests, and the aquatic and riparian ecosystems that flow within them.

Notably, the ESRF's size will enable us to explore and quantify the synergies and tradeoffs of these land management practices at a landscape scale through time. We will quantify the complex relationships among the multiple ecological, economic and social values in response to experimental landscape-scale treatments. To honor the rich legacy of this land, the ESRF should do nothing less than attempt to reimagine the future of forestry.

The below list are the types of potential short- and long-term research projects, questions, and collaborations that can occur on the ESRF.

The list is a result of conversations with the ESRF Exploratory Committee, researchers and collaborators participating in the college's Fish and Wildlife Habitat in Managed Forests Research Program, and external reviews from research faculty at the University of Oregon, Swedish University of Agricultural Sciences, University of Sheffield (UK), The National Center for Air and Stream Improvement, Colorado State University, and OSU.

Research at the ESRF should extend well beyond OSU. As we have for many of our programs, OSU will continue to look for partnerships and collaborations with local, state, regional, national, and international colleagues.

CLIMATE CHANGE & CARBON

- Microclimate instrumentation and modeling such as forest canopy wetness, temperature dynamics and accompanying physiological research.
- Interdependence of carbon sequestration and biodiversity across regions.
- Modeling of forest carbon, water stocks and fluxes to examine questions like the impacts of harvesting on carbon stocks, fluxes, and surface energy balance.
- Does terrain and fog in this rugged ecosystem provide hydroclimatological heterogeneity that contributes important biophysical refugia and environmental buffering to this system?
- Can we use forest management and conservation approaches to support ecosystem resiliency in a changing climate?
- What is the relationship between forest management practices and carbon cycling in temperate, conifer forests? The question can include an assessment of above and below ground (soil and root) carbon stocks.
- What are the impacts of climate change on soils, soil resources and soil processes? Contemporary harvesting practices have potentially brought down sedimentation levels back to normal levels, but rare events could negatively impact this outcome.

SOCIAL ECONOMIC & RECREATION

- How do we monitor and manage human access to forested landscapes across large spatial and temporal scales?
- How do we efficiently and effectively monitor the levels and patterns of recreation when it is low and highly dispersed/diffused across a large area?
- How do different management practices influence the social capital of stakeholder groups?
- How do we incorporate traditional ecological knowledge into the research, education, and outreach objectives for the ESRF?
- How do recreationists' perceptions of management practices change in relation to management treatments, and over time as landscapes change?
- How are experiences and values influenced by tree density and age, slope, viewshed, trail complexity and difficulty?
- What are the types, levels, and extent of recreation-related impacts across the ESRF?
- What are the socio-economic and cultural impacts of the management treatments?
- How do we provide a sustainable supply of forest products without compromising cultural ecosystem services?

AQUATIC

- Developing an intrinsic potential model from LIDAR to evaluate habitat conditions for Coho Salmon under different scenarios of forest management.
- Implementing stream temperature network instrumentation to evaluate downstream effects of forest management.
- Utilizing environmental DNA to assess aquatic biodiversity across working forests.
- How does the forest structure created by regeneration management and natural disturbances affect streams?
- How does timber harvests or fire influence how water storage and transit times change within a catchment? Is there a gradient considering a range of management activities?

- How does the gradient of potential management activities affect hydrologic and geomorphic processes (flow of groundwater, water T, landslides, debris flows, wind throw)? Is there a threshold where management levels produce a significant change?

FOREST PRACTICES & MANAGEMENT

- How do alternate road surfacing systems perform (operational performance, environmental impact, cost, sensitivity to fire, etc.)?
- Measure forest worker hazards recognition and risk assessment in complex silviculture systems.
- How can forest operations minimize energy consumption by comparing new ground-based steep slope harvesting systems and traditional cable systems?
- Partner with research forests throughout the globe to create a mirrored experimental project in a tropical forest.
- How does the gradient of potential management activities affect hydrologic and geomorphic processes (flow of groundwater, water temperature, landslides, debris flows, windthrow)?
- How does the frequency and magnitude of landslides change in managed and unmanaged terrain? How does this compare under baseline conditions or extreme events?
- What are organismal responses to harvest? How do harvests impact the dispersal of organisms that have sub-stand home range?
- What is the best way to meet the increasing wood demand while minimizing costs to other ecosystem processes/ services (including biodiversity)?
- Are there ways to conduct harvest system planning that lessens impacts on soil and water?
- Can we achieve a combination of biodiversity conservation and timber production goals under various climate change projections?

FIRE/DISTURBANCE

- Measure large-scale, prescribed fire impacts on terrestrial and aquatic ecosystems.
- Do natural influences (extreme events, geology, climate) outweigh management activities in the long-term?
- How do disturbances (fire, wind, invasive species) move across the landscape with different levels of management?
- Does a combination of management and prescribed fire improve ecosystem resilience to wildfire?
- How did historical indigenous burning practices influence the current ecosystem structure and function? What can we learn from these past practices that improve modern system function?

SOIL

- How will climate change impact soil productivity?
- How do intensive and extensive forest management practices influence soil productivity, nutrient stocks, and soil carbon?
- How does the inclusion of fire in management systems influence soil biodiversity and function?
- How do various management treatments influence soil biodiversity, composition and function? How does this change over time?

TERRESTRIAL

- How does edge density/ distance to edge influence marbled murrelet occupancy rates and nest success?
- Does mature fragment size influence occupancy and nest success?
- What management strategies best conserves Marbled Murrelet populations?
- How can we utilize audio data to monitor for species in diverse and expansive terrains?
- How do thinning activities impact nest success?
- Does edge contrast matter (mature forest to intensive management versus mature forest to 'ecological forestry')?
- Do conclusions about land management strategies from tropical agricultural landscapes hold, or are an entirely different set of hypotheses supported?

FISH AND WILDLIFE HABITAT IN MANAGED FORESTS (FWHMF) CONCEPT SUBMISSIONS

The FWHMF program's mission is to provide new information about fish and wildlife habitat within Oregon's actively managed forests through research, technology transfer, and service activities. The goals are to provide the information needed by forest managers to guide responsible stewardship of fish and wildlife habitat resources consistent with land management objectives, and by policy makers to establish and evaluate informed forest policy and regulations. Below is a list of concept research project submissions by OSU researchers and collaborators that could occur on the ESRF.

- How do riparian forest gaps affect macroinvertebrates and fish diet in headwater streams? –Dana Warren
- Development of a UAV based method of assessing the effectiveness of riparian areas in regulating stream temperature- Bogdan Strimbu, Kevin Bladon
- Balancing values in forested landscapes: Prioritizing distributions of beaver dams in riparian systems- Jimmy Taylor, Jason Dunham, Brenda McComb, Vanessa Petro, John Stevenson
- Choosing retention trees for cavity nesting wildlife- David Shaw, Jared LeBoldus, Joan Hagar, Francisca Belart
- The impact of fire and management actions on demographic rates of a forest health indicator group- James W. Rivers, Jake Verschuyl
- Aggregated early seral habitat in intensively managed plantations – do songbirds notice? - Klaus J. Puettmann, Matthew Betts
- Development of molecular monitoring tools for enhanced management of high priority species- Taal Levi, Brian Sidlauskas, Jim Rivers, Rich Cronn, Brooke Penaluna

- Biodiversity in natural and managed early seral forests of Southern Oregon - Meg Krawchuk, Matthew Betts, James Rivers, A.J. Kroll, Jake Verschuyl
- Assessing pollinator response to forest management: Method development that will determine the soil and ecological factors controlling the distribution of ground-nesting bee nests- Jeff Hatten, Jim Rivers, Ben Leshchinsky, John Bailey, Rebecca Lybrand, Chris Dunn
- Purple martins as indicators of high quality early seral forest habitat - Joan Hagar, Taal Levi
- Impacts of cable-assisted steep slope harvesting on soil and water resources- Woodam Chung, Kevin Bladon, Jeff Hatten, Ben Leshchinsky, and John Sessions
- Early seral habitat longevity in production forests in the Oregon Coast Range - Matt Betts, AJ Kroll
- Effect of tethered assist harvesters on water quality- Francisca Belart
- How does contemporary forestry influence aquatic food webs in headwater streams? – Ivan Arismendi, Dana Warren
- Development of molecular monitoring tools for enhanced management of high priority species – Taal Levi, Jim Rivers
- Reducing sediment discharge from forest roads using alternate surfacing materials – Kevin Lyons
- Assessing stump use by small mammals and pollinators in young and mature Douglas-fir stands – Matthew Powers, Joan Hagar
- Assessing the response of aquatic biota to alternative riparian management practices – Dana Warren, Ashley Coble
- Quantifying postfire salvage woodpecker habitat with 3D remote sensing – Michael Wing
- Black-Backed Woodpecker vital rates in unburned and burned forest within a fire-prone landscape – Jim Rivers, Jake Verschuyl
- Assessing pollinator response to natural and anthropogenic disturbances in mixed-conifer forests – Jim Rivers, Jim Cane
- Revisiting the CFIRP: Assessing long-term ecological value and characteristics of snags created for wildlife – Jim Rivers, Joan Hagar
- Assessing early seral songbird species' demographic response to intensive forest management – Matt Betts, Jim Rivers.

EXAMPLES OF NEAR-, MID-, AND LONG-TERM STUDIES

The list below represents a broad and in-depth look at the potential for research using our proposed research design. The time dimension of these projects spans one season to centuries with projects that could be classified as near-term (0-10 years), mid-term (20-60 years) and long-term (70+ years). This list demonstrates that the ESRF can provide a base for essential forest research.

Near-term

- Structured tests for tethered harvesting and grapple yarding on steep slopes (no one on the ground).
- Structured tests comparing short and longwood harvesting systems (stump to mill).
- Testing rock replacement strategies for forest roads.
- Testing rock substitutes for forest roads.
- Improving logistics for tree planting on steep ground.
- Improving pole recovery from forest stands.
- Testing non-mechanical methods of PCT.
- Optimizing thinning decisions in real-time.
- Monitoring 2nd generation genetically improved stock.
- Testing all electric trucks on steep forest roads.
- Monitoring regeneration under alternative leave tree configuration for extensive.
- Monitoring growth under extensive and intensive systems.
- Monitoring biodiversity and individual species under extensive, intensive and reserve systems.
- Monitoring soil productivity and function under extensive, intensive and reserve systems.

Mid-term

- Monitoring regeneration under alternative leave tree configuration for extensive.
- Monitoring growth under extensive and intensive systems.
- Monitoring biodiversity under extensive, intensive and reserve systems.
- Monitoring ecosystem carbon under extensive, intensive and reserve systems.
- Monitoring micronutrient needs for forest stands and micronutrient stocks in soils.
- Structured fertilization trials to accelerate growth in intensive and extensive systems.
- Testing 3rd/4th/5th generation genetically improved stock.
- Testing remote-controlled harvesting and transport equipment.
- Testing alternative harvesting systems that minimize soil disturbance.
- Monitoring human use of recreational trails and public perceptions.
- Assessment of integration of forest research and management activities with public use and perceptions.

Long-term

- Monitoring regeneration under alternative leave tree configuration for extensive.
- Monitoring growth under extensive, intensive and reserve systems.
- Monitoring biodiversity under extensive, intensive and reserve systems.
- Monitoring soil productivity under extensive, intensive and reserve systems
- Monitoring ecosystem carbon under extensive, intensive and reserve systems.
- Monitoring human well-being as influenced by recreational opportunities.

APPENDIX 3

Example Research Projects

Below are a few example research programs that could exist within the Triad research design. Descriptions of projects were drafted by members of the OSU Exploratory Committee and OSU College of Forestry faculty.

1 **Outdoor Recreation Research at the Elliott State Research Forest**
Ashley D'Antonio, Oregon State University, College of Forestry, Dept. of Forest Ecosystems and Society

2 **Aquatic and Riparian Forest Research at the Elliott State Research Forest**
Dana Warren, Oregon State University, College of Forestry, Dept. of Forest Ecosystems and Society
Gordon Reeves, US Forest Service, Pacific Northwest Research Station

3 **Research on Hydrology, Geomorphology and Geologic Hazards at the Elliott State Research Forest**
Ben Leshchinsky, Oregon State University, College of Forestry, Dept. of Forest Engineering, Resources and Management

4 **Marbled Murrelet Research at the Elliott State Research Forest**
Matt Betts, Oregon State University, College of Forestry, Dept. of Forest Ecosystems and Society
Jim Rivers, Oregon State University, College of Forestry, Dept. of Forest Engineering, Resources and Management

OUTDOOR RECREATION RESEARCH AT THE ELLIOTT STATE RESEARCH FOREST

Ashley D'Antonio
Oregon State University, College of Forestry, Dept. of Forest Ecosystems & Society

NOTE: The specifics of these questions and methodologies will depend on: 1) how outdoor recreation is ultimately managed on the ESRF, and 2) whether additional recreation-related facilities are provided beyond what currently exists.

Despite this, there are few recreation ecology or recreation social science studies that occur at large spatial scales, across long temporal scales, and at low use levels. The ESRF, regardless of how recreation will be managed, provides the perfect setting to examine these recreation-related research gaps in spatial and temporal scales.

RESEARCH OBJECTIVE

Develop monitoring approaches for measuring low density recreation use across large landscapes at longer temporal scales.

Relevancy

Outdoor recreation researchers have well-established approaches for monitoring the levels and extent of recreation use in heavily used areas at relatively small spatial scales. However, it is challenging to efficiently, both in terms of cost and labor, and effectively monitor low levels of recreation use. It can also be incredibly challenging to measure specifics of behavior, such as density and patterns of recreation use, when use is not only low but highly dispersed/diffuse across a large area. Methodological developments related to how to measure and monitor recreation use at large landscapes and across longer temporal scales will provide the baseline data needed for future outdoor recreation-related studies on the ESRF. Additionally, creative solutions to detailed, long-term recreation monitoring across large spatial scales are relevant to protected areas in both the U.S. and internationally.

RESEARCH QUESTION

How are the experiences, values, and perceptions of outdoor recreationists influenced by landscape attributes (including tree density, viewshed, Triad design treatments, etc.)?

Relevancy

Many protected areas provide outdoor recreation opportunities while also managing for multiple values (ex: U.S. Forest Service lands), yet few studies have explored how silviculture treatments impact the experience of outdoor recreationists. The Triad design provides a mosaic of landscape features that outdoor recreationists can experience within a single managed landscape. Thus, the ESRF provides the ideal setting to understand how recreational visitors' experiences and perceptions vary, if at all, with different treatments. Additionally, many recreation-related studies are short term. The long-term nature of research at the ESRF provides the opportunity to explore how outdoor recreationists' perceptions of treatments may change over time. Such studies could inform how to better manage landscapes to provide quality outdoor recreation experiences while also managing for other values and ecosystem services.

RESEARCH QUESTION

How do low levels of recreation use impact various components (vegetation, water quality, wildlife, etc.) of the ESRF ecosystem?

NOTE: The specifics of this question can be refined once a recreation management plan is in place, and we have a better understanding of what types of ecosystem components recreationists will experience and interact with and where this will occur in space and time. The above question could also explore the impacts of specific activity types such as motorized vs. non-motorized recreation and mechanized vs. non-mechanized recreation.

Relevancy

In the recreation ecology literature, we assume that initial use into an area and lower visitor use levels cause proportionally more resource impact compared to higher use levels at the same site/on the same resource. But this relationship has only been thoroughly empirically tested in vegetation. All this work has been done at small spatial scales using plot-style experimental designs borrowed from agriculture. Despite these obvious limitations, managers and some recreation researchers apply this generalized relationship between use and impact to many other ecological components of systems (wildlife, water, etc.). This relationship drives many outdoor recreation-related management decisions. Part of the lack of empirical studies around the impacts of low levels of recreation use on ecological systems is because most recreation-related research (in recent years especially) has focused on heavily used sites. The ESRF provides an excellent opportunity to better understand the impacts of low use levels on ecosystems and to do this in a long-term capacity. Such studies would go a long way in contributing to the basic research and understanding of the impacts of outdoor recreation on ecosystems.

METHODOLOGIES

Outdoor recreation-related studies are often inherently interdisciplinary– therefore, a variety of methods will be employed to understand and study outdoor recreation on the ESRF. These methodological approaches could include, but are not limited to: visitor use estimation techniques such as trail counters and vehicle counters, qualitative interviews, qualitative surveys/questionnaires, observational studies of visitor behavior, recreation ecology studies focused on mapping and quantifying the level and extent of any recreation-related ecological impacts to vegetation and/or wildlife.

AQUATIC AND RIPARIAN FOREST RESEARCH AT THE ELLIOTT STATE RESEARCH FOREST

Dana Warren, Oregon State University, College of Forestry, Dept. of Forest Ecosystems & Society

Gordon Reeves, US Forest Service, Pacific Northwest Research Station, Corvallis, OR

Forests and fish are ecologically, economically and culturally important resources in Oregon. Unfortunately, these two iconic natural resources for our state are often placed at odds with each other. The extraction of forest resources has been tied to negative impacts on stream fish and the regulations applied to forest management designed to protect fish impacts the capacity of landowners to utilize all of their forest resources. The most obvious place where this conflict between forestry and fisheries arises is in the designation of streamside (riparian) buffers. All parties agree that buffers are necessary, however, there is a great deal of debate around what those buffers should look like, and how much flexibility there should be in laying out or managing in a riparian buffer area. Further, recognizing that historic forest management actions (e.g cutting to the stream edge, wood removal and splash-damming) did negatively impact streams, there is also currently considerable effort and interest in stream restoration. However, there is debate in this field about where restorations should be focused and how extensively restoration actions need to be applied. Below, we outline three focal policy-relevant research questions about stream/riparian management and restoration that we would address working at the Elliot.

RESEARCH QUESTION

How does the size & vegetative composition of a Riparian Management Area (RMA) interact with stream size to affect key aquatic characteristics and processes such as water temperature & aquatic productivity (invertebrates & fish)?

Establishing and evaluating alternative RMA configurations would allow us to test the assumption that setting the size of the RMAs based on wood recruitment potential creates buffer areas that provide other ecological functions of riparian ecosystems such as, litter input, controls on temperature, and channel stability.

Relevancy

We will test how different process change with different buffer widths across 3 streams sizes. This will allow us to test a key conceptual framework around buffers as illustrated in the "FEMAT Curves".

RESEARCH QUESTION

How do effects of resource patches created by canopy gaps and/or wood addition "scale-up" along a stream network?

While we generally see localized increases in biota and nutrient cycling in the areas immediately around wood or immediately beneath gaps, few studies have addressed the spatial extent of these effects. Therefore, we do not know how many gaps or how much wood might be needed generate a response at the whole stream scale. We propose an experimental gap and wood addition to evaluate a series of alternative hypotheses about how the system will respond to increases in gaps and/or wood (Figure 3a).

Relevancy

Understanding how the larger system responds to increases in the density of these resource patches will provide information about how extensive our restoration efforts could or should be. And, in implementing these efforts, we will explicitly test the effect of alternative restoration actions.

RESEARCH QUESTION

Are stream networks in managed landscapes "better-off" (i.e. maintain or increase biota production or ecosystem processes) if we put more buffer protections in the headwaters or if we focus protections along mainstem streams?

Streams are connected networks. The contributions from fishless headwaters can be critical in the mainstem systems, but currently they receive much less protection. If we consider a larger network system with approximately the same amount of Riparian Conservation Area (RCA), what would be the impact of allowing smaller buffers on larger streams while increasing buffers in fishless headwaters? The Elliott State Forest has over 2000 miles of stream (including both fish-bearing and fishless streams). The size and extent of the Elliot will allow us to test alternative buffer configurations and their influence on aquatic ecosystems and aquatic biota, not only at the scale of a single reach or individual stream, but across different sub-catchments, allowing us to explore processes at the stream network scale (Figure 3b).

Figure 3a.

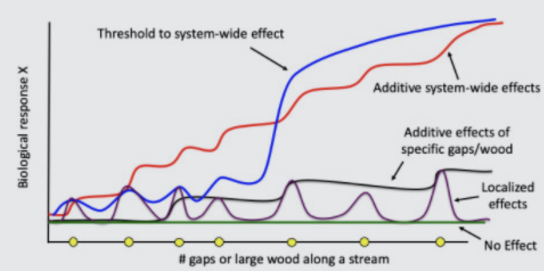


Figure 3a. *Alternative hypothesis for how biological processes or biota in streams will respond to increasing frequency of large wood or canopy gaps along a stream. Each dot on the x-axis represents a hypothetical gap or piece of large wood (or both since they often occur together).*

Figure 3b.

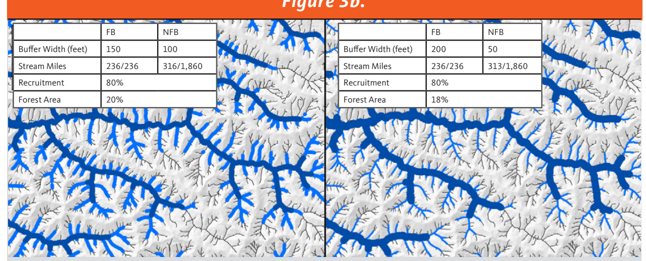


Figure 3b. *Alternative Riparian Management Area (RMA) configurations at the network scale for a sub-section of the Elliott Research Forest. FB refers to fish-bearing streams and NFB refers to non-fish-bearing streams).*

RESEARCH ON HYDROLOGY, GEOMORPHOLOGY AND GEOLOGIC HAZARDS AT THE ELLIOTT STATE RESEARCH FOREST

Ben Leshchinsky
Oregon State University, College of Forestry, Dept. of Forest Engineering, Resources and Management

Some very brief potential research questions relating to water and landslide hazards that would be served well through a Triad research design in the Elliott State Forest are briefly described below.

RESEARCH QUESTION

In context of landslide magnitudes and frequencies, what are the landsliding rates associated with current practices (conservation or harvest)? Where do these conditions fit in context of the equilibrium of ecosystems (terrestrial or aquatic) during typical conditions versus extreme events?

Hypothesis

Conventional forest management practices will result in more frequent shallow landslides during typical conditions, but less so during extreme events. The magnitude of shallow landslides/debris flows will not be sensitive to treatment, but will be sensitive to the extreme event. Extreme events will account for a majority of mass wasting observed in both treatments.

The size and geologic consistency of the ESRF size presents a unique opportunity to understand how forested terrain affects the equilibrium of a landscape, particularly in terms of how soil moves downslope in both short- and long-terms. There is significant uncertainty regarding the window in which timber harvest makes slopes susceptible to failure. This is a function of climate, vegetation, lithology, topography, and most importantly, time. Landslides are often driven by extreme events – heavy rains, earthquakes, wildfires – which often limit our true understanding of "baseline" conditions (i.e. rates of landsliding normalized to disturbance). A previous lack of infrastructure dedicated towards long-term monitoring of landslide activity at timescales of relevance have precluded our understanding of the relative impact of current practices from a perspective of typical winter conditions or that of extreme events. This part of the Coast Range has been subject to significant disturbances before (earthquakes, wildfires, intense storms) and still maintained an equilibrium in terms of landscape and ecology – what role do we play in the short- and long-term and can we (or are we already) managing this role? What about in the future or after a great change?

Relevancy

By establishing the infrastructure for long-term monitoring of unstable hillslopes in the Elliott, we would be better-suited to characterize baseline conditions in terms of sediment, mass wasting, etc., and likewise assess the relevance of frequent, smaller changes (e.g. management activities) with context of baseline conditions.

RESEARCH QUESTION

What is the best landscape-level design (Extensive, Reserves with Intensive, Triad-I, Triad-E) that minimizes deleterious landslide/debris flow occurrence? Activation or reactivation of deep-seated failures?

Hypothesis

The gradient of treatments will demonstrate that intensive treatments will increase the frequency of small landslides, but will have a more muted effect on larger landslides (e.g. earthflows, landslide complexes). The treatment threshold and timing at which management results in altered, weakened conditions for slope failures will vary with landslide size. That is, larger failures will be less sensitive to treatment, but may see a changed response over a longer period than shallow failures. Shallow failures will be more sensitive to treatment (e.g. threshold at extensive), but will see a short window in which weakened conditions exist.

Not all landslides are created equal. Deep-seated failures are dictated by major hydrologic disturbances and are of a magnitude where the reinforcing role of root systems in the soil mantle is questionable. However, the impact of lost evapotranspiration, reduced canopy cover, and amplified infiltration and snowmelt that stems from management practices may be critical to the activity of these large slope failures. If the influence of infiltration is key to the behavior of these slow-moving failures, then at what gradient off treatments can canopy interception and evapotranspiration be preserved to prevent slope movements? Do treatments matter for the activity of these types of failures? Shallow-seated failures that are typically associated with debris flows are largely governed by rapid changes in superficial hydrologic conditions and the loss of stabilizing root systems. Can we perform rapid replanting after intensive treatments or use prolonged extensive treatments to attenuate heightened landsliding rates?

Relevancy

The aforementioned changes have rarely been observed beyond a single hillslope or catchment scale. For example, how will earthflows/ landslide complexes (of which there are several in the Elliott) or shallow failures respond to a gradient of changes in land use or will they largely behave as they always have regardless of management activities? The only way to determine this is through monitoring and understanding the hydrological and geological changes that the suite of treatments is associated with (from conservation to intensive), both during typical winters and significant storm events.

RESEARCH QUESTION

How will the gradient of treatments influence the timing and transport of water, both through runoff and subsurface flow? How will these conditions evolve with climate change?

Hypothesis

The hydrologic, topographic and climatic conditions will strongly affect the magnitude and seasonality of stream flows, but treatments within catchments will be a second-order control on water movement.

The movement of water is a phenomenon that becomes increasingly complex as the scale of observation increases. At the scale of the ESRF, hydrologic conditions are already complicated despite the relatively uniform geology and topography. Current management practices may result in increased surface runoff, reduced water storage, and potentially altered summer flows. These conditions are subject to climatic variability, and highlight the importance of enabling forest management to evolve with a warming climate. The gradient of treatments and long-term monitoring of groundwater and stream flows will enable an understanding of whether a threshold exists between conservation and intensive management in context of water storage, flows and stream temperatures.

Relevancy

Determining such a threshold enables better forest management by (1) better planning forest management to meet a variety of ecosystem services that are dependent on cool, clean water, (2) highlighting the short- and long-term importance of a variety of treatments (how long and by how much is water storage affected?), and (3) providing a quantitative basis for future forest management for potentially hotter, drier summers and variably wet winters (i.e. how can we adapt?).

METHODS

Answering these questions will require extensive monitoring, both remotely and in-situ. Landslide activity will be monitored remotely through (1) repeat collection of aerial lidar, (2) high-resolution satellite imagery, and (3) InSAR change analyses. Soil moisture will be monitored remotely through (1) SMAP time-series and (2) NDVI. Landslide activity (i.e. movements) will be monitored in-situ through an extensive series of (1) extensometers, (2) in-place GNSS units, (3) inclinometers, and (4) time-lapse stereo cameras. Water will be monitored using an extensive series of (1) tensiometers, (2) piezometers, and (3) stream gauges. This only presents a small subset of potential tried-and-true techniques for monitoring that will certainly be enhanced with new remote and in-situ technologies being developed.

MARBLED MURRELET RESEARCH AT THE ELLIOTT STATE RESEARCH FOREST

Matt Betts
Oregon State University, College of Forestry, Dept. of Forest Ecosystems & Society

Jim Rivers
Oregon State University, College of Forestry, Dept. of Forest Engineering, Resources and Management

Below is a very short summary of potential research projects that could occur at the Elliott State Forest in the context of the Triad platform.

RESEARCH QUESTION

What is the best landscape-level design (Reserve with Intensive, Triad-I, Triad-E, Extensive) to maximize murrelet density and reproductive output?

Hypotheses

If marbled murrelet density and reproductive success respond poorly to thinning and other silviculture that disturbs mature forest canopy, the intensive/reserve treatment should be best. This is because timber production is concentrated in non-murrelet habitat (stands <50) and reserves will retain undisturbed habitat. Alternatively, if marbled murrelets are resilient to thinning effects over time, the extensive treatment should maximize murrelet densities because a greater proportion of the landscape will be covered in mature forest than in the Intensive treatment.

Relevancy

Addresses question of whether it is better to concentrate harvesting effects in a small area, or spread out harvesting effects using an ecological silviculture approach.

RESEARCH QUESTION

To what extent do ocean conditions drive marbled murrelet occupancy and reproductive success?

Hypothesis

Marbled murrelet occupancy will be strongly driven by ocean conditions, with warm ocean conditions that reduce food availability resulting in low breeding prevalence (see Betts et al. in press, Conservation Letters). Although we see this signal in the existing long-term timber harvest occupancy data for Oregon, it will be important to replicate this result using long-term data that establishes 'true' occupancy, and is a continuous, site-scale dataset (rather than cessation of monitoring once occupancy is established as in the current effort).

Relevancy

Will inform how often occupancy surveys should be conducted to determine proposed timber harvests, and will help parameterize murrelet population models under differing climate regimes.

RESEARCH QUESTION

Can marbled murrelet habitat be restored through silviculture, artificial platforms, and conspecific attraction playback?

We have already succeeded at attracting marbled murrelets to existing, previously unoccupied habitat using conspecific attraction playback (Valente et al. in review, Auk). We predict that if nesting platforms can either be created via silviculture (e.g., epicormic branching) or artificial means (installment of constructed platforms), we will be able to attract new breeders to these stands. This will potentially increase the effective population size (breeding population) of murrelets, thereby enhancing population viability.

Relevancy

Will inform potential murrelet restoration efforts for land-bases that have objectives less focused on timber harvest and may speed development of suitable murrelet habitat relative to traditional methods.

RESEARCH QUESTION

Is murrelet nesting success and density influenced by edge (due to clearcutting and/or thinning) and, if so, at what scales?

Previous work indicates that predation risk might increase near 'hard' edges, however little is known about whether other forest management treatments (e.g., thinning, variable retention harvesting) influence murrelet density and reproduction. Although the methods implemented to address Question 1 will likely address this question as well, it would be ideal to establish an experimental study that collects pre-treatment data on murrelet abundance and reproduction, and then implements various silvicultural methods and examines the 'scale of effect' (distances over which edge exerts an influence on these response variables).

Relevancy

The USFS and BLM frequently implement thinning treatments near murrelet habitat, so this research will inform the minimum size of no-harvest buffers in occupied areas.

RESEARCH QUESTION

Can deep learning methods be used to monitor murrelets from sound recordings, and to what extent can audio information be used to infer nest success?

Ultimately, our objective is to implement a long-term population monitoring program for marbled murrelets. To date, population monitoring (that informs ESA listing) is based on every other year at- sea surveys, that have been criticized on the grounds that they do not provide accurate information on population abundance. We expect that information from audio-recordings (e.g., number of calls, timing of calls over the day and season) may provide information not only on occupancy, but potentially on breeding success

Relevancy

If successful, such methods could lead to a long-term auto-ID monitoring system across the PNW (similar to the one implemented by USFS- PNW for spotted owls) and would help inform listing decisions.

BRIEF METHODS

We will collect murrelet data using multiple methods: (1) Nests will be found via ground- based surveys, then monitored using remote video cameras to determine nest success and causes of nest failure, (2) Audio monitoring sites will be established in a systematic design across all potential habitat at the Elliott, (3) Ground-based murrelet surveys will occur in a subset of these same habitats to enable us to relate (a) nesting and occupancy, (b) nesting and audio-recordings, (c) occupancy and audio-recordings.

APPENDIX 4

Draft Research Treatment Allocation Process

Outlines the processes used to determine the initial spatial extent and location of treatments in the proposed Triad research design.

ELLIOTT STATE FOREST AGE PATTERN

The Elliott State Forest has a bi-modal age class distribution (Figure 4a.) that can be explained by three general scenarios. Note these may not represent the stand history of every single stand, but the primary activities in the recent past.

1 Forests that regenerated naturally following fire, wind events, or landslides that were regenerated following clearcut harvests starting in 1955 (aside from one early harvest in 1945) to generate revenue for the Common School Fund. Some of them may have had a pre-commercial or commercial thinning. Regeneration methods varied over this period, starting with a reliance on natural regeneration, followed by aerial seeding, and hand planting starting around 1970. These practices resulted in approximately 41,000 acres of forest, consisting primarily of Douglas-fir with some alder, western hemlock, and western redcedar. Understory diversity is limited. These stands are 65 years or younger as of 2020.

2 Forests that regenerated naturally following fire, wind events, or landslides and had about 30% of the tree volume removed when the forests were approximately 75 to 125 years to improve the growth of remaining trees and generate revenue. These harvests occurred primarily between 1957 and 1977. Several of these forest stands have subsequently been clearcut and converted to Douglas-fir plantations, but we suspect, based on some old records, that somewhere between 5,000 to 10,000 acres may still exist. These stands are primarily 100 to 160 years in 2020.

3 Forests that regenerated naturally following fire, wind events, or landslides. The primary stand-replacing fire occurred in 1868, but other more localized fires and other disturbances may have happened. There are a little over 40,000 acres of naturally regenerated forests, but it is uncertain how many acres were partially logged (treatment outlined in scenario 2) due to spotty historical records. However, if one assumes that approximately 5-10,000 acres of these older forests were partially harvested, then that leaves 30,000-35,000 acres of unmanaged forests. The age range of these forests is from 80 to 230 years, with 71% of this forest type between 130 to 160 years.

Figure 4a. Elliott Forest Age Pattern

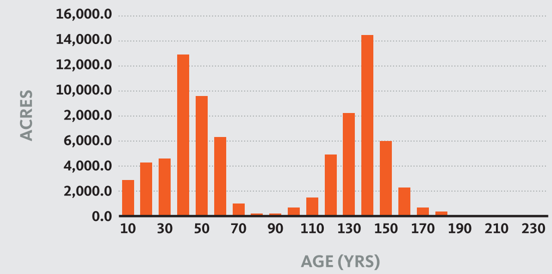


Figure 4a. *Age distribution on the Elliott State Forest by age class as of 2020. Under 65 years of age are forests that regenerated following a clearcut. Stands over 65 years of age regenerated naturally primarily from wildfire.*

4 Snags from the 1868 fire and other disturbances were systematically felled and sometimes removed from the Elliott State Forest to reduce fire danger. The activities occurred in areas that may not have been logged otherwise. Therefore, even the unlogged forests may not be an accurate baseline for the level of standing and down deadwood. We do not have records of the extent of this practice, but it warrants consideration.

INITIAL METHODS FOR ASSIGNING SUBWATERSHEDS AND THEN STANDS TO RESEARCH TREATMENTS

Obtain the most recent set of information with accurate stand locations and ages. This includes working with indigenous communities to ensure appropriate care is taken to avoid culturally significant areas and spiritual places. Identify recent management practices such as locating the approximately 10,000 acres of the 1868 burned areas that were partially harvested between 1957 to 1977.

1 **Look for bias in the placement of historic management units on the forest, based on elevation, aspect, and slope percentage.** There are several well-known scientific reasons for random allocation of treatments. Randomization aims to avoid true bias caused by confounding factors. For instance, it might not be by chance that old forest remains where it does (e.g., steep slopes, low productivity forest); harvests may have occurred in the most productive and easily accessible stands. Ignoring such factors may lead to misinterpretation by erroneously associating results with the Triad treatments. However, we did not find evidence that stand-scale treatments were biased as a function of such biophysical factors (see Figure 9a in Appendix 9). The results of our analysis are available upon request.

2 Forest regeneration harvesting began in 1955 about 65 years before the 2020 adjusted ages, so we consider anything below 65 years as managed for this analysis. We assigned treatments non-randomly using the following criteria: (1) ensure that there is no detectable bias among treatments in biophysical factors (i.e., elevation, aspect, site productivity, slope and aspect).

3 **Assign subwatersheds and stands within watersheds to the treatments by optimizing the following:**

A Prohibit any harvesting in stands that predate the 1868 fire. There are approximately 400 acres or 0.5% that remain from the nearly 5,000 acres of forests that predated the 1868 fire, when the Elliott State Forest was established. They are the remaining link to the past, are culturally and socially significant, and serve as an essential control to scientific study.

B Focus harvests in stands that have had prior clear-cut harvests and regenerated with a focus on wood production (primarily less than 65 years old in 2020 since harvests started in approx. 1955).

C Limit harvesting of stands greater than 65 years in 2020 to extensive treatments. No forests older than 65 years in 2020 will be assigned to the intensive treatment. We will include only forests that were clear-cut, starting in approximately 1955, in the intensive treatments going forward.

D Extensive harvests that are in stands greater than 65 years will be preferentially done in stands closest to 65 years in 2020, and the older stands (90-152 years), once identified, that have had a prior thinning. Thereby preserving the oldest unlogged forests in reserves to the greatest extent possible.

E Any stand that we determine predates the 1868 fire will be placed in reserve. In the case of Extensive subwatersheds (where there are no reserves) we will place in a special category called Extensive Reserve. Based on our current inventory, we have identified 164 acres in this category.

3 **Review and adjust assignments and this initial set of criteria based on:**

A continuing to work with indigenous communities to ensure that appropriate care is taken to avoid culturally significant areas and spiritual places;

B updated inventory, landscape analysis including the aquatic component and the ecological importance of headwater (non-fish bearing streams); and,

C other relevant information that is unavailable today.

4 The process is intended to be iterative and adaptive and will take place in the context of the decision-making structure and protocols established for managing the forest over time.

Following these criteria, the below figures and tables illustrate the age distribution across treatment types in the August 2020 iteration of the stand level research treatment allocations (Figure 4b-d, Table 4a and 4b).

Table 4a. Stand-level Allocations by Age

Stand Age	STAND LEVEL ALLOCATIONS (ACRES)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	MRW RCA	CRW (incl RCA)	
<= 65 yrs	14,334	10,047	1,905	2,852	12,528	41,666
> 65	0	3,366	12,190	3,686	21,612	40,854
Total	**14,334**	**13,413**	**14,096**	**6,538**	**34,140**	**82,520**

Table 4a. *Number of acres per treatment by age class on the proposed ESRF based on the August 2020 draft allocation and November 2020 Riparian Conservation Area (RCA) designations. We assume that forests 65 or younger are forests that regenerated following clearcuts and those over 65 years regenerated from natural disturbance, primarily wildfire.*

Table 4b. Stand-level Allocations by Age

Stand Age	STAND LEVEL ALLOCATIONS (PERCENT OF TOTAL FOREST AREA)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	MRW RCA	CRW (inclu RCA)	
<= 65 yrs	17.4%	12.2%	2.3%	3.5%	15.2%	50.5%
> 65	0.0%	4.1%	14.8%	4.5%	26.2%	49.5%
Total	**17.4%**	**16.3%**	**17.1%**	**7.9%**	**41.4%**	**100.0%**

Table 4b. *Percent of acres per treatment by age class on the proposed ESRF based on the August 2020 draft allocation and November 2020 Riparian Conservation Area (RCA) designations.*

Figure 4b. Stand-level Intensive

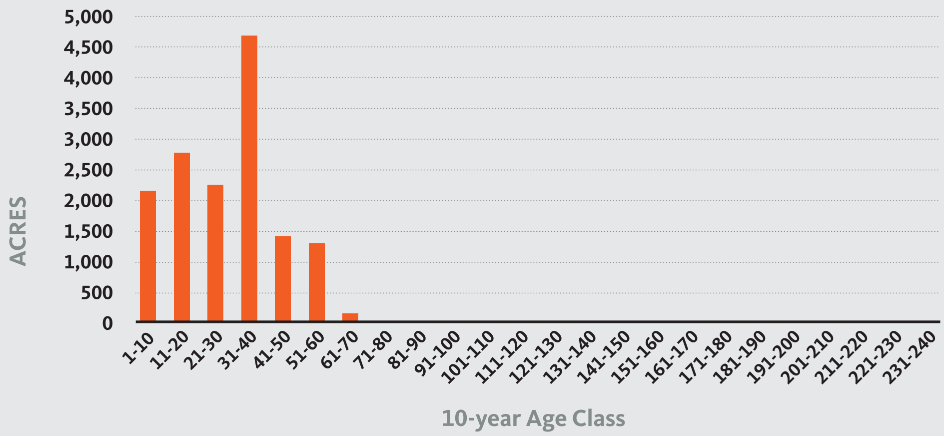


Figure 4b. *Proposed acres of forest in intensive treatment in the MRW by age class as of 2020. Allocation based on August 2020 draft allocation. We assume that stands under 65 years are forests that regenerated after clearcuts and those over 65 years regenerated from natural disturbance, primarily from wildfire.*

Figure 4c. Stand-level Triad Reserve

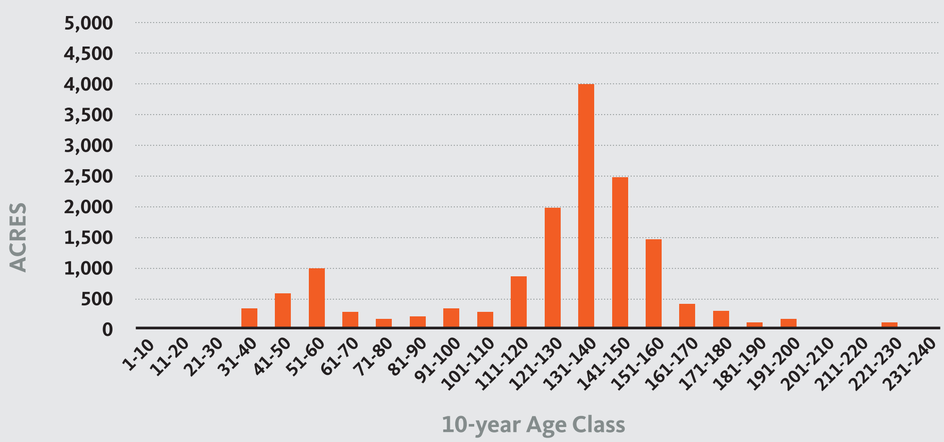


Figure 4c. *Proposed acres of forest in reserve treatment in the MRW by age class as of 2020. Allocation based on August 2020 draft allocation. We assume that stands under 65 years are forests that regenerated after clearcuts and those over 65 years regenerated from natural disturbance, primarily from wildfire.*

Figure 4d. Stand-level Extensive

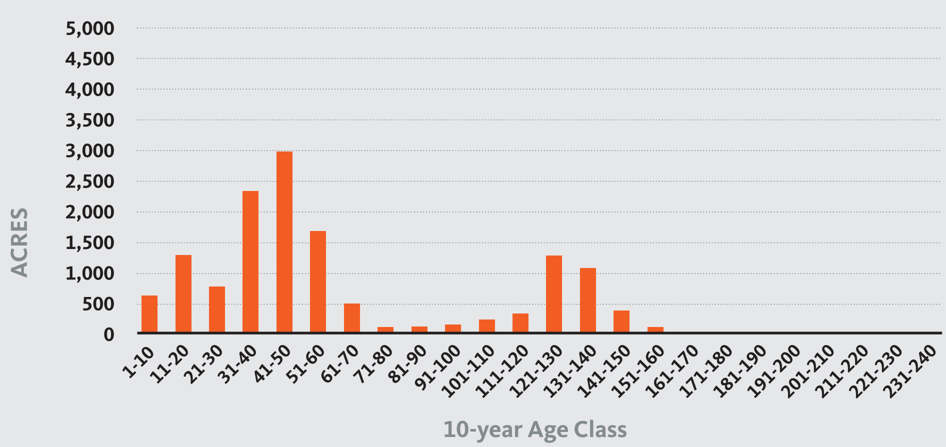


Figure 4d. *Proposed acres of forest in extensive treatment in the MRW by age class as of 2020. Allocation based on August 2020 draft allocation. We assume that stands under 65 years are forests that regenerated after clearcuts and those over 65 years regenerated from natural disturbance, primarily from wildfire.*

APPENDIX 5

Descriptions of Research Treatments (intensive, extensive, and reserve)

This appendix contains proposed descriptions of the scope and attributes of what is intended to constitute intensive, extensive, and reserve research treatments in stands on an ESRF within the context of the research principles, design, and attributes described above. We intend to use it as the starting point for designing the implementation of research treatments and experimentation that will occur within the context of the forest's future decision-making structure in support of research. There will be monitoring protocols established in all cases, including remote sensing, emerging instrumentation and technology, and historical records to determine if we are meeting key benchmarks before moving forward.

Figure 5a. Four largest wilderness areas in the Oregon Coast as compared to the Conservation Research Watershed

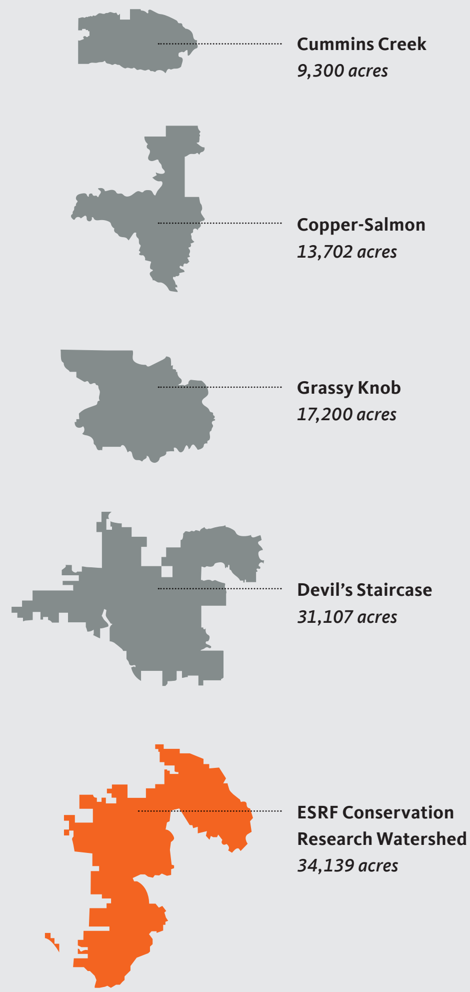


Figure 5a. *Size of the four largest wilderness areas in the Oregon Coast as compared to the Conservation Research Watershed. The CRW and Devil's Staircase Wilderness Area are adjacent and represent a 65,246 acre reserve, the largest in the Oregon Coast Range.*

RESEARCH TREATMENTS

RESERVES IN THE MANAGEMENT RESEARCH WATERSHEDS (MRW) AND CONSERVATION RESEARCH WATERSHEDS (CRW):

1. Committed to maintaining the current proposed CRW as one of the largest contiguous reserves in the southern Coast Range (See Figures 5a and 5b).

2. No logging in forests greater than 65 years as of 2020.

3. Assess plantations (forests 65 years and younger) in the CRW and MRW for conservation and restoration within the context of the surrounding landscape.

4. Design and implement an experiment to explore methods for increasing the likelihood of achieving old forest structure, increasing species diversity and creating complex early seral forests from dense single-species plantations. This experimenta will take advantage of recent findings from various studies that investigated the possibility of accelerating development of late-successional stand structures and compositions(Bauhus et al. 2009), including DEMO, DMS, YSTD, others (for a summary of studies, see (Monserud 2002; Poage and Anderson 2007). For examples of findings, e.g., (Puettmann et al. 2016). Depending on conditions, thinnings treatments could be composed of one or several of following treatments: variable density thinnings, including skips and gaps, creation of snags and downed wood, retain unique tree forms and structures, retain and/or encourage the variety of tree sizes and species, protecting desirable understory vegetation, planting in gaps or in the understory to encourage species diversity, or removal of invasive species.

5. Design and implement an experiment to explore methods for increasing the likelihood of achieving old forest structure, increasing species diversity and creating complex early seral forests from dense single-species plantations.

6. The research protocols will include treatments and controls and will be implemented over a range of forest ages up to 65 years as of 2020.

7. The timing of the treatments will depend upon the experimental design and stand age; however, anticipate

Figure 5b. Forest Reserves in the Oregon Coast Range

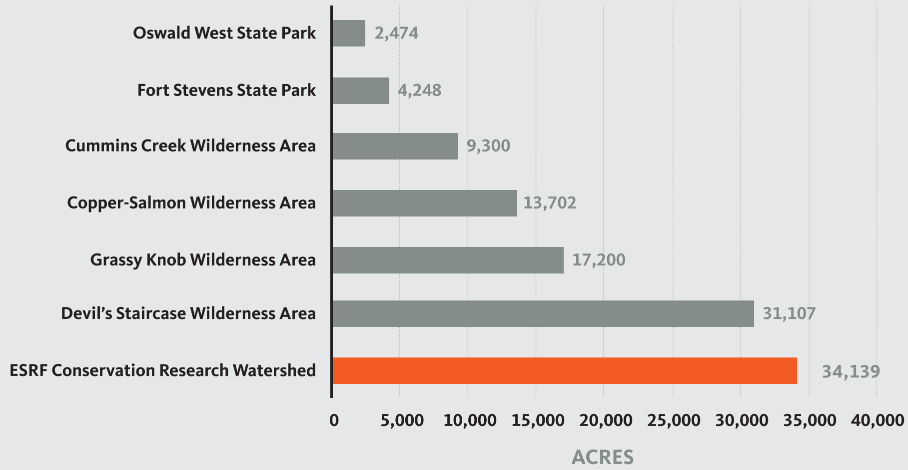


Figure 5b. *Number of acres of the largest state parks and wilderness areas in the Oregon Coast Range as compared to the proposed Conservation Research Watershed in an Elliott State Research Forest.*

the experimental treatments will complete in the CRW in approximately two decades. The MRW may take longer, given the stepwise implementation.

8 Following initial treatments, the only disturbances going forward will be natural and will not include logging.

9 Natural disturbances such as drought, disease, wind, and insects will occur without salvage.

10 Suppress fire, but will not salvage if mortality does occur.

11 Potentially treat riparian areas on a limited basis during thinning to reduce density and promote the development of older forest structure. No individual trees older than 65 years in 2020 will be harvested or felled.

Examples of research concepts and outcomes associated with reserve treatments:

- Emulate natural disturbances
- Incorporate tribal perspectives and traditions
- Vary the level of retention of the existing forest canopy in the plantations and riparian forests
- Vary distribution of retained trees in a dispersed or aggregated fashion in the plantations and riparian forests
- Apply treatments across the spectrum of forest ages up to age 65
- Natural thresholds of the size and quantity of standing dead and downed wood
- Carbon uptake and release with natural disturbance
- Climate impacts in unmanaged forests relative to actively managed forests
- Active management as compared and contrasted with natural disturbance processes

A more comprehensive list of potential research questions and opportunities that are compatible with our experimental approach on the ESRF can be found in Appendix 2.

INTENSIVE TREATMENTS IN THE MANAGEMENT RESEARCH WATERSHEDS

1 Even age management using clearcut harvesting techniques suitable for the terrain.

2 Follow all Oregon Forestry Protection Act rules except for self-selected, more stringent requirements in the ESRF riparian areas in headwalls and all streams.

3 Post-harvest application of site preparation and vegetation control practices to ensure seedling establishment and initial growth. This can include a variety of experimental methods to increase our knowledge about the role of vegetation control on seedling establishment and growth. This may consist of the aerial application of herbicides if in compliance with OFPA. Aerial spraying will be used only when necessary and other types of herbicide application are operationally impractical. Over a 60 year period, an intensively treated stand could potentially receive 1-2 applications of herbicide. We need to conduct research using broadly applicable practices so our work can extend beyond the borders of the ESRF. In addition, we are committed to transparency in our herbicide applications and monitoring of them. OSU will engage in monitoring water quality in areas where aerial spraying takes place. Should any evidence be found that herbicide applications in specific target areas are adversely affecting nearby aquatic areas, the practice will be changed in that area.

4 Animal control techniques will not involve the use of rodenticides.

5 Establish plantations at densities that ensure relatively quick canopy closure using species and seed sources best suited for future predicted climate conditions.

6 Maintain stand densities at levels that provide vigorous trees and maintain high wood production through thinning

operations. With commercial thinning typically occurring between 35-50 years.

7 Determine regeneration harvest and commercial thinning by growth patterns (mean annual increment), vulnerability to disturbances, and markets. With a minimum rotation age of approximately 60 years.

8 Based on context, treatments may vary in rotation length, type of site preparation, species planted, and other processes. Riparian buffers will be a minimum of 120 feet on fish bearing streams and 50ft on non-fish bearing streams. The specific size and configuration of the different RCA components will depend on the level of desired wood delivery potential.

9 As a baseline, all activities will comply with the Oregon Forest Practices Act, the federal Clean Water and Endangered Species Acts.

Examples of research concepts and outcomes that may be associated with intensive treatments:

- Resilience and resistance to minimizing tree loss to drought and diseases over decades
- Social values as represented by differences in perceptions and behaviors
- Economic and carbon analysis of increasing rotation length
- Market analysis and impacts of tree size
- Carbon fluxes and pools through time
- Logging technology and forest engineering
- Site preparation and seed sources
- Species and genotypes for climate resilience and resistance
- Clear-cut harvest impacts hydrological changes, erosion and mass wasting events
- Recreation use levels/patterns and perceptions over time
- Density management and wood yield over time
- Response of aquatic ecosystems
- Non-lethal strategies for animal control

A more comprehensive list of potential research questions and opportunities that are compatible with our experimental approach on the ESRF can be found in Appendix 2.

EXTENSIVE TREATMENTS IN THE MANAGEMENT RESEARCH WATERSHEDS

1 On average, extensive treatments will seek to produce harvest volumes that are approximately 50% of the fiber production of stands managed according to intensive experimental treatments. This means that some treatments with lower retention (20%) will have more than 50% relative yield, and those with high retention (80%) will have a less than 50% relative yield. The goal is to have the yield average 50% at the subwatershed level.

2 Extensive stand treatments are limited to stands that were established following the 1868 fire or regeneration harvests that have occurred primarily since the 1950's. If there are obvious discrete stands and individuals within younger stands that predate the 1868 fire, we make a commitment to not harvest these. However, aging large trees is not precise enough to specify an age to the year. Even with increment cores, determining tree age is not an exact science, especially when some of the oldest trees do not always "look" their age. We also recognize that due to safety issues in camp sites and logging operations and other unforeseen circumstances trees that predate the 1868 fire may need to be removed on rare occasions. However, we are committed to working with the stakeholders to achieve our commitment to the oldest forests and individual trees as part of further planning and project-level implementation of the research platform. The adaptive management approach calls for the development of a list of criteria or "trigger points" that would trigger changes in experimental protocols. Our intention is that members of the advisory board will be a part of developing these criteria or trigger points.

3 Retain the number of live trees needed to meet various experimental goals. The percent retained will range from 20-80% of pre-harvest density and should occur in a variety of spatial and age class patterns (including aggregated and dispersed) to encourage a wide range of conditions that align with the integration of objectives.

4 Size of the experimental units will represent the ecosystem's natural disturbance patterns, including the appropriate mix of clumps and open patches, snags, and down wood while recognizing operational constraints. This design will function as a test of pressing questions such as reduced fragmentation on biodiversity and other attributes such as harvest efficacy and safety.

5 Tree age will vary within a stand, with most having a minimum of two age or canopy position age classes. Return intervals for harvest will depend on monitoring growth and meeting the objectives for a range of conditions, including complex early seral to old growth forests.

6 Focus retention areas and prioritize retention preference based on the following:

A A landscape analysis that identifies what is limiting biodiversity today and into the future using a variety of metrics, including species richness, species at risk, genetic diversity, and landscape diversity).

B Prioritize retention of large, mature (complex canopy structures) trees (based on a combination of factors, including DBH, bole and bark characteristics, tree height, and crown and branching characteristics that are underrepresented.

C If the number of large standing dead and down trees are low relative to controls, experimentally test ways to increase their abundance.

D Incorporate designated marbled murrelet management areas and northern spotted owl habitat (not already located in designated reserves) into the highest (80%) retention category to explicitly incorporate into an experimental protocol designed to quantify the impact of extensive treatments on species abundance. Selective tree harvests in murrelet occupied stands will be done for research purposes and will not reduce current tree relative density by more than 20%. We will survey for the presence of murrelets in all potential occupied habitat. See Appendix 11 for more detailed recommendations and analysis of occupied murrelet habitat.

6 Experimentally test if aggregating retention on unstable slopes is critical to providing attributes including mitigation of landslides, delivery of large wood to streams, habitat for owls, murrelets, and other terrestrial species, and corridors for movement within and among watersheds.

7 Limit and selectively use herbicides only where necessary to manage invasive species or as a last resort to promote tree regeneration.Targeted application of herbicides will be used in extensive treatments if regeneration is not successful. Use of fixed wing planes or helicopters will not be practiced due to the large number of retained trees.

8 Plant only where regeneration goals cannot be met otherwise.

9 In the landscape analysis, assess and monitor the spatial pattern of retention areas using a combination of factors; including, but not limited to: population dynamics of at-risk species, maximizing opportunity for biodiversity, aesthetics, promoting wildlife habitat favoring early seral conditions, retention of hardwood trees, wood production, harvest methods, and harvest unit size.

10 Riparian forests that emulate their critical roles in natural disturbance and are fully integrated with upland management, thereby meeting the goals outlined in the riparian management plan. These extensive forests will have different configurations of the riparian ecosystem that maintain critical ecological processes.

11 While the goal to enhance biodiversity may be the same in all cases, the extensive treatments will be adjusted because the initial conditions are highly variable. For example, the initial conditions as represented by age on the ESRF are highly variable; therefore, the experimental treatments will require flexibility to maintain relevance.

12 Considering these treatments at a landscape level will allow us to incorporate varied seral-stages into our research design thereby allowing us to fully attain biodiversity, habitat, and recreation objectives.

Examples of research concepts that may be associated with extensive treatments:

- Emulate and measure response of natural disturbance including reintroduction of complex early seral ecosystems that are being replaced by rapidly growing plantations.
- Tribal perspectives and traditions
- Level of retention of the existing forest canopy
- Distribution of retained trees in a dispersed or aggregated fashion
- Treatments across the spectrum of forest ages
- Thresholds of size and quantity of standing dead and downed wood
- Selective and no use of herbicides
- Tree and shrub regeneration
- Prescribed fire to generate pyro-diversity
- Riparian integration with upslope conditions
- Logging systems under varying levels of retention
- Economic thresholds and markets
- Monitoring objectives and protocols

A more comprehensive list of potential research questions and opportunities that are compatible with our experimental approach on the ESRF can be found in Appendix 2.

Examples of attributes that would not characterize an extensive treatment:

- Conversion of a forest from a diverse to a less-diverse condition by not retaining key existing legacies
- A selective harvest without accounting for whether the objective of regeneration has been accomplished so that the long-term desired characteristics of the stand are not sustained
- Establishing merchantable volume as the primary or dominant management objective
- Routine or pervasive use of herbicide
- No plan for or monitoring of desired forest, riparian or wildlife attributes
- No landscape level plan

REFERENCES

Bauhus, J., K. Puettmann, and C. Messier. 2009. Silviculture for old-growth attributes. Forest Ecology and Management 258(4):525-537.

Monserud, R.A. 2002. Large-scale management experiments in the moist maritime forests of the Pacific Northwest. Landscape and Urban Planning 59:159-180.

Poage, N.J., and P.D. Anderson. 2007. Large-scale silviculture experiments of western Oregon and Washington. USDA Forest Service, General Technical Report PNW-GTR-713(Portland, OR):44 pp.

Puettmann, K.J., A. Ares, J.I. Burton, and E.K. Dodson. 2016. Forest restoration using variable density thinning: Lessons from Douglas-fir stands in western Oregon. Forests 7(12):310.

APPENDIX 6

Aquatic and Riparian Area Research Strategy

KEY ATTRIBUTES OF A RIPARIAN CONSERVATION STRATEGY

A Land Use Allocation and Arrangement

Land use allocation is a primary means by which aquatic and riparian values are protected within the proposed Elliott State Research Forest. The two broad land-use classes referred to throughout the proposal – the CRW and MRW – provide the foundation of the riparian and aquatic conservation strategy.

At 34,140 acres the CRW anchors the conservation strategy by establishing a contiguous reserve area managed for long term ecological functions supported by restored and undisturbed terrestrial, riparian, and aquatic ecosystems. Within the CRW site-disturbing research and management activity will be limited to projects that are likely to benefit the long-term conservation of native biota (e.g., restoration thinning to enhance forest complexity, stream restoration projects, road decommissioning). The MRW comprises four primary land treatments totaling 48,380 acres: intensive (14,334 acres), extensive (13,413 acres), reserve (14,096 acres), and RCA (6,538 acres). Research and management in the MRW will include the implementation of forest management strategies that apply different spatial arrangements and practices to these treatments in support of timber harvest, and the evaluation of corresponding ecological and economic outcomes.

The Triad research design allows for flexibility in how each sub-watershed in the MRW can best be arranged to optimize desired outcomes for a given set of management objectives and constraints. The relative proportions of each Triad treatment type in the MRW (reserve, extensive, intensive) are fixed and correspond to sub-watershed designations (Figure 4); however, the spatial arrangements of these treatments within the designated sub-watersheds are flexible within other constrains such as age. Flexibility in the spatial arrangement of retention areas in extensive, intensive, reserve treatments facilitate the accommodation of non-timber values, such as habitat for old-growth dependent species, protections for areas prone to landslide and debris torrent not otherwise protected in RCAs, and refugia and migration corridors for amphibians. In extensive treatments, for example, steep headwall areas could preferentially be afforded additional tree retention to support root-zone integrity and soil stability, and to provide a source of large wood should the slope fail. Although less flexible than the spatial arrangement of tree retention in extensive treatments, in some areas we expect that boundaries between intensive and reserve stand-level treatments will be adjusted to afford such protections. This spatial arrangement of the treatments will be refined further using a landscape analysis as part of the Elliott State Research Forest Management Plan.

Inclusive of MRW reserves, MRW RCAs, and the CRW, a total of 54,774 acres of the 82,520-acre ESRF (66% of total ESRF acres) will be in reserve status. Aside from single-entry restoration treatments in existing plantations expected to take place over the next 10 to 20 years (see discussion on thinning below) OSU is proposing no timber harvest in these reserve areas. Though subject to natural disturbance processes such as wildfire and extreme weather events, we intend these areas to follow successional pathways largely unaffected by human intervention.

B Conservation and Modeling of the Wood Recruitment Process

Throughout the Pacific Northwest, including the Oregon Coast Range (OCR) and the ESRF, past and current land management practices have led to a reduction in both the quantity of large wood in streams and rivers and potential sources of large wood on the terrestrial landscape. Reestablishing natural wood recruitment processes is a key component of OSUs riparian and aquatic conservation strategy; a means of evaluating wood recruitment is therefore necessary for planning, research, and adaptive management purposes.

Stream-adjacent sources of large wood recruitment, such as bank erosion, mortality, and windthrow, are assumed to be protected to a greater or lesser degree according to the width of a stream buffer, are the customary focus of wood recruitment evaluation (see, for example, Murphy 1995). Recruitment models that evaluate only stream-adjacent large wood sources may overlook other important sources of large wood, however. Specifically, large wood delivered by landslide and debris torrent from small headwater streams potentially comprise a sizeable fraction of the total large wood budget of fish-bearing streams in the OCR. For example, May and Gresswell (2003) found that 33% of large wood pieces in a third-order alluvial mainstem stream had been transported to the stream by debris torrent through second-order tributaries, Bigelow et al. (2007) reported that between 31% and 85% of large wood pieces identified in fish-bearing streams came from debris torrent deposits associated with first- or second-order tributaries, and Reeves et al. (2003) reported that 65% of large wood pieces surveyed in a fourth-order stream were delivered by landslides or debris flows from distances greater than 90 meters. Given these findings we expect large wood recruitment by debris torrent to be a significant component of the large wood budget of fish-bearing streams on the ESRF.

For the evaluation of wood recruitment protected under prospective management strategies we use a wood recruitment model, *ElliottSFWood*, developed by Dr. **Dan Miller** of Earth Systems Institute that estimates the relative proportions of total wood recruitment attributable to streamadjacent, landslide, and debris torrent processes (Miller and Carlson, in prep). Output of ElliottSFWood is integrated with large wood source-distance relationships described by McDade et al. (1990) within a GIS environment to estimate protected wood recruitment (Carlson et al. in prep).

We employ the concept of *potential wood recruitment* to facilitate evaluation of the degree to which a prospective riparian conservation strategy protects sources of large wood. As the name suggests, potential wood recruitment is the quantity of large wood that could be recruited to a specified aquatic ecosystem, given the existence of certain conditions. A more complete exposition of this concept is being prepared by OSU doctoral candidate **Deanne Carlson**. In summary, *full potential wood recruitment* (FPWR) is an estimate of the potential total annual large wood quantity expected to be delivered to a wood recruitment target, given reference forest stand conditions. *Protected potential wood recruitment* (PPWR) is an estimate of the quantity of potential annual wood recruitment protected by specified conservation strategies, such as recruitment protected within RCAs, the CRW, and MRW reserve allocations. PPWR is expressed as a percentage of FPWR.

C Riparian Conservation Areas

The management of riparian ecosystems is a challenge for managers and policy makers. Policies and practices often include protective buffers, within which activity, such as vegetation management, is restricted (Richardson et al. 2012; Boisjolie et al. 2017). Management has almost exclusively used fixed-width buffers, with the prescribed width determined by the stream size (average flow) or type (presence or absence of fish) (Richardson et al. 2012). This approach is easy to administer and apply, and is less costly than developing site-specific recommendations, in part because of the analysis required for the latter approach. The combination of these factors and uncertainty about results has limited the development and application of a context-dependent approach to riparian management.

Delineation of the stream network

The delineated stream network used for OSU's ESRF planning process is based on LiDAR-derived digital elevation models (DOGAMI 2009). LiDAR-derived topographic data provides greater stream mapping accuracy and finer resolution than do older stream delineation methods based on, for example, 40-foot contour interval topographic maps. The delineated stream network used by OSU is intended to facilitate the identification of areas of convergent topography susceptible to landslide initiation and debris torrent, including features such as zero-order basins and bedrock hollows with no defined stream channel or surface water flow. In nearly all cases the OSU-delineated stream network extends further into headwall areas than do the Oregon Department of Forestry (ODF) and National Hydrography Dataset (NHD) stream delineations (see Figure 6a). Total delineated stream miles differ by data source: there are 2,087 miles of stream in the OSU layer, 702 miles of stream in the ODF layer, and 747 miles of stream in the NHD stream layer. The greater number of stream miles in the OSU stream layer should not be interpreted to mean that all of these stream miles will be protected within an

Figure 6a. CRW Example Area Full Stream Network

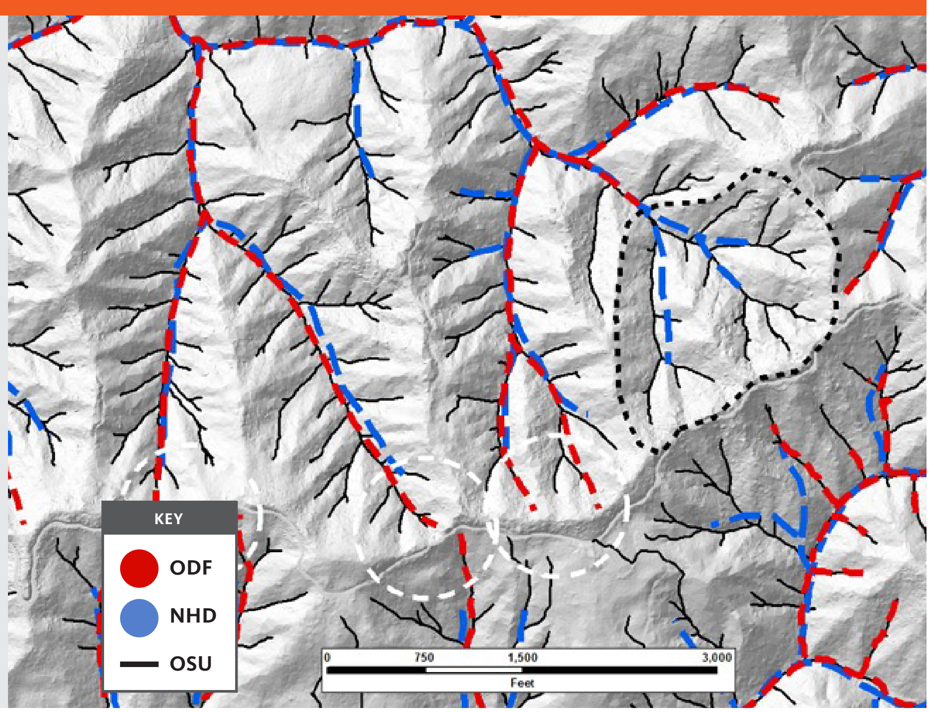


Figure 6a. *Example comparison of stream delineations for the ESRF. The OSU stream layer is based on a LiDAR-derived DEM, and in nearly all cases extends further into headwall areas than do ODF and NHD stream layers. The ODF layer is less consistent than either the OSU layer or the NHD layer. For example, no streams within a 65-acre catchment (center-right, encircled by black dashed lines) are delineated in the ODF layer, yet that layer delineates some streams initiating near the ridgetop with very little hydrologic contributing area (white-dash circles).*

RCA; however, we believe the LiDAR-derived stream layer provides a more suitable basis upon which to evaluate stream protections. A stream protection strategy based on the ODF stream layer that affords some degree of protection for all delineated streams, for example, would include only those streams that were part of the delineated stream network; such a strategy would not protect potentially important streams that were not part of the delineated network (Figure 6a). Our stream delineations make express the potential importance of all headwater streams. By fully delineating the stream network to a fine scale of resolution we are better able to evaluate what is protected within the boundaries of reserve allocations and riparian conservation areas, and what is not protected outside of these areas.

Fish-bearing and non-fish-bearing stream classifications

We used the regulatory definition of fish-bearing streams, which encompasses the upper limit of coastal cutthroat trout in stream networks. Cutthroat trout presence generally extends further into the headwaters of stream networks than any other fish species, even higher than non-game fish such as sculpin. We have defined fish bearing streams as those with a gradient of 20% or less, which is based on eDNA (Penaluna et al. 2021) and electofishing (Latteral et al. 2003) for resident cutthroat trout and provides a fish-bearing stream network approximately 70 miles longer than that identified by OFPA on the Elliott State Forest.

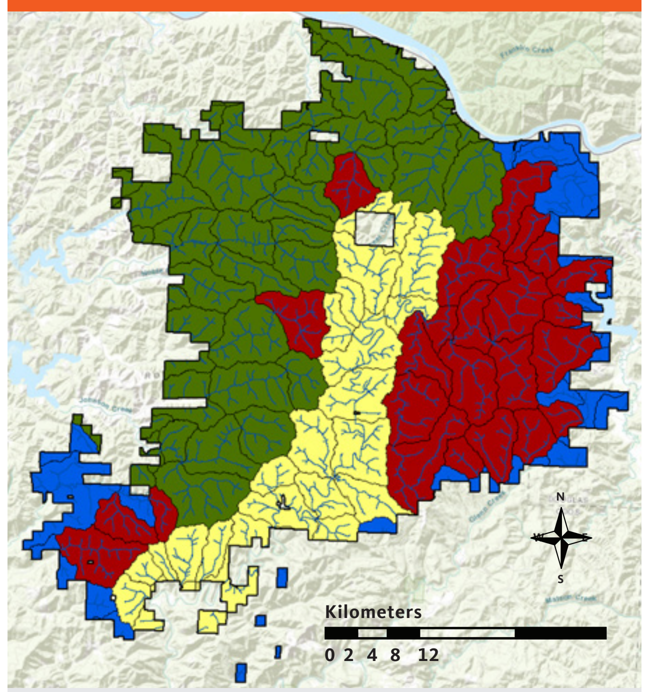
The scientifically recognized extent of the riparian ecosystem has expanded beyond fish-bearing streams as result of the flurry of research conducted after the implementation of the Northwest Forest Plan in 1993. Of particular significance is the recognition of the ecological importance of non-fish bearing streams, which generally make up 70 percent or more of the stream network (Downing et al. 2012, Gomi et al. 2002). Headwaters are sources of sediment (Benda and Dunne 1997a, 1997b; May and Lee 2004; Zimmerman and Church 2001) and wood (Bigelow et al. 2007; May and Gresswell 2003, 2004; Reeves et al. 2003) for fish-bearing streams; provide habitat (Kelsey and West 1998, Olson et al. 2007) and movement corridors (Olson and Burnett 2009, Olson and Kluber 2014) for several species of native amphibians and macroinvertebrates (Alexander et al. 2011, Meyer et al. 2007); and may be important sources of food for fish (Wipfli and Baxter 2010, Wipfli and Gregovich 2002, Wipfli et al. 2007). Wood jams in small streams are important sites of carbon storage (Beckman and Wohl 2014), and these streams export large amounts of carbon; one-third is emitted to the atmosphere and the remainder transported downstream (Argerich et al. 2016).

Non-fish bearing streams are the most abundant portion of the riverine network of the ERSF, comprising approximately 89% of delineated stream miles. ESRF-based research on these streams will focus on: (1) Their ecological role and influence on fish-bearing streams; (2) How they may serve as movement corridors within and among watersheds for terrestrial organisms and riparian organisms, energy and carbon; (3) How to treat previously managed forest areas adjacent to these streams to change the vegetative composition and structure. Doing so will create opportunities to study the influences on riparian soils and use by terrestrial and riparian organisms, the behavior of landslides and the effects on fish-bearing streams, and the production of invertebrates and nutrients that transport to fish-bearing streams.

The following stream classifications have been applied across the ESRF according to the following definitions:

- Fish-bearing (FB) streams are defined as streams with a maximum downstream channel gradient[1] of 20% and a

Figure 6b. ESRF Stream Protection Zones



KEY

- **CRW**
- **Lower Milicoma**
- **Other MRW (full watersheds)**
- **Other MRW (partial watersheds)**

Figure 6b. *Four stream protection zones proposed for the Elliott State Research Forest.*

[1] Maximum downstream gradient is the maximum channel gradient downstream of the subject reach, as calculated over a reach length equivalent to 20 channel widths. It is the steepest channel gradient game fish would be expected to pass; channel gradients greater that 20% are assumed to be complete fish-passage barriers.

minimum average annual streamflow of approximately 0.2 CFS.

- Perennial non-fish-bearing (PNFB) streams are non-fish-bearing streams that have flowing water throughout the year, with no minimum streamflow requirement. Flow duration can vary from year-to-year and may also vary depending on the vegetative condition of the contributing watershed. We assume that streams with a contributing watershed area greater than 6.2 hectares (approximately 15 acres) are perennial streams.
- Wood-delivery non-fish-bearing (WNFB) streams are non-fish-bearing streams that are estimated to deliver greater than a threshold quantity of large wood to fish-bearing streams by debris torrent; they may be either perennial or non-perennial. To determine WNFB status, all non-fish-bearing stream reaches were ranked according to estimated annual wood recruitment contributions to fish-bearing streams, and the top-ranked of these streams were classified as WNFB.
- Other non-fish-bearing (XNFB) streams are streams that are not classified as FB, PNFB, or WNFB. XNFB streams are seasonal or intermittent streams, usually located in the headwalls of stream networks. In many instances delineated XNFB streams may not have a defined stream channel, and thus do not meet the regulatory definition of a stream (e.g., OAR 629-600-0100[76]).

The above stream classifications are applied across the entire ESRF; however, RCA widths associated with these classifications vary according to the protection zone in which streams are situated. For purposes of RCA implementation, there are four stream protection zones: the CRW, Lower Millicoma watersheds (includes all full and partial watersheds tributary to the Millicoma River downstream of Elk Creek), other MRW full watersheds, and other MRW partial watersheds (Figure 6b).

Stream buffer widths and stream miles within each of the four stream protection zones are summarized in Table 7c in Appendix 7.

D Steep Slopes and Headwater Streams

Steep slopes are a distinguishing feature of the ESRF. The topography of the ESRF is variable, as reflected in the difference in distribution of classified slope gradients between the CRW and the MRW (Figure 6c). For example, slopes with gradients greater than 65% comprise 73% of the area of the CRW, whereas such slopes comprise just 54% of the area of the MRW. Similarly, slopes less than 50% gradient comprise 30% of the MRW, compared to 13% of the CRW.

As with most of the Oregon Coast Range, the ESRF is characterized by high stream channel densities and, by extension, high headwater stream channel densities. Perennial stream density of the ESRF is 2.3km•km^{-2}, and stream density of all first order and larger stream channels is 4.8km•km^{-2}. Stream channel density based on all delineated streams, including zero-order channels, is 10.1km•km^{-2}. In more conventional terms, zero-order channels have an average of (approximately) 2 acres of contributing area and first-order channels have an average of (approximately) 8 acres of contributing area. Based on an analysis of flow duration of streams on the Siuslaw National Forest (Clarke et al. 2008), streams with a contributing area greater than (approximately) 15 acres are classified as perennial streams.

The delineation of stream channels facilitates our understanding and analysis of hydrologic and erosional processes as they apply separately to streams and their adjacent topography; however, on steep hillslopes and headwall areas of the Oregon Coast Range these processes are intertwined, and clear distinctions between stream and hillslope processes are seldom possible. Our delineation of the ESRF stream network is intended to facilitate the identification of areas of convergent topography susceptible to landslide and debris torrent processes. These processes occur at the transition between hillslopes and stream channels, forming a crucial link between hillslope, headwall, and stream channel processes, and between terrestrial and aquatic ecosystems

Figure 6c. Distribution of classified hillslope gradient across the MRW and the CRW

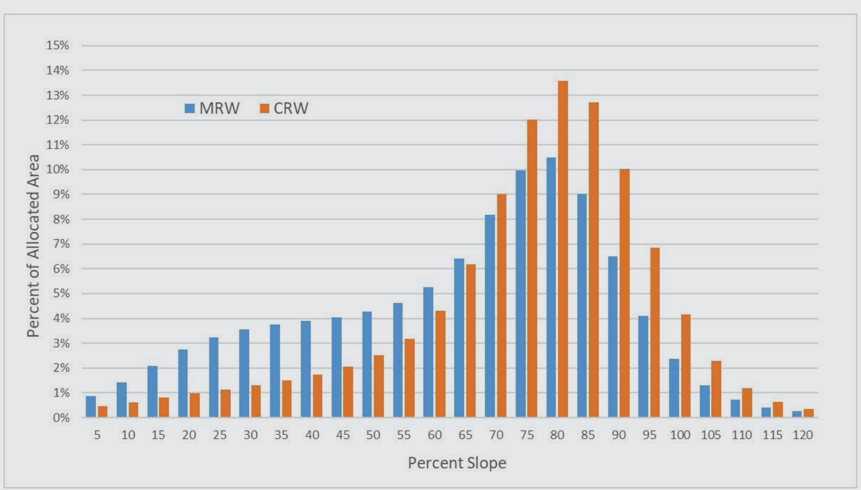


Figure 6c. *Distribution of classified hillslope gradient across the MRW and the CRW. Both the CRW and MRW have areas of very steep slopes, but the MRW and CRW exhibit some generalized topographic differences. Vertical axis values refer to the percent of MRW area and percent of CRW area, not percent of total ESRF area.*

(Benda et al. 2005, Gomi et al 2002). As described above in subsection (c) *(Delineation of the stream network)*, for planning and analytical purposes we have extended the stream network into headwall areas to better recognize the integral nature of streams and their associated terrestrial counterparts, and the effects that these transitional processes have on downstream aquatic ecosystems.

As integrators of local and watershed-scale processes, streams are ideal locations to research how steep slopes and headwater channels, directly and indirectly, affect ecological processes in downstream aquatic ecosystems. There are opportunities to better understand the integration of steep slopes and the streams confined by them and how this relationship changes with time and space. Do key processes leading to the production and delivery of large wood and sediment/nutrient pulses to the aquatic systems occur at different rates in steep landscapes? And if so, what implications does this have for the retention of carbon, nutrients, and biota in headwater ecosystems? We are particularly interested in quantifying the role of large wood in sorting sediments and creating functional habitat in steep landscapes. This process is generally understood but lacks long-term empirical data. Studies on the ESRF will seek to provide knowledge of short and long-term impacts of headwater stream tree retention (such as will occur in extensive harvests and reserves) and headwater stream tree removal in intensive harvests following current Forest Practices Rules.

Protection Strategies for Steep Slopes (65%) and Headwater Streams

OSU's conservation strategy is placed within the context of an over-arching research forest strategy of integrating multiple objectives, including the conservation of listed species (e.g., coho salmon) and research that is relevant to the management of lands beyond the borders of the ESRF (e.g., federal, state, and private forestlands). The conservation strategy is organized around different layers of protection that together provide significant protection and conservation benefits to riparian, aquatic, and terrestrial ecosystems while allowing research that is relevant across multiple land ownership classes, including intensively managed forests. These layers of protection are:

- CRW (approx. 34,000 acres of reserves in one block)
- Reserve treatments within the MRW (approx. 14,000 acres of reserve distributed throughout the MRW with each subwatershed having equal amounts of reserve and intensive treatments see Figure 4 in Appendix 1)
- RCAs within the MRW (approx. 6,500 acres in the MRW See Table 7e for widths and Figures 7a, b and c)
- Extensive treatments with 20-80% retention and longer rotations (see Appendix 5 for more details on practices, approx. 13,000 acres in the MRW)
- Intensive treatments with riparian RCA widths meeting or exceeding the Oregon Forest Practices Rules (every acre of intensive is matched with an acre of reserves in all subwatersheds with intensive treatments in them, a 60yr min rotation age see Appendix 5 for more details on proposed practices and Table 7e for RCA widths, approx.14,000 acres of intensive treatment areas in the MRW.)
- Steep slopes are slightly over-represented in reserve areas. Combined, the CRW, MRW reserves, and RCAs comprise 67% of the total area of the ESRF and 72% of the area of the ESRF with hillslope gradients greater than 65%. The balance of these steep slopes is in the extensive allocation (13%) and in the intensive allocation (16%) (Figure 6d). The prevalence of headwater streams with gradients greater than 50% shows a similar distribution pattern to steep slopes relative to reserve, extensive, and intensive treatments. Thus, at the scale of the entire ESRF, reserve treatments (CRW, MRW

Figure 6d. Distribution of classified hillslope gradient by allocation

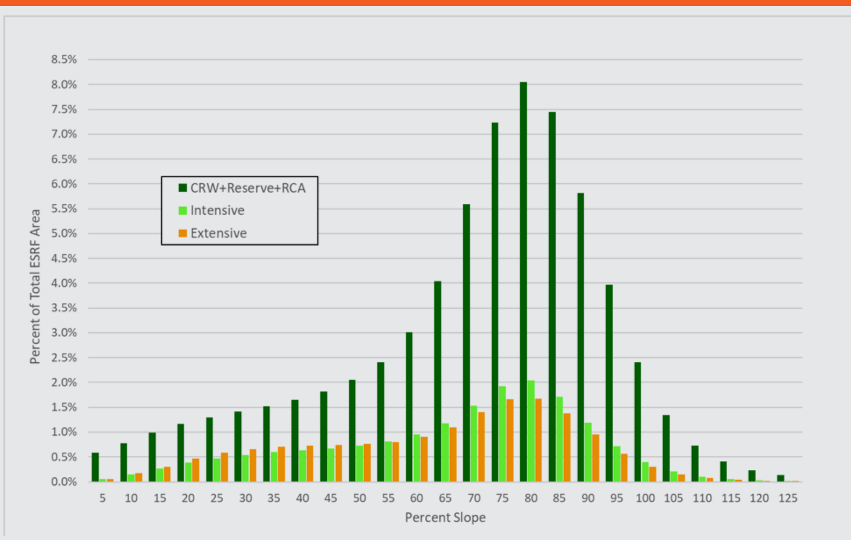


***Figure 6d.** Distribution of classified hillslope gradient by allocation. Reserve treatments (red) are non-harvest areas that are protected* from the effects of forest harvest. Intensive treatments (green) are intended to be representative of lands managed primarily under an industrial timber production approach within Oregon Forest Practices Rule requirements and the additional ESRF intensive approach overlays. Extensive treatments (orange) represent alternative forest management strategies, including high retention and extended rotation lengths and retention of an average of 50% of pre-harvest forest density providing increased conservation.*

**once restoration thinning of Douglas-fir plantations is complete.*

reserve, and RCAs) provide an appreciable level of protection to steep slopes and headwater streams.

By design extensive treatments are intended to explore forestry practices that result in enhanced conservation practices compared to intensive forestry practices by using extended rotation lengths and by retaining 20-80% of the pre-harvest forest density during harvest cycles. Consideration of and protections for steep slope and headwall areas at risk to landslides from management activity can be part of this retention allocation, integrated into other considerations (e.g., terrestrial habitat / MaMu) during the FMP landscape assessment and project-level process.

The intent of intensive treatments is to explore management practices relevant to industrial forestland management. Protective mechanisms that apply to industrial forestland in Oregon are the Oregon Forest Practices Rules (OFPR); therefore, OFPR will provide the minimum regulatory standards for practices within intensive treatments. As proposed, RCAs are allocated on all FB, NFB perennial and HLDP streams adjacent to intensive (and extensive) treatments and provide a greater level of protection (e.g., wider) than OFPR. Therefore, in practice OFPR will apply only to the terrestrial landscape (i.e., steep slopes) and to XNFB streams. OFPR provides the minimum standards in these areas; we expect to use a range of protective measures in intensive stand treatments, depending on research designs and objectives. Intensive treatments will always be coupled with an equivalent area of reserve within each sub-watershed (see, for example, figure 4 in Appendix 1); thus, exclusive of RCAs, no more than 50 percent of any sub-watershed will be in the intensive treatment.

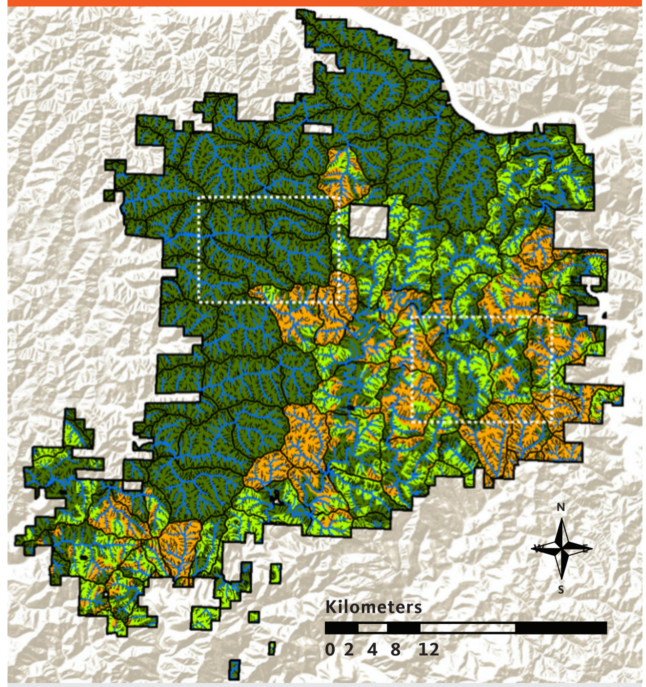
E Restoration Thinning in Riparian Conservation Areas

Some proportion of riparian areas on the proposed ESRF will require restoration efforts because they have been altered by past management. The exact extent of this is currently unknown but is likely to be at least moderately extensive given past activities and policies that allowed for timber extraction in riparian areas. Affected areas likely have dense overstocked stands of conifers and/or an absence of hardwoods. In any case, prudent management may be needed to set these stands onto a different and more ecologically appropriate trajectory focused on aquatic health, and OSU intends flexibility (within sideboards articulated further below) to pursue this restoration approach.

Active management-based restoration activities in riparian reserves have been limited regionally because of concerns about potential negative effects, particularly increased water temperatures and decreased wood-delivery potential, but also due to lack of funding and lack of trust of land managers. The lack of active riparian restoration activities has resulted in a lack of data on the effect of management activities that may have net benefits to aquatic and riparian ecosystems and their associated biota. Given the limited extent of riparian alteration that has occurred in western Oregon and elsewhere, developing and evaluating methods to manage riparian areas to restore their ecological capacity will be a component of the ESRF research program. The intent of active management is that that the activities will promote key ecological processes such as development of the largest trees (Reeves et al. 2018).

Thinning is a potential technique for increasing tree growth (Dodson et al. 2012), and the purposeful placement of some

Figure 6e. Lidar-based stream network for the ESRF



KEY

- **CRW, MRW Reserve, RCA**
- **Extensive treatment**
- **Intensive treatment**
- **RCA-protected stream network**
- **XNFB streams**
- **Sub-watershed boundary**

***Figure 6b**. The Lidar-based stream network layer for the ESRF overlaid upon the subwatershed land allocation assignments and other OSU protective designations (e.g., RCA buffers, 50% of intensive subwatersheds assigned to reserves, etc.). The figure depicts higher gradient steep slope XNFB streams and the extent to which they exist within the various treatment areas (bright green and orange colors) versus protected areas (green). As explained in Appendix 6 & 7, further refinement of XNFB protections in extensive and intensive treatment areas will occur as part of the FMP process and project level based on the flexibility retained to do such protections. Boxes outlined are shown in more detail in Figures 6f and 6g. Note due to scale not all XNFB streams could be represented in this map. If we did map them all, the entire subwatershed would be obscured.*

Figure 6f. Portion of the MRW on the ESRF Illustrating level of riparian conservation relevant to all streams

Figure 6f. *A portion of the MRW on the Elliott State Forest illustrating the level of riparian conservation relevant to all streams especially the abundant higher gradient / steep slope XNFB streams. The extent of protections and increased conservation for a given XNFB will vary depending on research treatment designation and may differ on each side of the stream where there is a reserve on one side and intensive or extensive treatment area on the other. Extensive treatments offer the ability to offer increased conservation for XNFBs as part of the longer rotation and 20-80% retention strategy. And in intensive treatment areas, opportunities for additional XNFB protection exist at the FMP and research planning scale.*

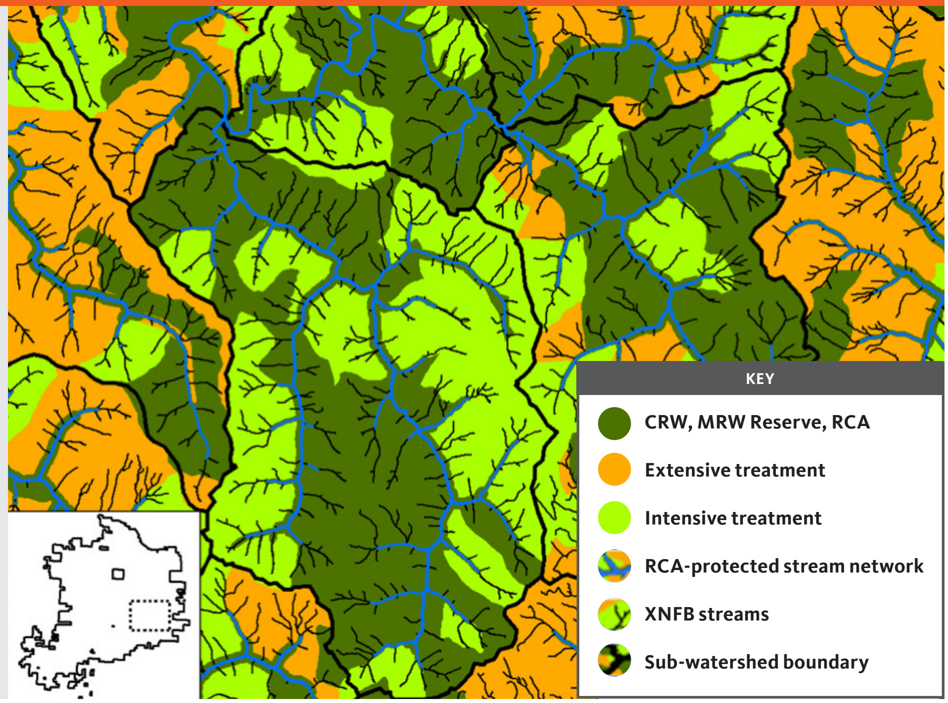
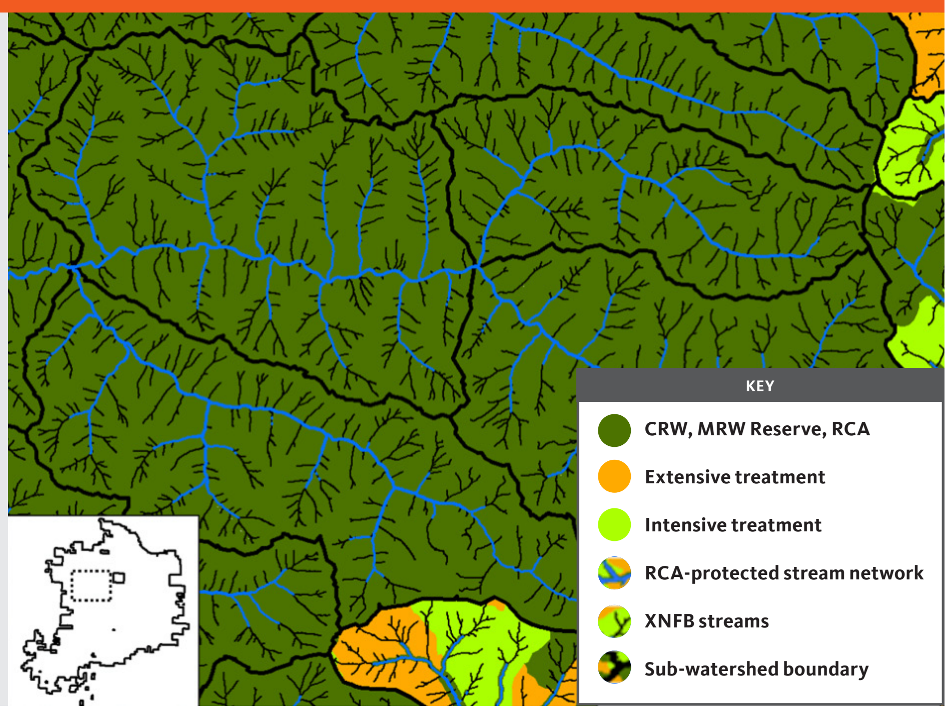


Figure 6g. Portion of the CRW primarily in the CRW reserve on the ESRF illustrating density of/the level of riparian conservation relevant

Figure 6g. *A portion of the CRW primarily in the CRW reserve on the Elliott State Forest illustrating density of the and level of riparian conservation relevant to higher gradient / steep slope XNFB protections. As depicted in Figure 6(d) and Table 7(a), the majority of steep slopes on the ESRF exist within protective reserve designations (CRW, MRW reserves, or RCAs).*

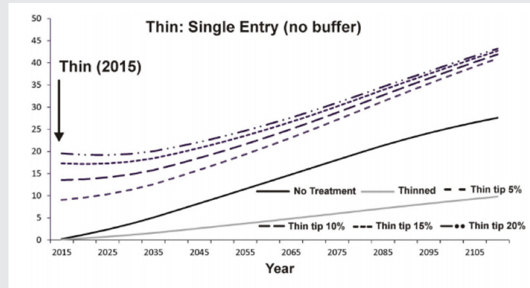


proportion of the harvested wood in the channel or on the forest floor could immediately reduce deficiencies in dead wood that exist in many streams and riparian areas (Benda et al. 2015; see also Olson and Burnett 2009 and Olson and Kluber 2014). Thinning would produce larger dead wood in riparian areas and streams, following placement, in the short term than a stand that is left unthinned, where dead trees accumulate slowly from the smallest size classes as a result of competition, disease, disturbance, and other factors. In some stand conditions, such actions could have the added benefit of accelerating future development of very large-diameter (>40 inches) trees (Spies et al. 2013). However, any thinning activity to increase wood recruitment in the near and long terms will also have to consider potential impacts on water temperature and water quality.

Benda et al. (2015) explore potential effect of introducing portions of the wood thinned to the wood loading in a stream by modeling the amount of instream wood that would result from thinning a stand from 400 trees per acre to 90 trees per acre, then directionally falling or pulling over varying proportions of the trees scheduled for harvest (Figure 7). This was compared to the amount of wood that would be expected to be found in the stream without thinning the stand. The amount of wood increased above the "no thin" level immediately after the entry in all of the options of wood additions. However, the cumulative total amount of wood expected in the stream over 100 years relative to the unthinned stand varied depending on the amount of wood delivered. Adding less than 10 percent of the wood that would be removed during thinning produced less wood in the channel over time than the unthinned option. However, when 15-20% of the volume of thinned trees was tipped from one side of the stream at each entry, the total amount of dead wood in the channel over time exceeded the unthinned scenario (Figure 7a). Management of riparian areas on the ESRF will include devoting 15-20% of the thinned total volume to the stream channel.

The challenge is to be able to pay for restoration efforts. Writing the cost of doing thinning into timber sale contracts without being able to harvest any of the thinned trees is likely to severely restrict restoration efforts and opportunities to conduct research on approaches to riparian restoration. Therefore, the removal of some proportion of the thinned trees beyond 120' will be allowed in the entire Riparian Conservation Area (RCA) where appropriate within the CRW and MRW reserve designations. The RCA in these reserves is 200', which is the distance equal to the height of one site potential tree. It is unlikely that trees in the area between 120' and 200' will be tall enough at the time of thinning to reach the channel. Attempting to place such pieces in the stream would incur additional costs to the operation and potentially result in additional undesirable disturbance to the RCA. Therefore, the 15-20% of the total volume thinned that is devoted to the channel placement will come from the first 120', provided there is sufficient volume in this area to do so.

Figure 6a. Prediction from reach scale wood model of Benda et al. (2015).



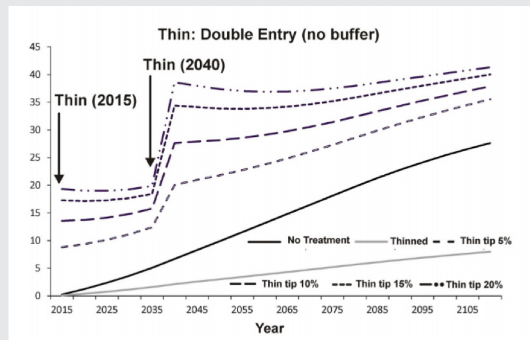


Figure 6h. *Predictions from the reach scale wood model showing cumulative wood volume over time (included decay) for a single and double entry thinning, without a 10 m buffer, simultaneously on both sides of the channel. Also shown are results from tree tipping from 5 to 20% of the thinned trees into the stream.*

The predicted increases in the volume of in-stream wood due to tipping could offset concerns about reductions of instream wood and loss of fish habitat during a thinning operation (Beechie et al. 2000). Additionally, in tipping, the amount of wood increases immediately rather than being delayed for 25–50 years in the no treatment, unmanaged stand. This could be particularly important for improving habitat conditions for U.S. Endangered Species Act-listed species such as the Coho salmon in the near term, rather than waiting an additional half century or more for higher levels of wood recruitment and storage. The increase in the size of the trees in the riparian zone over time that results from thinning is also important ecologically because they will be more effective in forming pools than smaller sized pieces, although the instream piece size effect might not occur until after the first century.

Trees sold from RCA thinning will be a biproduct of the restoration thinning research design. In keeping with the ESRF's "research-first" mission, OSU will not conduct RCA thinning for the purpose of generating profit. The sole purpose of this activity is to restore riparian stands that have been affected by previous management. No conifers >65 years old (in 2020) will be harvested. Of the conifers harvested, 15-20% of the total volume thinned will be devoted to the channel placement and will come from the first 120 feet adjacent to subject streams, provided there is sufficient volume in this area to do so. Log volume in the zone from 120’ to 200’ will be removed and revenue from this work will remain part of the overall ESRF operations and accounting. Net revenue from all timber sale operations, including restoration thinning, will be used to fund and advance the mission of the ERSF as a research forest.

F Roads

We commit to reducing the current road network density and their related adverse impacts on the ESRF, particularly in the Conservation Research Watersheds, while maintaining and balancing for necessary access for research, harvesting, management, education, fire protection, and recreation. Roads are imposed on the landscape to maintain access to remote sites for several uses, including recreation, firefighting, and removing wood products. Roads also represent a significant human impact on the larger forest system in terms of chronic long-term disturbance, fragmentation, sediment yield, and access for invasive species. Regardless of the use, gaining access via roads often disrupts ecosystem processes essential for the proper functioning of aquatic and riparian ecosystems. This disruption is especially evident where there are hydrologic connections between the road and aquatic networks such as sediment-laden runoff and rapid peak flows. Given the density of roads and streams on the ESRF and the presence of listed species, ways to mitigate impacts of strong hydrologic connections are areas of potential significance and wide application in the Northwest.

While still early in development, the OSU proposal for an ESRF envisions studies on the degree of hydrologic connections of current and legacy roads and their primary locations on the ESRF. Monitoring will identify candidate roads for modification to test methods for reducing hydrologic connections through road restoration and long-term monitoring of subsequent habitat impacts. In support of this, the ESRF will maintain an inventory of the road network to identify current and legacy roads that present a risk to the aquatic and riparian system and seek to implement modifications to the road system prioritizing segments that pose the highest risk to aquatic resources.

We will decommission some roads to reduce ecological risks but will also be mindful of providing access for firefighting and recreation consistent with reserve goals and State Land Board guidance. The road network in the CRW and MRW reserve watersheds will decline over time, and new, permanent roads may be constructed as part of a strategy to decommission road segments that are a problem. Still, we must implement such a strategy in the context of the forest research plan.

In addition to the aforementioned attributes of the riparian strategy, OSU commits to working with the local watershed councils and other organizations to restore and improve the ecological condition of streams on the ESRF. OSU will ensure that the work of these groups continues by:

- Supporting their efforts to secure funds from OWEB and other sources.
- Attempting to integrate restoration efforts into the research design.
- Providing data for and input into the restoration work of the various watershed groups.

The councils should be able to use the establishment of the ESRF as the foundation for developing a comprehensive watershed recovery program for each of the independent populations that occur on the ESRF. The councils will be briefed on research activities and findings regularly once the ESRF is established.

LITERATURE CITED

Alroy, J., 2015. Current extinction rates of reptiles and amphibians. Proceedings of the National Academy of Sciences 112(42): 13003-13008.

Alexander, L.C.; Hawthorne, D.J.; Palmer, M.A.; Lamp, W.O. 2011. Loss of genetic diversity in the North American mayfly Ephemerella invaria associated with deforestation of headwater streams. Freshwater Biology. 56: 1456–1467. doi:10.1111/j.1365-2427.2010.02566.x.

Argerich, A.; Haggerty, R.; Johnson, S.L.; Wondzell, S.M.; Dosch, N.; Corson-Rikert, H.; Ashkenas, L.R.; Pennington, R.; Thomas, C.K. 2016. Comprehensive multiyear carbon budget of a temperate headwater stream. Journal of Geophysical Research Biogeoscience. 121: 1306–1315.

Beckman, N.D.; Wohl, E. 2014. Carbon storage in mountainous headwater streams: the role of oldgrowth forest and logjams. Water Resources Research. 50: 2376–2393.

Beechie T., Pess G.R., Kennard P., Bilby P.R., and Bolton, S. 2000. Modeling recovery rates and pathways for woody debris recruitment in northwestern Washington streams. North American Journal of Fisheries Management 20:436–452.

Benda, L.E., Litschert, S.E., Reeves, G. and Pabst, R., 2016. Thinning and in-stream wood recruitment in riparian second growth forests in coastal Oregon and the use of buffers and tree tipping as mitigation. Journal of Forestry Research 27: 821-836.

Benda, L.; Dunne, T. 1997a. Stochastic forcing of sediment supply to channel networks from landsliding and debris flow. Water Resources Research. 33: 2849–2863.

Benda, L.; Dunne, T. 1997b. Stochastic forcing of sediment routing and storage in channel networks. Water Resources Research. 33: 2865–2880.

Benda, L., Hassan, M.A., Church, M. and May, C.L., 2005. Geomorphology of steepland headwaters: the transition from hillslopes to channels 1. JAWRA Journal of the American Water Resources Association, 41(4), pp.835-851.

Bigelow, P.E.; Benda, L.E.; Miller, D.J.; Burnett, K.M. 2007. On debris flows, river networks, and the spatial structure of channel morphology. Forest Science. 53: 220–238.

Boisjolie, B.A., Flitcroft, R.L. and Santelmann, M.V., 2019. Patterns of riparian policy standards in riverscapes of the Oregon Coast Range. Ecology and Society, 24(1).

Clarke, S.E., Burnett, K.M. and Miller, D.J., 2008. Modeling Streams and Hydrogeomorphic Attributes in Oregon From Digital and Field Data 1. JAWRA Journal of the American Water Resources Association, 44(2), pp.459-477.

Dybala, K.E., Matzek, V., Gardali, T. and Seavy, N.E., 2019. Carbon sequestration in riparian forests: A global synthesis and meta-analysis. Global change biology, 25(1), pp.57-67.

Dodson, E.K., Ares, A., and Puettmann, K.J. 2012. Early responses to thinning treatments designed to accelerate late successional forest structure in young coniferous stands of western Oregon, USA. Canadian Journal of Forest Research 42:345–355

Downing, J.A.; Cole, J.J.; Duarte, C.A.; Middelburg, J.J.; Melack, J.M.; Prairie, Y.T.; Kortelainen, P.; Striegl, R.G.; McDowell, W.H.; Tranvik, L.J. 2012. Global abundance and size distribution of streams and rivers. Inland Waters. 2: 229–236.

Everest, F.H.; Reeves, G.H. 2007. Riparian and aquatic habitats of the Pacific Northwest and southeast Alaska: ecology, management history, and potential management strategies. Gen. Tech. Rep. PNW-GTR-692. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 130 p.

Forest Ecosystem Management Assessment Team (FEMAT). 1993. Forest ecosystem management: an ecological, economic, and social assessment. Portland, OR: U.S. Department of Agriculture; U.S. Department of the Interior[and others]. [irregular pagination].

Goetz, J.N.; Guthrie, R.H.; Brenning, A. 2015. Forest harvesting is associated with increased landslide activity during an extreme rainstorm on Vancouver Island, Canada. Natural Hazards Earth Systems Science. 15: 1311–1330.

Gomi, T.; Sidle, R.C.; Richardson, J.S. 2002. Understanding processes and downstream linkages of headwater systems: headwaters differ from downstream reaches by their close coupling to hillslope processes, more temporal and spatial variation, and their need for different means of protection from land use. BioScience. 52: 905–916.

Guthrie, R.H. 2002. The effects of logging on frequency and distribution of landslides in three watersheds on Vancouver Island, British Columbia. Geomorphology. 43: 273–292.

Hibbs, D.E.; Giordano, P.A. 1996. Vegetation characteristics of alder-dominated riparian buffer strips in the Oregon Coast Range. Northwest Science. 70: 213–222.

Kelsey, K.A.; West, S.D. 1998. Riparian wildlife. In: Bilby, R.E.; Naiman, R.J., eds. River ecology and management: lessons from the Pacific coastal ecoregion. New York: Springer-Verlag: 235–260.

Jakob, M. 2000. The impacts of logging on landslide activity at Clayoquot Sound, British Columbia. Catena. 38: 279–300.

Latterell, J.J., Naiman, R.J., Fransen, B.R. and Bisson, P.A., 2003. Physical constraints on trout (Oncorhynchus spp.) distribution in the Cascade Mountains: a comparison of logged and unlogged streams. Canadian Journal of Fisheries and Aquatic Sciences 60: 1007-1017.

May, C.L.; Gresswell, R.E. 2003. Large wood recruitment and redistribution in headwater streams of the Oregon Coast Range, U.S.A. Canadian Journal of Forest Research. 33: 1352–1362.

May, C.L.; Gresswell, R.E. 2004. Processes and rates of sediment and wood accumulation in headwater streams of the Oregon Coast Range, U.S.A. Earth Surface Processes and Landforms. 28: 409–424.

May, C.L.; Lee, D.C. 2004. The relationships among in-channel sediment storage, pool depth, and summer survival of juvenile salmonids in Oregon Coast Range streams. North American Journal of Fisheries Management. 24: 761–774.

McIntyre, P.J.; Thorne, J.H.; Dolanc, C.R.; Flint, A.L.; Flint, L.E.; Kelly, M.; Ackerly, D.D. 2015. Twentieth century shifts in forest structure in California: denser forests, smaller trees, and increased dominance of oaks. Proceedings of the National Academy of Sciences of the United States of America. 112: 1458–1463.

Meyer, J.L.; Strayer, D.L.; Wallace, J.B.; Eggert, S.L.; Helfman, G.S.; and Leonard, N.E. 2007. The contribution of headwater streams to biodiversity in river networks. Journal of the American Water Resources Association. 43: 86–103.

Naiman, R.J.; Bilby, R.E.; Bisson, P.A. 2000. Riparian ecology and management in the Pacific coastal rain forest. BioScience. 50: 996–1011.

Olson, D.H.; Anderson, P.D.; Frissell, C.A.; Welsh, H.H., Jr.; Bradford, D.F. 2007. Biodiversity management approaches for stream–riparian areas: perspectives for Pacific Northwest headwater forests, microclimates, and amphibians. Forest Ecology and Management. 246: 81–107.

Olson, D.H. and Burnett, K.M., 2009. Design and management of linkage areas across headwater drainages to conserve biodiversity in forest ecosystems. Forest Ecology and Management 258: pp. S117-S126.

Olson, D.H. and Kluber, M.R., 2014. Plethodontid salamander distributions in managed forest headwaters in western Oregon, USA. Herpetological Conservation and Biology 9:76-96.

Penaluna, B.E., Allen, J.M., Arismendi, I., Levi, T., Garcia, T.S. and Walter, J.K., 2021. Better boundaries: identifying the upper extent of fish distributions in forested streams using eDNA and electrofishing. Ecosphere, 12(1), p.e03332

Reeves, G.H.; Burnett, K.M.; McGarry, E.V. 2003. Sources of large wood in the main stem of a fourthorder watershed in coastal Oregon stream. Canadian Journal of Forestry Research. 33: 1363–1370.

Reeves, G.H., D.H. Olson, S.M. Wondzell, P.A. Bisson, S. Gordon, S.A. Miller, J.W. Long, and M.J. Furniss. 2018. The aquatic conservation strategy of the Northwest Forest Plan—A review of the relevant science after 23 years. In: Spies, TA; Stine, PA; Gravenmier, R.; Long, JW; Reilly, MJ, tech. coords. 2018. Synthesis of science to inform land management within the Northwest Forest Plan area. Gen. Tech. Rep. PNW-GTR-966. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station P. 461-624.

Reid, A.J., Carlson, A.K., Creed, I.F., Eliason, E.J., Gell, P.A., Johnson, P.T., Kidd, K.A., MacCormack, T.J., Olden, J.D., Ormerod, S.J. and Smol, J.P. 2019. Emerging threats and persistent conservation challenges for freshwater biodiversity. Biological Reviews 94: 849-873.

Richardson, J.S.; Naiman, R.J.; Bisson, P.A. 2012. How did fixed-width buffers become the standard practice for protecting water from forestry? Freshwater Science. 31: 232–238.

Spies, T., Pollock, M., Reeves, G. and Beechie, T. 2013. Effects of riparian thinning on wood recruitment: a scientific synthesis. Science Review Team Wood Recruitment Subgroup, USDA Forest Service, PNW Research Station, Portland.

Strayer, D.L. and Dudgeon, D. 2010. Freshwater biodiversity conservation: recent progress and future challenges. Journal of the North American Benthological Society 29(1): 344-358.

Swanson, M.; Franklin, J.F.; Beschta, R.L.; Crisafulli, C.M.; DellaSala, D.A.; Hutto, R.L.; Lindenmayer, D.B.; Swanson, F.J. 2011. The forgotten stage of forest succession: early-successional ecosystems on forest sites. Frontiers in Ecology and the Environment. 9: 117–125.

Vörösmarty, C.J., McIntyre, P.B., Gessner, M.O., Dudgeon, D., Prusevich, A., Green, P., Glidden, S., Bunn, S.E., Sullivan, C.A., Liermann, C.R. and Davies, P.M. 2010. Global threats to human water security and river biodiversity. Nature 467(7315): 555-561.

Wipfli, M.S.; Baxter, C.V. 2010. Linking ecosystems, food webs, and fish production: subsidies in salmonid watersheds. Fisheries. 35: 373–387.

Wipfli, M.S.; Gregovich, D.P. 2002. Export of invertebrates and detritus from fishless headwater streams in southeastern Alaska: implications for downstream salmonid production. Freshwater Biology. 47: 957–969.

Wipfli, M.S.; Richardson, J.S.; Naiman, R.J. 2007. Ecological linkages between headwaters and downstream ecosystems: transport of organic matter, invertebrates, and wood down headwater channels. Journal of the American Water Resources Association. 43: 72–85. doi:10.1111/j.1752-1688.2007.00007.x.

Zimmerman, A.; Church, M. 2001. Channel morphology, gradient profiles and bed stresses during a flood in a step-pool channel. Geomorphology. 40: 311–327.

APPENDIX 7

Riparian Area Research and Conservation Tactics

Intended to provide initial riparian area treatments and details on stream buffers in the CRW, MRW, and the West Fork of the Millicoma River.

A SUITE OF RIPARIAN AREA RESEARCH TREATMENTS

Aquatic and riparian treatments are structured to test the effectiveness and tradeoffs of providing critical ecological processes, such as wood recruitment, cold water, litter fall, and sediment, all of which are important to Coho salmon.

The focus of OSU's riparian approach is on maintaining key ecological processes that influence the productivity of aquatic ecosystems and associated resources. Rather than relying on a single mechanism, such as RCAs, land use allocation, and outcome-based wood delivery potential, or a single stream type such as fish-bearing or non-fish perennial or non-perennial, steep headwall vs defined stream channel, it is the combination of these attributes that provides protection and conservation of many of the key ecological processes essential for aquatic ecosystems. Protection (e.g., reserves) and increased conservation (e.g., extensive) will include fish bearing streams and non-fish bearing streams. Under the ESRF proposal:

- approximately 1,595 miles (or 86%) of non-fish bearing streams on the ESRF--from headwalls down to fish bearing streams--are in a protected (CRW, MRW reserve, and RCA) or increased conservation (extensive allocation) status.
- the remaining 14% of the ESRF's non-fish bearing streams are in an intensive or less protected status, with 29 miles having 50-120-foot RCA protection and 252 miles having no RCA.

This overall riparian approach is in alignment with the research platform on the ESRF using a systems-based approach to investigate the integration of intensively managed forests, forest reserves, dynamically managed complex forests and the aquatic and riparian ecosystems that flow within them.

STREAM TYPES

1. **Fish-bearing (FB):** Streams with a maximum downstream gradient of less than 20% and a minimum average annual streamflow of approximately 0.2 CFS.

2. **Perennial non-fish-bearing (PNFB):** Streams modeled as providing year-round flow but not having game fish.

Figure 7a. Elliott Research Forest Stream Protection Classes

KEY

- Fish-bearing stream
- HLDP non-fish stream (perennial and non-perennial)
- Perennial non-fish stream
- Other non-perennial, non-fish stream

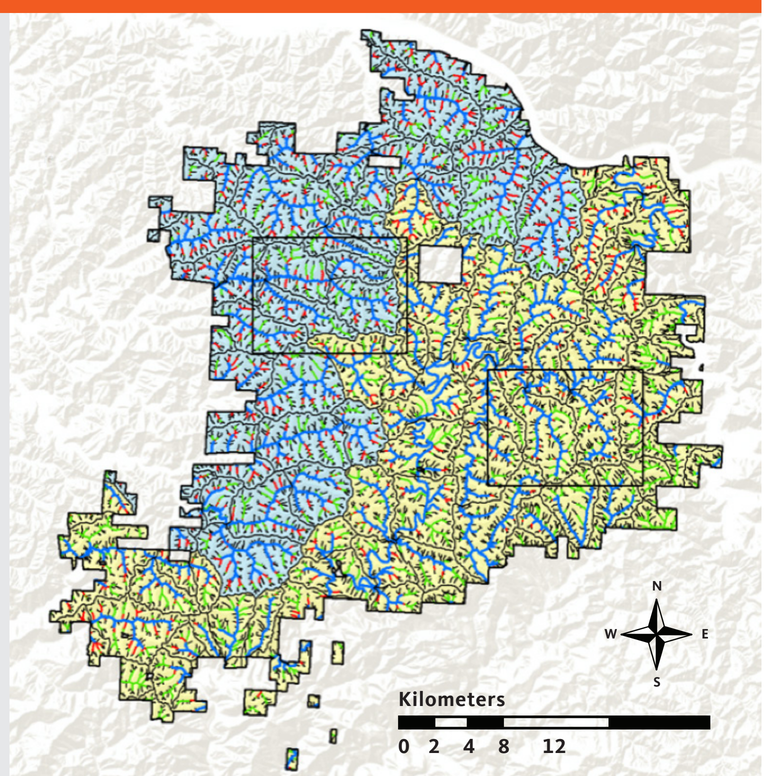


Figure 7a. *The Lidar-based 2087-mile stream network on the Elliott State Research Forest (for visual purposes not all non-fish streams are shown). There are approximately 235 miles of fish bearing and 1852 miles of non-fish perennial streams and non-fish non-perennial streams identified. The high landslide delivery potential (HLDP) non fish streams are highlighted in red, note their abundance in many of the reserved areas. Boxes outlined are shown in more detail in Figures 7b and 7c.*

3 **Priority wood delivery non-fish-bearing (WNFB) debris torrent streams:** Non-fish-bearing streams (perennial, seasonal, or intermittent) with a high relative potential to deliver large wood to fish-bearing streams.

4 **Other (XNFB):** Streams primarily intermittent streams with low potential for wood delivery to fish-bearing streams.

Our analysis begins with many more miles of stream than typically assessed. This increase is a function of using a stream layer based on Lidar that identifies 2087 miles of streams on the Elliott (Figure 7a). In contrast, the ODF layer, identifies about 702 miles of stream. Fish-bearing streams are those with a gradient of less than 20% gradient. This results in 42% more miles (235 ESRF vs. 165 ODF) of fishbearing streams being identified on the ESRF. Thus, in comparison to the ODF stream layer, seventy miles of stream previously classified as perennial non-fish bearing are now classified as fish-bearing on the ESRF as a result of using the 20% gradient.

Research protocols call for RCAs to vary in size and configuration according to stream type and upslope research treatment (Table 8b). Stream types reflect the presence of fish, timing of flow (perennial versus seasonal), and susceptibility to landslide-associated debris flows that deliver wood to fish-bearing streams. Measure RCAs as the horizontal distance from the outer edge of the channel migration zone and reference to a site potential tree height of 200 feet, per local BLM data. The ESRF research design, in which the RCAs play a critical role, allows for varying, site-specific implementation, with a minimum set of standard prescriptions applied as set forth below.

RCA BUFFERS IN THE CRW AREA AND AREAS DESIGNATED AS RESERVES IN THE MRW

The treatments in the CRW and MRW reserves include restoration-based thinning in Douglas-fir plantations, recognizing that past management the CRW area and MRW reserves has created dense plantation stands in areas including riparian zones and that the need exists for a focused effort to recruit future old stands and unlogged naturally regenerated older forests. Therefore, reserves will have two starting points: a) Exploring treatments to restore and enhance conservation value in established plantations by transitioning to older, more complex forests including in RCAs; b) Conserving unmanaged mature forests as they move through natural successional processes. Since there is no harvesting in "b", there is no need for designated RCAs. Designated RCAs are only applicable when thinning adjacent to reserve stands to restore dense Douglas-fir plantations and/or increase the presence of desired hardwoods. Once these thinning treatments are complete, there will be no more harvesting in the reserve treatments, thus the designated RCA will integrate with the surrounding forest over time. However, during thinning, RCAs at these locations will be 200 feet slope distance on fish-bearing and non-fish-bearing perennial streams, and key debris flow torrents that deliver wood to the fish-bearing streams (see Table 7a).

Thinning to reduce the density of existing plantation stands within RCAs buffers will be undertaken only in plantation stands less than 65 years of age as of 2020 and only if determined necessary to support and enhance long-term ecological functions of the RCAs. Thinning would occur as part of the one-time entry into these plantations and for conservation purposes primarily focused in promoting the more rapid development of large trees that can potentially be recruited to the stream or the establishment of hardwoods to provide higher quality litter resources to the stream, increase habitat diversity and stream productivity. No harvest of trees will occur from the RCA if they are determined to be older than 65-year-old as of 2020, situated on landslide-prone steep or unstable conditions, or if there is overlap with designated wildlife habitat (e.g., Mamu).

RCA BUFFERS IN THE MRW

Initially, specific size and configuration of the different RCA components in the respective stream types will depend on the level of desired wood delivery potential needed to attain the MRW outcomes-based wood recruitment objective of a minimum of 70% outside the MRW reserves. Table 7c and 7d describes the minimum buffer widths and approach for the various stream types and stream protection zones. Within the MRW, the flexibility to reallocate buffer protections from fish bearing streams to HLDP upper reaches, especially those within intensive stand treatments, is important to our research-based desire to develop and test different configurations of riparian conservation on fish-bearing and non-fish bearing streams to achieve the target level of wood delivery (min. of 70%). This is the reason for a range of 100'-120' for the fish bearing portion of streams outside the lower Millicoma (i.e., where 100' is applied, increased buffering would be allocated to the HLDP portions of the stream network in order to attain the target level of wood delivery and associated resources) and to ensure areas with a high potential for failure will have trees in place for soil stability and root

Table 7a. Proposed level of protection of riparian and aquatic systems in all non-fish bearing streams on the ESRF

Land-use category adjacent to NFB streams	PNFB (miles)	WNFB (miles)	XNFB (miles)	Total (miles)
Reserves >65 years (CRW and MRW)	77.5	43.1	737.4	858.0[1]
Restoration Thin in Reserves <65 years	29.0	21.0	275.0	325.0
Extensive (20-80% retention harvest outside of RCA)	31.9	6.8	264.4	303.1
Subtotal of Conservation and Restoration miles	138.4	70.9	1276.8	1486.1
Intensive Treatment (clear-cut 60yr rotation)	22.5	7	252.1	281.6
Total	**160.9**	**77.9**	**1528.9**	**1767.7**

Table 7a. *Quantifying the proposed level of protection of riparian and aquatic systems in all non-fish bearing streams on the Elliott State Research Forest by calculating the number of stream miles adjacent to each land management strategy. In addition, all non-fish perennial streams (PNFB) and the high landslide delivery potential (HLDP) streams have a minimum 50'buffer where wood harvest may occur adjacent to the buffer. Remaining non-fish bearing non-perennial streams (XNFB) have a minimum buffer width of 0. (For additional details on fish-bearing and non-fish bearing streams see Table 8b).*

[1] *All streams have a 200' Riparian Conservation Area buffer*

Figure 7b. CRW Example Area Full Stream Network

KEY

- CRW/Reserve
- Intensive
- Extensive
- RCA
- Fish-bearing stream
- HLDP non-fish stream (perennial and non-perennial)
- Perennial non-fish stream
- Other non-perennial, non-fish stream

Figure 7b. *A portion of the CRW on the Elliott State Forest illustrating the level of riparian conservation in the CRW. See Table 8b for details of RCA widths. Given that CRW thinning will be limited to existing dense Douglas fir plantations < 65 years old (as of 2020), the research design will result in nearly 100% of the potential wood recruitment within the CRW.*

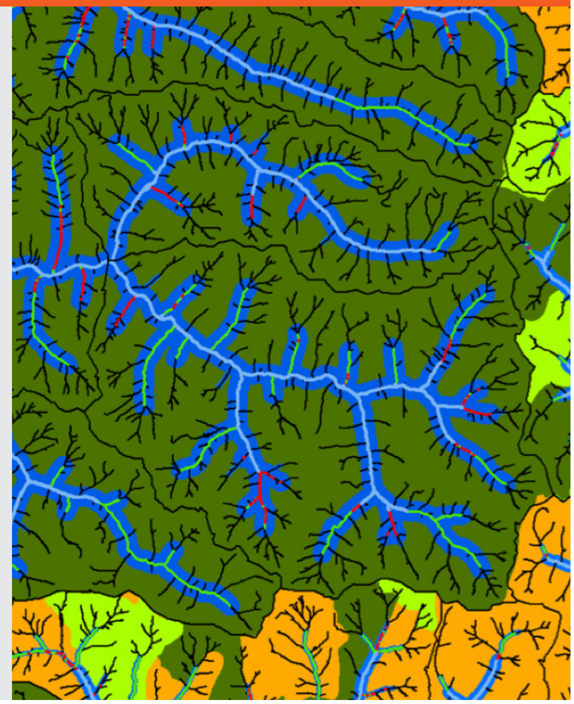
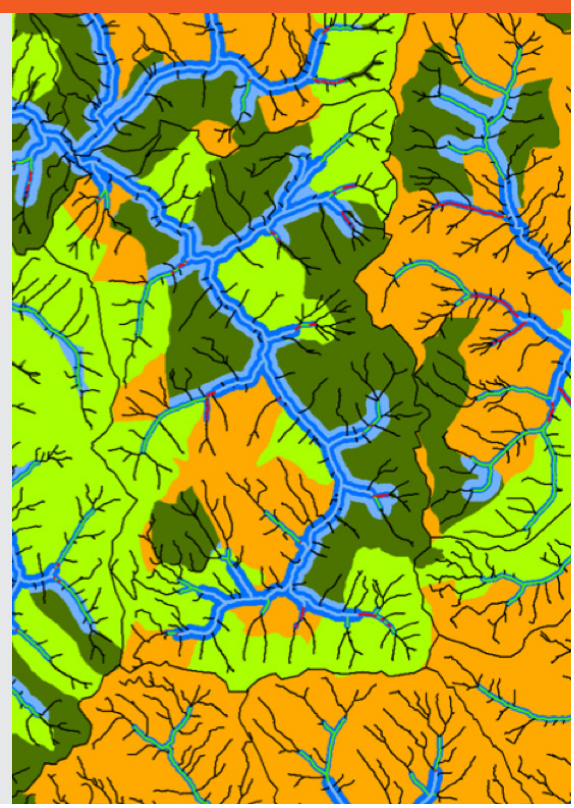


Figure 7c. MRW Example Area Full Stream Network

KEY

- CRW/Reserve
- Intensive
- Extensive
- RCA
- Reserve Recruitment
- Fish-bearing stream
- HLDP non-fish stream (perennial and non-perennial)
- Perennial non-fish stream
- Other non-perennial, non-fish stream

Figure 7c. *A portion of the MRW on the Elliott State Forest illustrating the range of riparian conservation strategies. See Table 8b for details of RCA widths. Note that the size of the RCA will vary depending on research designation and may differ on each side of the stream where there is a reserve on one side and intensive harvest on the other. Note the number of other non-perennial non-fish streams located in treatments that will maintain tree cover in the reserve and extensive stand-level treatments. Regardless of the RCA widths in other portions of the landscape, all streams flowing through reserves will have much larger riparian buffers since harvest activities will not take place (except for limited one-time restoration thinning in Douglas-fir plantations if needed).*



strength. This also provides researchers a means to consider other factors (wildlife, operational efficiency, etc.) in designing an efficient and effective riparian protection network.

WEST FORK MILLICOMA RIVER PROPOSED RCAS

In recognition of the distinct relative values the Millicoma system provides to Coho salmon and other ecological values, the designated RCAs for the West Fork Millicoma River from its entry into the ESRF in the southwest portion of the forest through the confluence with Elk Creek will be established and maintained as follows (see also Table 7b below):

- The RCA will be a distance equal to the site potential tree height, (200 feet measured as the horizontal distance from each side of the channel migration zone) on either side of the river mainstem and 120 feet measured as horizontal distance along any non-fish bearing stream that has a high potential to deliver wood to the adjacent fish-bearing stream and fish-bearing tributaries to the mainstem.
- Note that under the current research plan, the river's main channel will be bordered by 68% reserves, 26% extensive and 6% intensive treatments. Since 68% of the river will be bordered by reserves that will not experience timber harvests, the actual area protected within the Millicoma system greatly exceeds the 200' designated RA (Table 7b.).
- To further minimize the potential for adverse impacts to this ecologically and recreationally valuable region, the approximately 30% of the West Fork Millicoma watershed in reserves and 30% of the area in extensive can be integrated with the non-fish bearing streams identified as high potential for debris flow torrents that deliver wood to fish-bearing streams. Doing so would ensure the wood delivered during a debris flow will be large diameter.

SUMMARY

A primary purpose of the Elliott State Research Forest is to explore a range of options for managing forested landscapes and their associated aquatic and riparian ecosystems to achieve a suite of legal, social, economic, and ecological objectives. We will test the hypothesis that an approach relying on land use, wood delivery potential, restoration thinning, and RCAs will result in a high level of protection for Coho and other riparian and aquatic species while maintaining flexibility to conduct research that will inform future policy.

Table 7b. Percent of river miles along the West Fork of the Millicoma River

Treatment	Percent bordering river	Proposed riparian conservation area width (ft)
Extensive	26%	200
Intensive	6%	200
Reserve	68%	NA

Table 7b. *Percent of river miles along the West Fork of the Millicoma River that are bordered by the proposed experimental treatments in Figure 7c.*

Figure 7d. Example of the first step in integrating treatments along the West Fork of the Millicoma River

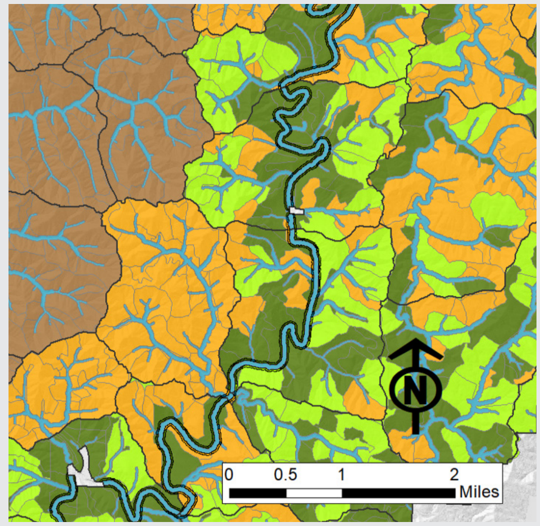
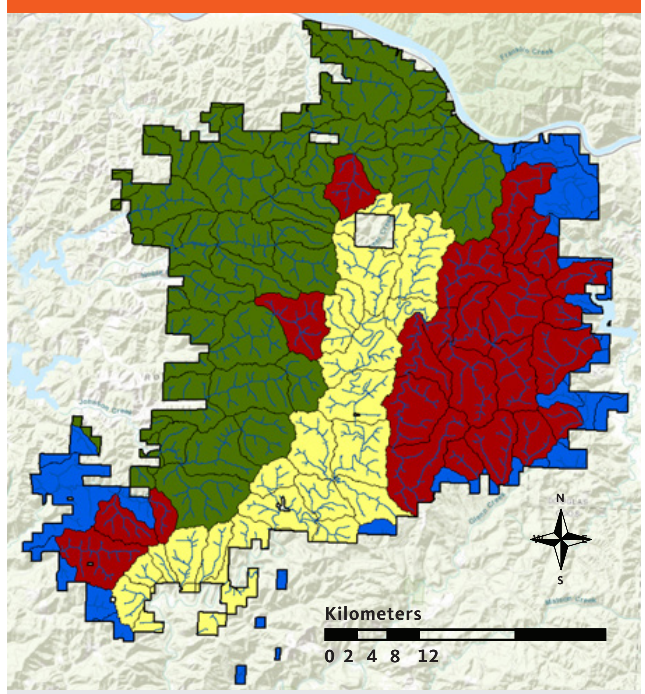


Figure 7d. *Example of the first step in integrating riparian and upslope treatments along the West Fork of the Millicoma River on the ESRF. The goal is to ensure the presence of large trees where wood recruitment is most likely to occur from riverside to headwall. The current percentage of each riverside riparian treatment is listed in Table 7b.*

Figure 7e. ESRF Stream Protection Zones



KEY

- **CRW**
- **Lower Milicoma**
- **Other MRW (full watersheds)**
- **Other MRW (partial watersheds)**

Figure 7e*.* *Proposed stream protection zones on the Elliott State Research Forest.*

Table 7c. Stream buffer widths and approximate number of stream miles by stream protection zone						
Stream Protection Class	Buffer Width	CRW	MRW Lower Millicoma Watersheds	MRW Other (full watersheds)	MRW Other (partial watersheds)	Total
		MILES OF STREAM				
FB	100	0	0	74	0	74
FB	120	0	43	0	15	145
FB	200	87	16	0	0	16
PNFB	50	0	38	49	24	111
PNFB	120	67	0	0	0	67
HLDP	50	0	0	15	5	20
HLDP	120	48	9	0	0	57
Total RCA miles		202	106	138	44	490
XNFB	0	680	308	434	174	1,596
Grand Total		882	415	572	218	2,087

Table 7d. Proposed minimum buffer widths and the number of stream miles in each category on the ESRF												
Stream Class	Minimum Buffer Width (feet)	STREAM ADJACENCY: MILES OF STREAM WITHIN 100 FEET OF ALLOCATED STAND**										
		MRW Lower WF Millicoma Full & Partial Watersheds			Other MRW Full Watersheds			Other MRW Partial Watersheds			CRW	
		Reserve	Intensive	Extensive	Reserve	Intensive	Extensive	Reserve	Intensive	Extensive	Native Forest (GT65)	Restore Thin (LTE65)
FB	100	0.0	0.0	0.0	39.0*	23.2	34.6	0.0	0.0	0.0	-	-
FB	120	19.8*	16.4	15.7	0.8*	0.5	0.5	12.9*	2.8	1.3	-	-
FB	200	13.2*	1.3	4.7	0.0	0.0	0.0	0.0	0.0	0.0	69.0	37.0
HLDP	50	0.0	0.0	0.0	6.9*	6.1	6.6	1.1*	4.1	0.6	-	-
HLDP	120	2.7*	5.1	3.7	0.0	0.0	0.0	0.0	0.0	0.0	-	-
HLDP	200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	35.0	21.0
PNFB	50	16.2*	19.0	14.5	21.3*	18.9	25.1	13.0*	8.1	8.4	-	-
PNFB	200	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	51.0	29.0
XNFB	0	112.4*	133.6	102.7	165.1*	147.7	187.1	97.9*	58.6	32.3	458.0	275.0

Table 7d. *Proposed minimum buffer widths and the number of stream adjacency miles in each category on the Elliott State Research Forest. We have broken the forest into four areas for this calculation: 1)The MRW Lower Millicoma (includes partial watersheds that are not directly part of the research but do flow in the WF Millicoma below Elk Creek), 2) the other full watersheds that are part of the MRW study area, 3) the remaining partial watersheds in the MRW, 4) the Conservation Research Watersheds (CRW) as seen in Figures 7a, b and c.*

FB = Fish-bearing stream (235miles total ESRF)
HLDP = High landslide delivery potential non-fish bearing stream. May be either perennial or non-perennial (77 miles total ESRF)
PNFB = Perennial non-fish bearing stream not otherwise protected as WNFB (244miles total ESRF)
XNFB = NFB streams that are neither WNFB nor PNFB (1596 miles total ESRF)

**The width will be 200ft within allocated reserves with a few exceptions for longitudinal reserves along the streams that are narrower than 200' or if the reserve (LT65) is going to have a restoration thinning.*
***Note, could be reserve allocation on one bank of the stream and intensive or extensive on the other so these may exceed the lengths measured on GIS since we counted them in both categories.*

APPENDIX 8

Integrating Riparian Areas with Adjacent Research Treatments

Describes the steps we are taking to conduct a landscape analysis to allocate and integrate the riparian areas with adjacent research treatments and for determining RCA width requirements in intensive and extensive research treatments.

The process for determining where wood delivery will occur and prioritization for RCA width requirements in extensive and intensive stand level research treatments.

We propose to use modeled potential large wood recruitment to fish-bearing streams as a criterion for the development and evaluation of stream buffer strategies incorporated into the research designs of MRWs. The aquatic and riparian research strategy envisioned for the ESRF relies on wood recruitment for its specific value as habitat for imperiled species and as a proxy for the attainment of other ecological functions. Typically, most large wood recruited to fish-bearing streams comes from channel-adjacent sources through processes such as chronic and episodic tree mortality, bank erosion, and landslides. These same processes recruit large wood to non-fish-bearing channels. In steep and constrained non-fish-bearing (NFB) channels, episodic debris flows can deliver substantial quantities of accumulated large wood to fish-bearing streams. However, not every NFB tributary has the same potential to deliver wood. Therefore, we want to integrate our treatment of the riparian system with the upslope forests' treatments to ensure water quality and fish habitat as follows.

1. Establish the wood recruitment goal for the MRWs in the ESRF. The CRWs will have a goal of 100% of potential wood recruitment to fish bearing streams since the system is being managed as a reserve.
2. Delineate and classify NFB streams on the ESRF as to their potential for wood recruitment to fish bearing streams. Identify tributaries and headwalls with high potential for wood recruitment and other conservation components.
3. Calculate site potential tree height and riparian buffer needed to ensure wood delivery to the stream.

Figure 8. Proposed stand level allocation of extensive, instensive and reserve treatments

KEY

- MRW Reserve
- Intensive
- Extensive
- CRW
- Extensive Reserve (GT152)
- GRCA

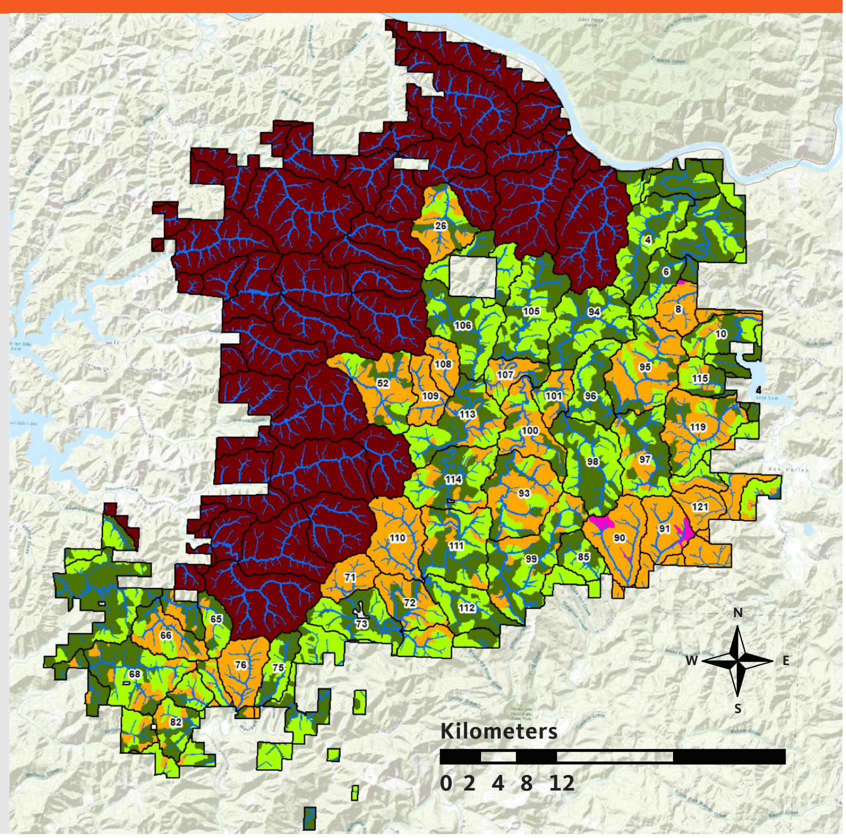


Figure 8. *Map showing proposed stand level allocation of MRW reserves, intensive, extensive, extensive reserve and GRCA (Generic Riparian Conservation Areas). GRCA is Generic Riparian Conservation Area and was estimated by buffer widths of 100ft and 50ft on fish bearing and non fish bearing streams respectively to achieve potential ~70% wood recruitment in the MRW. Extensive Reserve are areas of extensive stand treatments that are greater than 152 years old and will be placed in reserve status within those extensive allocations.*

4 Overlay potential reserves, intensive and extensive treatments, and adjust to better integrate reserves and extensive with NFB streams with high potential for wood recruitment. Forest reserves, extensive treatments, and RCA's will have the largest trees on the landscape, so they will best emulate historical conditions.

5 Calculate wood recruitment potential and compare against goal. Repeat as needed.

6 Create riparian systems in which different combinations of stream buffers on fish-bearing and non-fish-bearing systems achieve a stated goal for wood recruitment into FB streams.

7 Use riparian systems to test the effectiveness of buffer combinations relative to tradeoffs with other social and ecological attributes, such as habitat, accessibility, and fiber yield. Design several different wood recruitment strategies that meet the goal and develop an experiment to test effectiveness and tradeoffs with other values (see example Figure 8a and Table 8a).

Figure 8a. Two example buffer configurations with ~70% wood yield on the Elliott State Forest

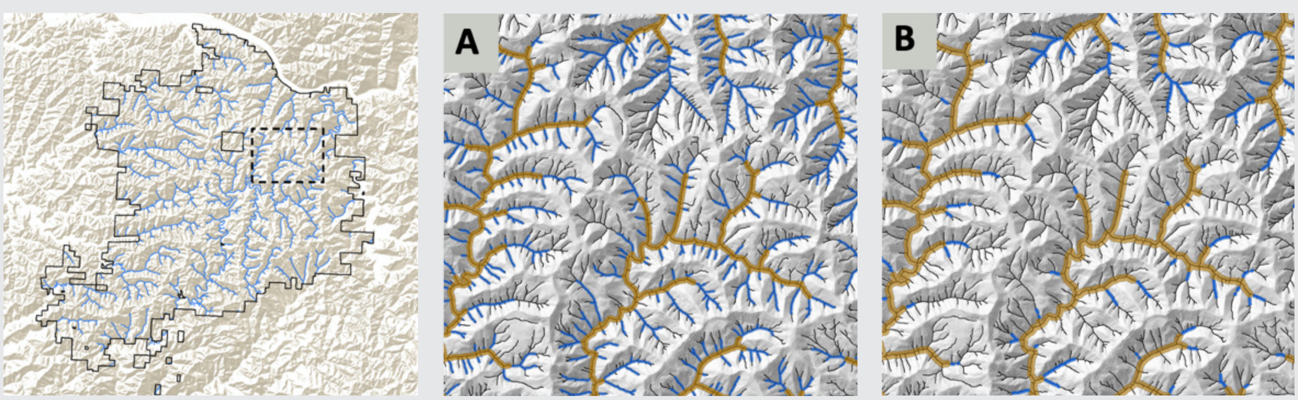


Table 8a. Two example riparian buffer width scenarios attaining ~70% wood recruitment

Alternative	FISH-BEARING			NON-FISH-BEARING			Total Modeled Stream Miles	Total ODF Stream Miles	Total NHD Stream Miles	Protected Potential Recruitment	Total NHD Stream Miles
	Buffer Width (ft)	Buffered Miles	Total FB Stream Miles	Buffer Width (ft)	Buffered Miles	Total NFB Stream Miles					
A	100	237	237	50	721	1,862	2,099	702	747	70%	16.5%
B	120	237	237	60	151	1,862	2,099	702	747	70%	10.8%

APPENDIX 9

Figures, Tables, and Photos

Provides figures, tables and photos illustrating the elements of the proposed research design for an Elliott State Research Forest.

Figure 5. Potential Subwatershed Triad Treatment Assignments

KEY

- CRW
- Extensive
- Triad-E
- Triad-I
- Reserve with Intensive
- MRW Partial

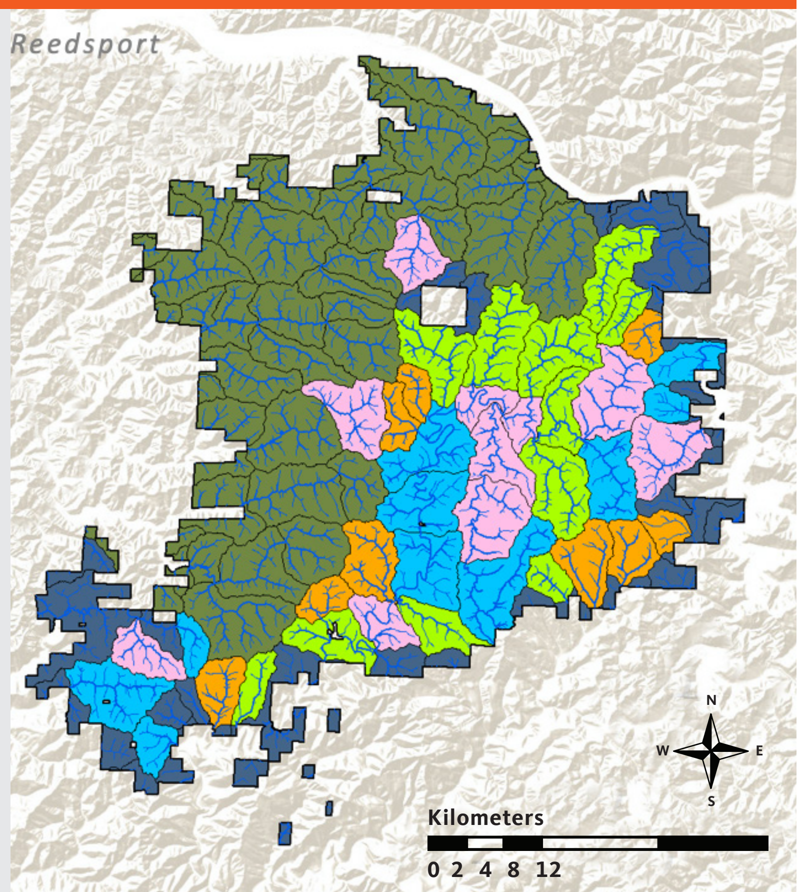


Figure 5. *Map illustrating the proposed western reserve area (Conservation Research Watershed; CRW, in dark green) and the potential allocation of subwatershed-scale Triad treatments in the ESRF's eastern part. Partial watersheds (dark blue) are only partly contained in the ESRF, so they will not have a formal subwatershed Triad treatment assigned. Map is based on August 2020 allocation.*

Figure 8. Proposed stand level allocation of extensive, instensive and reserve treatments

KEY

- MRW Reserve
- Intensive
- Extensive
- CRW
- Extensive Reserve (GT152)
- GRCA

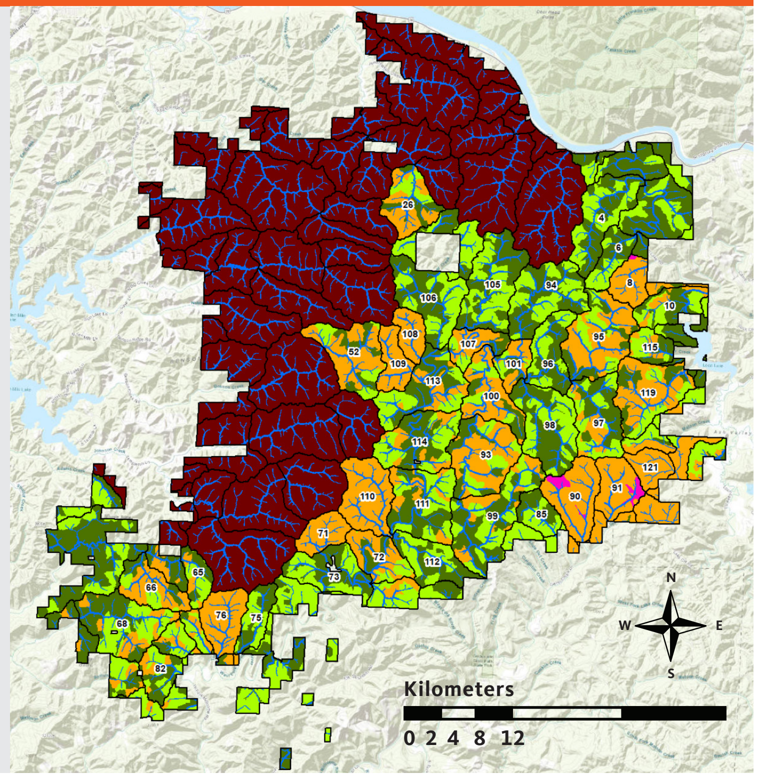


Figure 8. *Map showing proposed stand level allocation of MRW reserves, intensive, extensive, extensive reserve and GRCA (Generic Riparian Conservation Areas). GRCA is Generic Riparian Conservation Area and was estimated by buffer widths of 100ft and 50ft on fish bearing and non fish bearing streams respectively to achieve potential ~70% wood recruitment in the MRW. Extensive Reserve are areas of extensive stand treatments that are greater than 152 years old and will be placed in reserve status within those extensive allocations. Map based on August 2020 allocation.*

Table 4a. Stand-level Allocations by Age

Stand Age	STAND LEVEL ALLOCATIONS (ACRES)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	MRW RCA	CRW (incl RCA)	
<= 65 yrs	14,334	10,047	1,905	2,852	12,528	41,666
> 65	0	3,366	12,190	3,686	21,612	40,854
Total	**14,334**	**13,413**	**14,096**	**6,538**	**34,140**	**82,520**

Table 4a. *Number of acres per treatment by age class on the proposed Elliott State Research Forest based on the August 2020 draft allocation and November 2020 Riparian Conservation Area (RCA) designations. We assume that forests 65 or younger are forests that regenerated following clearcuts and those over 65 years regenerated from natural disturbance, primarily wildfire.*

Table 4b. Stand-level Allocations by Age

Stand Age	STAND LEVEL ALLOCATIONS (PERCENT OF TOTAL FOREST AREA)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	MRW RCA	CRW (inclu RCA)	
<= 65 yrs	17.4%	12.2%	2.3%	3.5%	15.2%	50.5%
> 65	0.0%	4.1%	14.8%	4.5%	26.2%	49.5%
Total	**17.4%**	**16.3%**	**17.1%**	**7.9%**	**41.4%**	**100.0%**

Table 4b. *Percent of acres per treatment by age class on the proposed Elliott State Research Forest based on the August 2020 draft allocation and November 2020 Riparian Conservation Area (RCA) designations.*

Table 9a. Acres per stand level treatment in each Triad subwatershed allocation based on August 2020 draft allocation

Subwatershed Level Triad Treatment	STAND-LEVEL ALLOCATION (ACRES)					ESRF Total
	MRW Intensive	MRW Extensive	MRW Reserve	CRW Reserve	RCA	
Extensive	0	5,028	146	0	756	5,930
Triad-E	1,691	4,985	1,650	0	1,452	9,778
Triad-I	3,550	1,759	3,422	0	1,591	10,322
Reserve with Intensive	4,715	0	4,638	0	1,508	10,861
MRW Partial	4,378	1,641	4,242	0	1,229	11,490
CRW	0	0	0	34,139	Included in CRW acres	34,139
Total Acres	**14,334**	**13,413**	**14,098**	**34,139**	**6,536**	**82,520**

Table 9a. *Estimated acres per stand level treatment in each Triad subwatershed allocation based on the August 2020 draft allocation. The Riparian Conservation Area (RCA) was allocated as proposed in November 2020 and described in Appendix 6.*

For political, ethical, and logistical reasons we deliberately chose not to implement a fully randomized design to test the Triad at the Elliott. There are several important scientific reasons for random allocation of treatments. Most importantly, randomization avoids true bias. For instance, it might not be by chance that old forest remains where it does (e.g., steep slopes, low productivity forest). To explore this possibility, we tested whether the particular watershed-scale treatments tended to fall on steeper slopes than others, or were characterized by higher site-quality ground. We found no evidence for such biases, except that our "extensive" treatment watersheds tend to be smaller, on average.

Figure 9a. tests for whether lack of fully random subwatershed-scale treatments at the Elliott resulted in any substantial confounding between treatments and other underlying features at the Elliott State Forest. If this were the case, it would be possible to mis-attribute treatment effects when in fact other features were the cause. Neither elevation, site index, precipitation showed substantial differences among treatments. Only watershed areas in the Extensive treatment tended to be smaller than the other treatments. Not that the CRW (Conservation Research Watershed) is not a formal treatment, so the differences above are not detrimental to the overall Triad design.

Figure 9a.

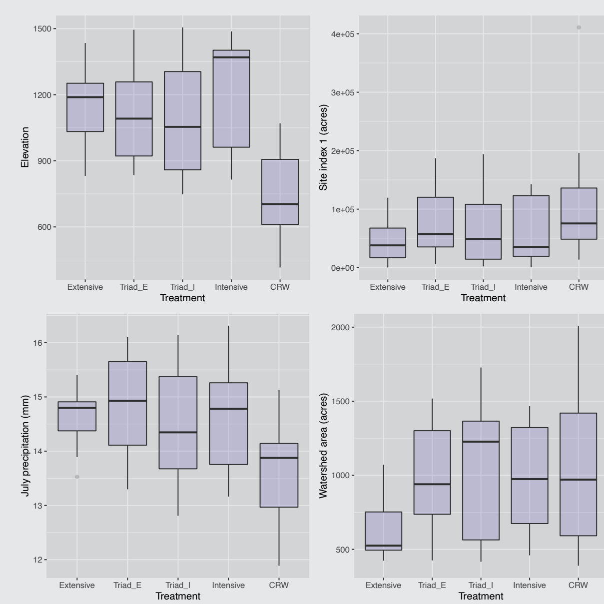


Figure 9a. *Analysis of subwatershed treatments for bias in elevation, July precipitation, site index and watershed area on the Elliott State Forest.*

Photo 1. Range of age classes in the Upper end of Big Creek Management Basin

Photo 1. *Photo illustrating the range of age classes in the ESF as shown in the Upper end of Big Creek Management Basin. All stand ages were based on information provided by DSL GIS data. Photo from Scott Harris.*

Photo 2. ESF looking NW from the top of Dean Mountain

Photo 2. *Photo of the Elliott State Forest (ESF) looking NW from the top of Dean Mountain. Photo illustrates the road network, mosaic of clear-cuts, young plantations, and older stands current in the Elliott State Forest. Photo from Scott Harris.*

Photo 3. Diversity of age classes

Photo 3. *Photo of a stand in the Elliott State Forest that includes a diversity of age classes. This photo is illustrative of the types of complex forest that would be generated through extensive harvest treatments in an Elliott State Research Photo.*

Photo 4. Dean Mountain

Photo 4. *Photo taken from the top of Dean Mountain in the ESF. The clear-cut on the right side of the photo is illustrative of intensive, production oriented, harvest treatments that would be conducted under the current research design in parts of the ESRF. Photo by Katy Kavanagh.*

Photo 5. Jerry Phillips Reserve

Photo 5. *Old growth forest in Jerry Phillips Reserve. The DSL GIS information ages these stands at 172 years, signs in the grove state 250 years (photo from Scott Harris). This photo is illustrative of the potential for the upwards of 65% of the proposed ESRF that will be in reserve treatment. These forests will be managed for conservation, over time adding to the amount of older forest in the Oregon Coast Range.*

APPENDIX 10

Power Analysis of the Elliott State Forest Research Design

Report prepared by:
Scott H. Harris, Matthew G. Betts, John Sessions, Ariel Muldoon
College of Forestry, Oregon State University

SUMMARY

One component of the Elliott State Forest Research Design is to examine how a Triad-based forest management plan can integrate timber output and biodiversity conservation, over broad spatial and long temporal scales. To support this experimental design, we conducted a power analysis that examined the effect of altering the number of replicates of subwatershed scale treatments on the probability of detecting differences in important response variables. Our analysis helps to answer the question: does the experimental design with 9 to 11 replicates have the statistical power to detect differences in important responses over the course of a 100-year experiment? Our nine response variables were carbon stored in live and dead trees, the densities of seven early seral songbird species, and potential nesting platforms for marbled murrelets. We developed a forest planning model with the Woodstock software package that optimized the timing of harvests for even timber flow and calculated our estimated responses over a 100-year planning horizon. Our power analysis using these estimated responses showed high power at 100 years (all responses) and 50 years (8 out of 9 responses). Estimated power at 20 years was affected by the number of treatment replicates. These results suggest that the current experimental design has sufficient sample size to detect differences by at least 50 years. However, this conclusion should not be extrapolated for other responses we did not examine. Furthermore, our model does not account for important effects such as natural disturbance, climate change, and the surrounding landscape – factors that can potentially increase error and therefore lower statistical power. We discuss limitations in detail at the end of this report.

WOODSTOCK

We developed our forest planning model with the Woodstock forest planning software (Remsoft Corporation, Fredericton, New Brunswick, Canada) to parameterize response variables and run a 100-year Triad-based forest management plan based on the Elliott State Forest Research Design. Woodstock uses linear programming to optimize the timing of specified forest management activities. Woodstock is widely used by the global forest industry and has been used to model Triad forest management approaches in Canada (MacLean et al. 1999, Ward and Erdle 2015).

Figure 3. Percentage of reserve, intensive and extensive treatments in the TRIAD framework

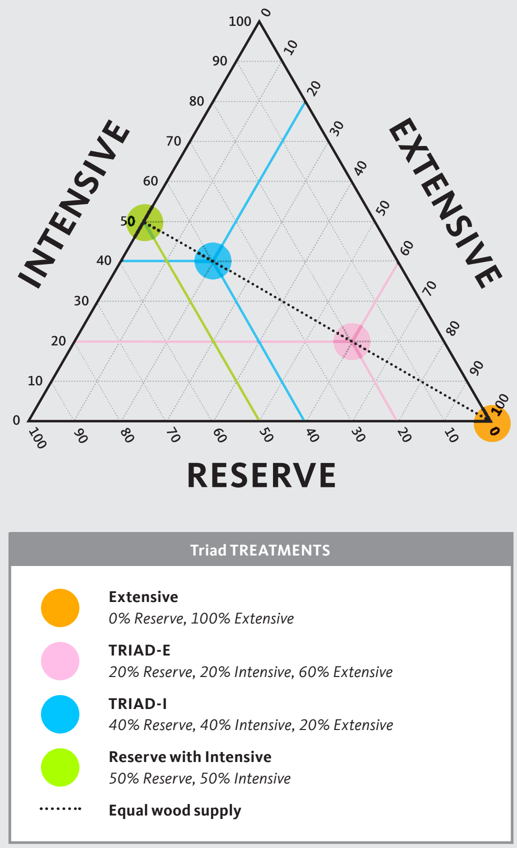


Figure 3. *Conceptualizing the four different Triad Treatments. Each colored dot represents a subwatershed level Triad treatment. The text below specifies the proportions of stand level research treatments (intensive, extensive, reserve).*

We used Woodstock to optimize the timing of harvests in the intensive and extensive stand-level treatments to meet our goal and constraints, and then calculate responses at each 5-year planning period. Our goal (objective function) was to maximize the combined timber harvest (but constrain harvest in each subwatershed, see below), at each planning period, for the 32,573 acres that comprise the Managed Research Watersheds (Figure 10a). Our constraints were based on the Elliott State Forest Research Design as follows:

1. **Upper limit of timber output for each subwatershed.** The research design specifies that the four watershed-level treatments in the Managed Research Watersheds (MRW) produce equal wood supply (Figure 3). We calculated that quantity to be 3.01 mbf/ac per 5-year planning period. This calculation was based on the average yield from the 11 intensive subwatersheds (where approximately 50% of the acres are intensive and 50% are reserve), assuming a clearcut harvest at 60 years, and using the regenerated intensive

Figure 10a.

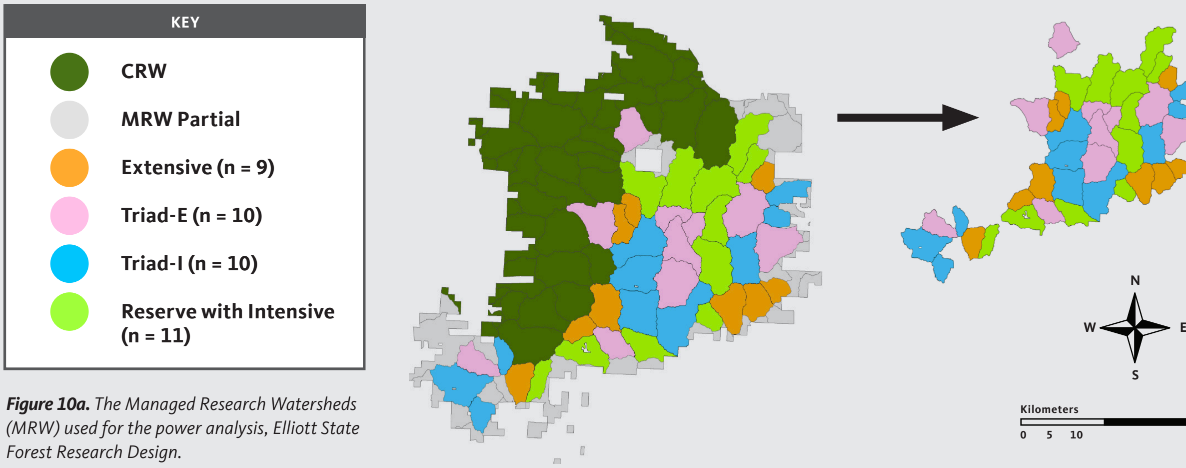


Figure 10a. *The Managed Research Watersheds (MRW) used for the power analysis, Elliott State Forest Research Design.*

stand yield tables provided by Mason, Bruce, and Girard (see description below). In Woodstock, we specified that the timber output for each subwatershed (harvests plus any commercial thinnings) cannot exceed 3.10 mbf/ac/period. This subwatershed timber yield constraint is equivalent to a timber yield of 19.6 MMBF/yr for the Elliott State Forest. Historically, the Elliott State Forest produced an average of 51.5 MMBF (1972-01968), 17.74 MMBF (1991-1996), and 25 MMBF (1995-2010) of timber per year across an approximately 90,000 acre forest (Phillips 1996, ODSL-ODF 2011).

2 **Sustainability.** To ensure that Woodstock did not "overharvest" and that the research design would be sustainable indefinitely, we specified that the inventory of merchantable volume at the end of our planning horizon (100 years) in each subwatershed meet or exceed the starting inventory. This quantity was calculated for each subwatershed.

3 **Even harvest flow.** To ensure that timber supply from the whole forest was relatively constant, we specified that the combined yield from harvests and commercial thinnings never varied by more than 10% over subsequent 5-year periods for the 100-year planning horizon.

TREATMENTS

SUBWATERSHED LEVEL TREATMENTS

We used the Managed Research Watershed (MRW) allocations according to the September 2020 version of the Elliott State Forest Research Design. Conservation Research Watersheds were not included in this analysis (Figure 10a). We removed the 9,061 acres assigned to riparian management zones and the "MRW partial" treatment – resulting in 32,574 acres for our analysis. Subwatershed treatments and number of replicates in the MRW consisted of: Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Reserves with Intensive(n=11). Henceforth, we refer to this set of replicates as the "complete sample".

STAND-LEVEL TREATMENTS

We also assigned stand level treatments according to the September 2020 allocations. Specific stand-level treatments (e.g. the timing and type of thinning and harvest) are dictated by Woodstock model limitations and the growth and yield estimates provided by Mason, Bruce, and Girard (MBG). Allowing for multiple timing options for commercial thinning greatly increases the complexity of Woodstock models, so we specified the timing of commercial thinning, but allowed the timing of harvest to be optimized based on our model goal and constraints. The MBG growth and yield estimates are based on the 2014 inventory of the Elliott State Forest. The MBG growth and yield estimates and the stand-level treatment simulations were done during a 2019 financial analysis. The week prior to this report, MBG provided another set of estimated yields that modeled different treatments than we describe here. There was insufficient time for us to develop a new Woodstock model based on these new yield projections. Details of stand-level treatments from 2019 we used for our analysis are:

1 **Reserve stands.** Grow only. No management actions (Figure 10b - A).

2 **Intensive stands.**
   A **Existing stands.** For stands younger than 40 years, a commercial thin occurs when those stands reach 40 years of age and if relative density meets a commercial thin threshold. Clearcut harvest can occur anytime at 45 years or later (Figures 10b - B and 10b - C).
   B **Future stands.** Following clearcut harvest, MBG modeled future stand development using a forest inventory from an intensive management regime (site preparation and broadleaf release control with herbicides, pest control (beaver), and dense planting of Douglas fir). Future stands are commercially thinned at 40 and 60 years of age and are eligible for clearcut harvest starting at 65 years.

3 **Extensive stands.**

A **Existing stands.** For stands younger than 60 years, a commercial thin occurs when those stands reach 60 years of age and if relative density meets a commercial thin threshold. An RD20 harvest can occur anytime at 90 years or later. The RD20 harvest is intended to represent an extensive, or ecological forestry, type of treatment where the harvest reduces Curtis' Relative Density to 20. For a 100 year-old stand, the RD20 harvest is roughly equivalent to a 30% dispersed retention harvest (Figure 10b - D).

B **Future stands.** Following harvest, MBG modeled future stand development starting with the trees retained from the RD20 harvest. These retained trees were evenly distributed across diameter classes. To account for expected delays in regeneration and slower growth due to the presence of an overstory, regeneration establishment was delayed by 20 years. Future stands are commercially thinned at 60 years of age and are eligible for RD20 harvest starting at 90 years.

4 **Commercial thinning.** Commercial thinning is the same prescription in intensive and extensive stands. Stands are thinned to 40% maxSDI, evenly distributed across all diameter classes.

ESTIMATING YIELDS AND RESPONSES

TIMBER

We used the yield tables provided by MBG to calculate timber yields from harvest and thinning activities, as previously described.

CARBON

We used published forest volume-to-biomass models to estimate stored carbon in live and dead standing trees (Jenkins 2003, Smith et al. 2003). Jenkins (2003) conducted a meta-analysis to develop individual-tree diameter-based regression equations for estimating biomass for multiple tree species in the United States. This approach is widely used to estimate national-scale forest carbon stocks when detailed inventory data are available. To forecast carbon stocks based on growth and yield models at stand scales, Smith et al (2003) expanded the scope of this work by developing stand volume-to-biomass regressions. The Smith regressions estimate the biomass of standing live and dead trees, including coarse roots. For our analysis, we use the volume provided by the MBG yield tables and the Smith regressions for Douglas-fir forests on the west-side of the Cascade Mountains. Carbon was then estimated to be 50% of our calculated biomass (Schlesinger 1991).

SONGBIRDS

We chose seven species of songbirds that utilize early seral forests, represent a wide range of habitat preferences, for which we have sufficient data, and met at least one of the following additional criteria:

Figure 10b.

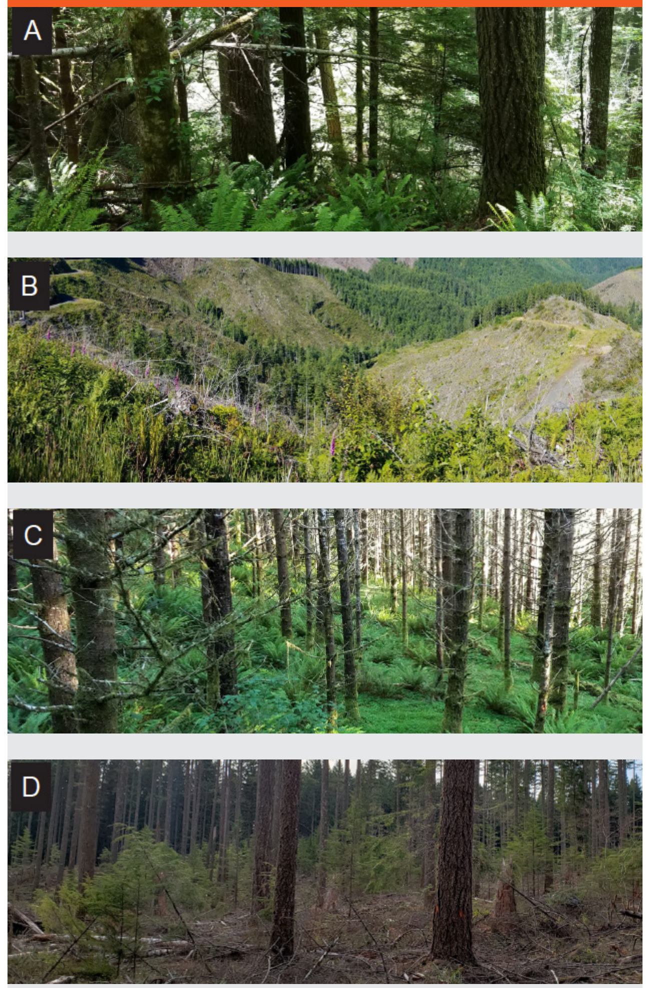


Figure 10b. *Representative examples of stand-level treatments. A) Reserve, 169 years. B) Intensive, 3 years. C) Intensive, 47 years. D) Extensive, 1 year. A, B, and C are stands in the Elliott State Research Forest. D is a BLM stand in the west Oregon Cascades (BLM photo).*

1 Are a species of regional concern according to the Partners in Flight Database (PIF 2020a, PIF 2020b): rufous hummingbird, willow flycatcher, black-throated gray warbler, golden-crowned kinglet,

2 The Pacific Northwest region contains at least 60% of their breeding population: rufous hummingbird, hermit warbler,

3 Are uniquely representative of early seral forest habitat: willow flycatcher, orange-crowned warbler, Wilson's warbler.

We collated estimates of songbird densities from published studies conducted in forests of the Oregon Coast Range and the west side of the Oregon Cascades, as well as data from unpublished sources (Table 10a).

Figure 10c.

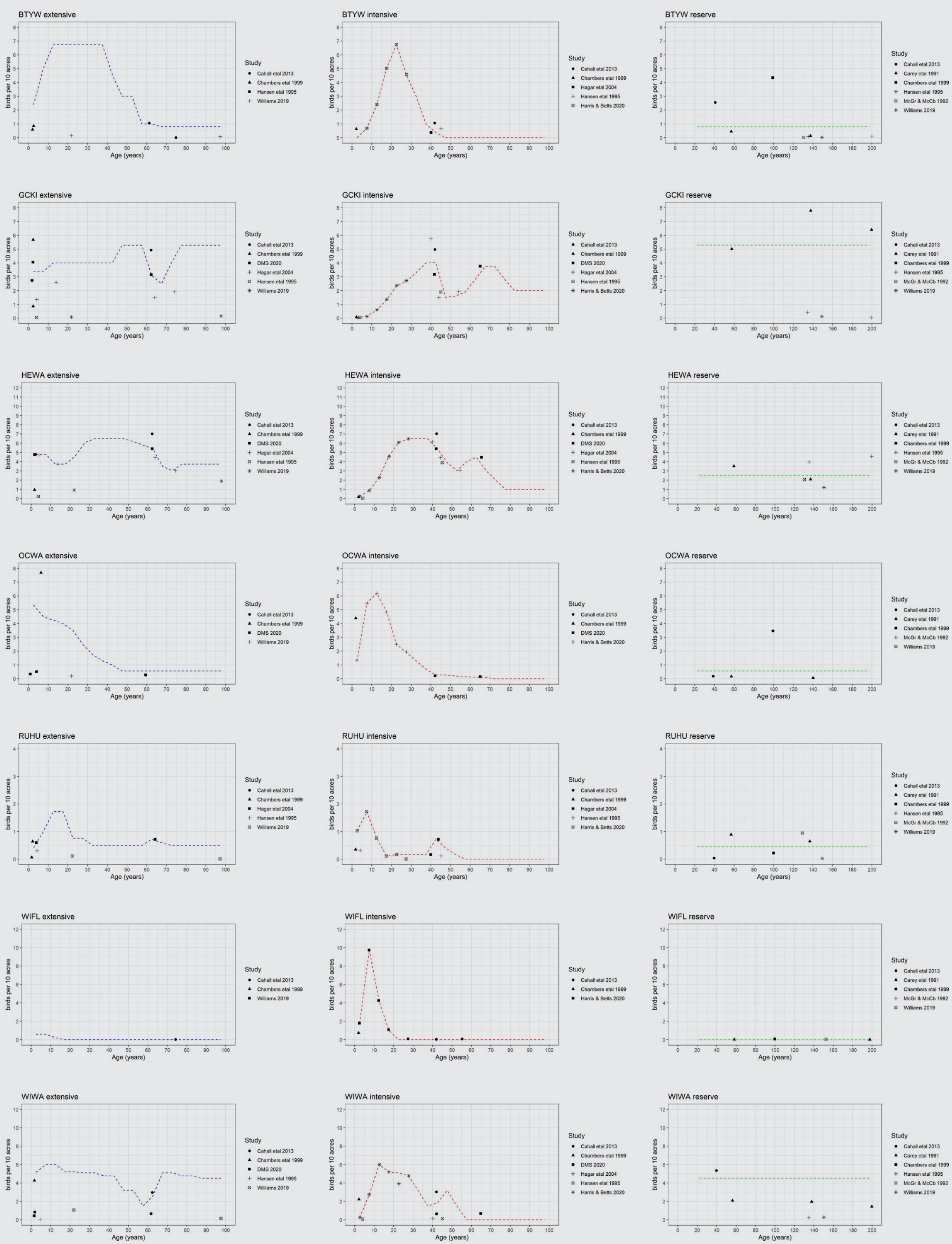


Figure 10c. *Estimated responses of the density of 7 early-seral songbird species as a function of stand age, for the three stand-level treatments of the Elliott State Forest Research Design. Estimated responses are indicated by the dashed lines. Empirical data and sources are indicated by the symbols.*

Table 10a.				
Study	STAND LEVEL RESEARCH TREATMENTS			Study Area
	Intensive	Extensive	Reserve	
Harris and Betts. In prep	X			Central Oregon Coast Range
Williams 2019		X	X	Oregon Coast Range, W. Oregon Cascades
Density Mgmt Study, unpub.	X	X		Western Oregon
Cahall et al. 2013	X	X	X	Tillamook State Forest
Hagar et al. 2004	X	X		Willamette National Forest
Chambers et al. 1999	X	X	X	McDonald-Dunn Forest (OSU)
Hansen et al. 1995	X	X	X	W. Oregon Cascades
McGarigal & McComb 1992			X	Central Oregon Coast Range
Carey et al. 1991			X	Central Oregon Coast Range

Table 10a. *Sources of empirical data used for deriving estimated response curves of 7 songbird species to management treatments. The extensive treatments described in each of these studies only approximated the extensive treatment defined in the Elliott State Forest Research Design. We assigned the treatments described in each study to one of our Triad stand-level treatments (reserve, intensive, extensive). We plotted these estimates as a function of stand age and treatment, then relied on expert opinion to fill in gaps in the empirical data. We made every effort to consistently convert the raw abundance numbers reported in these studies to a density estimate (birds per 10 acres). The available data for treatments that approximated our intensive stand treatment were robust and at relatively fine temporal scale. The data for the reserve treatment was sparse, but we assumed songbird densities in reserve stands to be relatively constant because of the advanced age of the stands and the lack of treatments. For the extensive treatment, we relied heavily on expert opinion due to the paucity of data for extensive forest management. Figure 10c shows our estimated response curves.*

NESTING PLATFORMS FOR MARBLED MURRELET

We used empirically-based estimates of potential tree-branch nest platforms for murrelets. Platforms are good predictors of nesting habitat for murrelets (Burger et al. 2010) and platforms have been shown to be the best-performing covariate when comparing model predictions to known nesting sites (Raphael et al. 2011). Potential nesting platforms are defined as horizontal tree limbs with a diameter of at least 6 inches. Using a large sample of trees, Raphael et al. (2011) developed estimates of the number of platforms by tree diameter class for multiple conifer species. We combined this data with the MBG growth models to estimate the number of potential platforms as a function of age in each stand. Figure 10d shows the estimated change in density of potential murrelet nesting platforms for each subwatershed level treatment over the 100-year planning horizon.

Figure 10d. Estimates of Potential nesting platforms for Marbled Murrelets

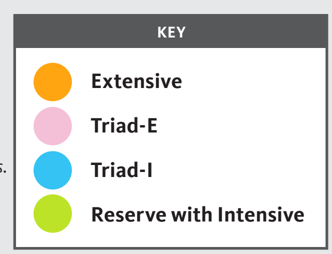


Figure 10d. *Change in the density of potential nest platforms for marbled murrelets, per subwatershed level Triad treatment, derived from Woodstock model outputs and stand-level timber growth models. Nest platforms are defined as horizontal limbs at least 6 inches in diameter. Treatments used to derive these estimates are from the previous 2019 treatment descriptions and differ from the current ESRF treatments. For example, the extensive harvest treatment used for this model removed a greater density of large trees than in the current proposal for the ESRF, and therefore this model likely represents a conservative estimate of platform density. We used nest platforms primarily as a variable to determine the power to detect a difference among treatments, and not to estimate the amount of habitat suitability for murrelets."*

THE POWER ANALYSIS

Power is the long-run probability of detecting a specific effect given that the effect exists. A power analysis can be used to estimate power for a given alpha level (here we use 0.05), sample size per group, and defined effect sizes and variances. In our power analysis, groups are the subwatershed treatments and effect sizes and variances are defined as the Woodstock Model outputs for the complete sample of Managed Research Watersheds (11 Reserves with Intensive, 10 Triad-I, 10 Triad-E, and 9 Extensive subwatersheds). In a simulation-based power analysis, true effects are defined and then assumptions from the model used for analysis are assumed to be true.

Our analysis is based on a Welch's ANOVA, which assumes normality of errors but variances can differ among treatments (Welch 1951). Therefore, we assume that the observed values in a sample taken will follow a normal distribution that is defined by the Woodstock Model outputs for each treatment. Since there is variability around our defined true mean, any observed sample will contain different values; how different each sample is depends on the variability around the effects. To estimate power we draw some number of samples (1000 draws, or simulations, in our analysis) per treatment from our defined distribution, fit the model we expect to use, and record the p-value from the overall F test that tests against the null hypothesis that the means for all treatments are the same. We then estimate power as the proportion of times we reject the null hypothesis based on our defined alpha across all simulations. To estimate power at different sample sizes, we vary the number of samples per treatment.

Note that for any given field experiment we will only take a single sample. Power is a theoretical construct about long-run behavior to help with study planning as long as 1) our estimates of effects and variances are reasonably what we expect and 2) model assumptions are met and so the distribution we draw samples from mirrors what can truly happen in the landscape.

In our power analysis, the Woodstock model run gives us estimates of values for every subwatershed. There are no other subwatersheds to select. What does the power analysis do for us in this case? We still assume that if we actually take a sample on the group there will be variability in the outcome, based on the variability around the Woodstock-based estimates. Power analysis allows us to understand if we are likely to reject the overall null hypothesis for different sample sizes based on the modeled effect sizes and variances.

Code for power analysis is available on GitHub at https://github.com/aosmith16/elliott-power

RESULTS

TIMBER

Our Woodstock model run over a 100-year planning horizon resulted in an annual timber yield of 16.8 MMbf. This annual yield was lower than our upper limit of 19.6 MMbf likely due to the timing limits imposed by our additional model constraints. All existing intensive stands were harvested by year 60 and 99% of existing extensive stands were harvested by year 100. The average stand age at harvest for the existing intensive and existing extensive stands was 55 and 105 years, respectively.

ESTIMATED POWER FOR THE 9 RESPONSE VARIABLES

At the end of the 100 year planning horizon, the estimated power for all 9 responses was greater than 0.8, for sample sizes of 6 and greater. After 50 years, the estimated power for all responses except orange-crowned warblers was greater than 0.8, for sample

Figure Set 1. Stored Carbon

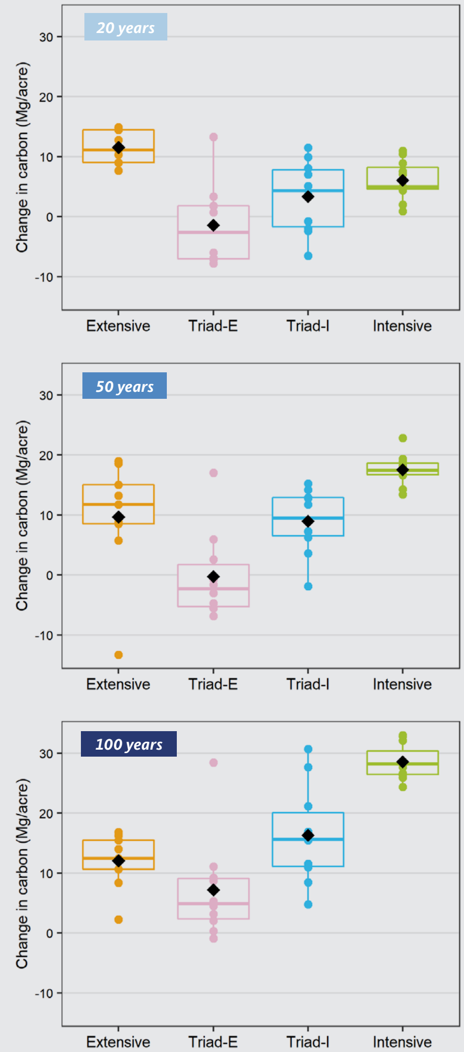


Figure Set 1. Boxplots (above). *Estimates of the change in stored carbon (standing live and dead trees including coarse roots) between the specified time and initial carbon stores at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

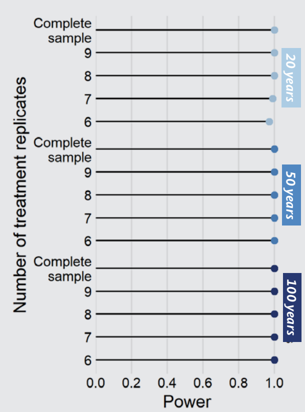


Figure Set 1. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 2. Orange-crowned warbler

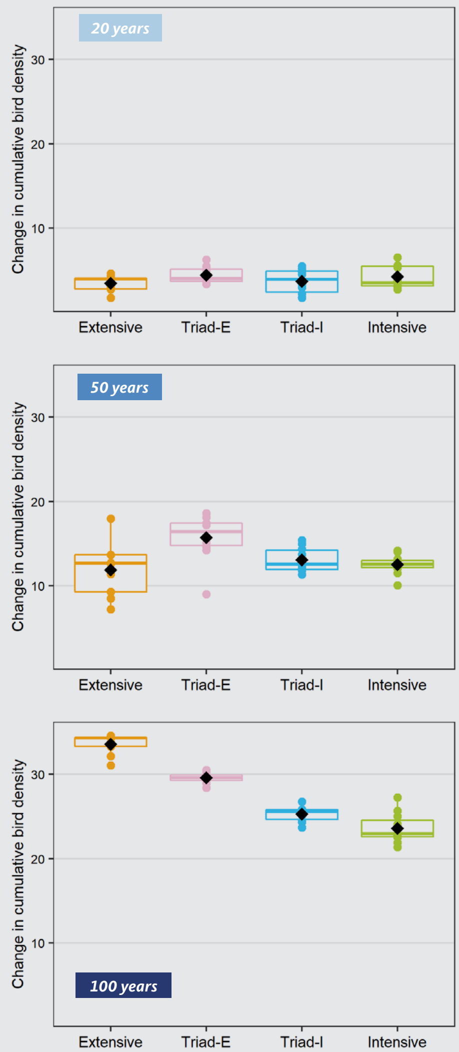


Figure Set 2. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of orange-crowned warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

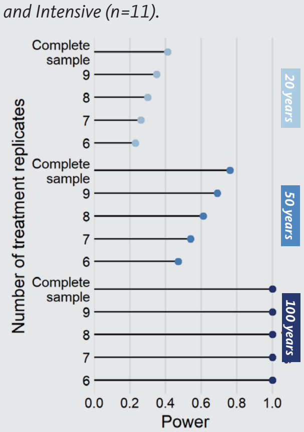


Figure Set 2. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 3. Marbled murrelet

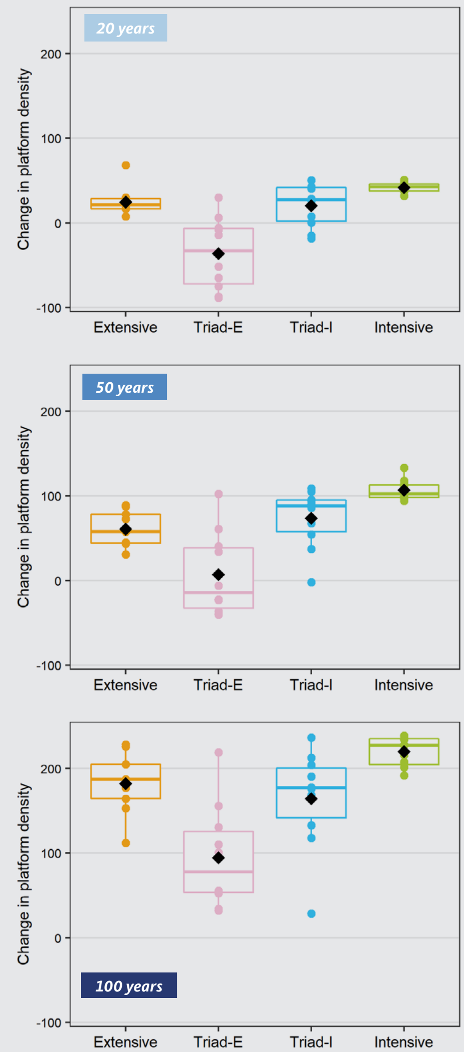


Figure Set 3. Boxplots (above). *Estimates of the change in density (platforms per 10 acres) of potential nesting platforms for marbled murrelets between the specified time and the initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

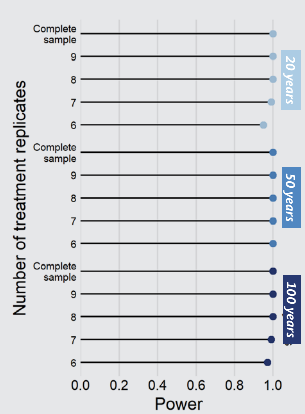


Figure Set 3. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

sizes of 6 and greater. After 20 years, the estimated power was affected by sample size for all responses except carbon, golden-crowned kinglets, and hermit warblers. For example, we estimated a minimum sample size of 6 in order for power to be at least 0.8 for marbled murrelet nest platforms. Figure sets 1-3 (for carbon, orange-crowned warblers, and murrelet platforms, respectively) are good examples of the range of the influence of sample size and time on power. For carbon, we estimated high power for all sample sizes and times. For orange-crowned warblers, we estimated low power for all sample sizes until year 100. And the estimated power for marbled murrelet falls between these two extremes. We show results for the other 6 response variables in Figure sets 4-9.

LIMITATIONS

Several limitations and caveats are important to consider when making inference about the results of this power analysis. Any of the following limitations could increase uncertainty around our estimated responses. Therefore, our estimates of the minimum number of replicates to achieve satisfactory power should be considered conservative.

Modeling processes

1. Woodstock does not easily allow for the modeling of variability around timber yield estimates and the responses. The implication is that, for example, the error around the point estimate for the density of a songbird at 10 years in one of the treatments is not propagated to the watershed-level estimates, nor to the treatment-level estimates.

2. There will be many other response variables measured in the actual experiment. Our power analysis may not apply for these additional variables. Also, the effect sizes of importance for these additional variables may differ from our estimates, again affecting power to detect differences.

3. We had insufficient empirical data to validate our estimated response curves for the 7 songbird species and the habitat score for marbled murrelet.

4. There is a paucity of empirical and observational data for the extensive treatment – one good reason for this experiment! We relied more on expert opinion for estimating responses to the extensive treatment than for the intensive and reserve treatments.

5. Assumptions inherent to power analyses are described above.

Ecological processes

1. Our models do not account for natural disturbances or changing environmental conditions, such as those induced by climate change. In our analysis, we assume that environmental conditions are constant throughout the 100-year planning horizon.

2. We estimated our responses for songbirds and marbled murrelet based on stand age. In this way, we assume that stand age is a surrogate for the full suite of changing habitat conditions in the forest.

Figure Set 4. Black-throated gray warbler

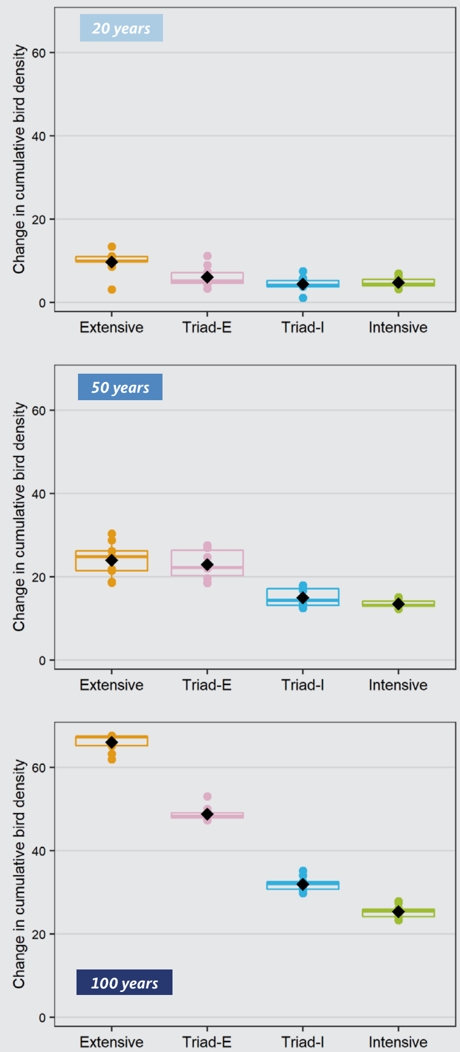


Figure Set 4. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of black-throated gray warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

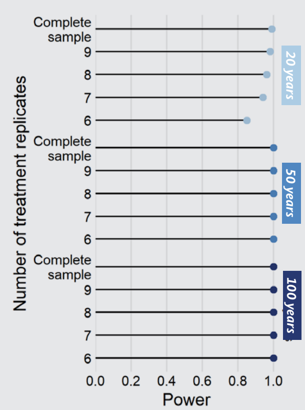


Figure Set 4. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 5. Golden-crowned kinglet

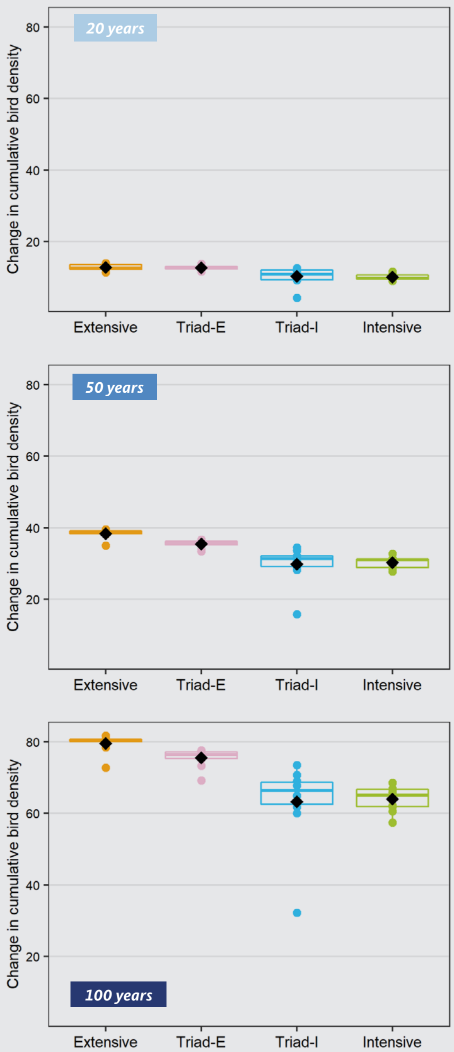


Figure Set 5. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of golden-crowned kinglets between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

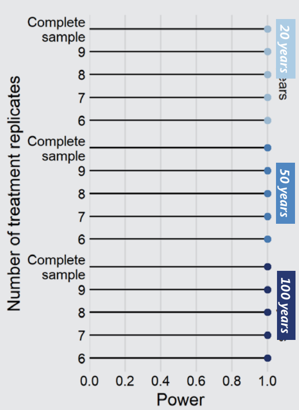


Figure Set 5. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 6. Hermit warbler

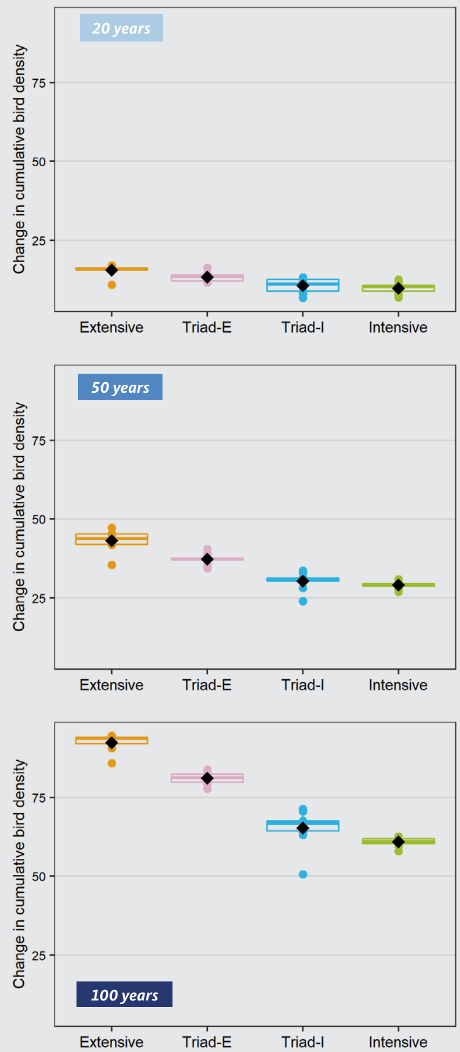


Figure Set 6. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of hermit warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

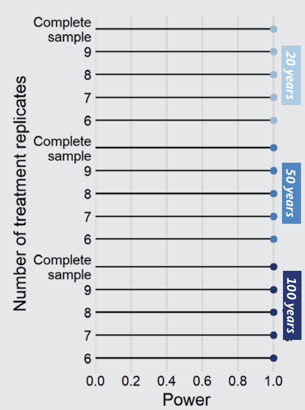


Figure Set 6. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

3 Our estimates do not account for landscape and riparian effects. This is particularly important for marbled murrelets as they are known to be negatively influenced by forest edges (van Rooyen et al. 2011), and the prevalence of nest predators in the surrounding landscape (Malt and Lank 2009).

REFERENCES

Bahn, V. 1998. Habitat Requirements and Habitat Suitability Index for the Marbled Murrelet (Brachyramphus marmoratus) as a Management Target Species in the Ursus Valley, British Columbia.:168.

Burger, A.E., Ronconi, R.A., Silvergieter, M.P., Conroy, C., Bahn, V., Manley, I.A., Cober, A., Lank, D.B., 2010. Factors affecting the availability of thick epiphyte mats and other potential nest platforms for Marbled Murrelets in British Columbia. Can. J. For. Res. 40, 727–746. https://doi.org/10.1139/X10-034

Cahall, R. E., J. P. Hayes, and M. G. Betts. 2013. Will they come? Long-term response by forest birds to experimental thinning supports the "Field of Dreams" hypothesis. Forest Ecology and Management 304:137–149.

Carey, A. B., M. M. Hardt, S. P. Horton, and B. L. Biswell. 1991. Spring bird communities in the Oregon Coast Range. Pages 123–142 Wildlife and Vegetation of Unmanaged Douglas-fir Forests. USFS Pacific Northwest Research Station, Portland, OR, USA.

Chambers, C. L., W. C. McComb, and J. C. Tappeiner. 1999. Breeding bird responses to three silvicultural treatments in the Oregon Coast Range. Ecological Applications 9:171–185.

Hagar, J., S. Howlin, and L. Ganio. 2004. Short-term response of songbirds to experimental thinning of young Douglas-fir forests in the Oregon Cascades. Forest Ecology and Management 199:333–347.

Hamer, T. E., D. E. Varland, T. L. McDonald, and D. Meekins. 2008. Predictive Model of Habitat Suitability for the Marbled Murrelet in Western Washington. Journal of Wildlife Management 72:983–993.

Hansen, A. J., W. C. McComb, R. Vega, M. G. Raphael, and M. Hunter. 1995. Bird Habitat Relationships in Natural and Managed Forests in the West Cascades of Oregon. Ecological Applications 5:555–569.

Jenkins, J. C. et al. 2003. National scale biomass estimators for United States tree species. Forest Science 49:12–35.

MacLean, D. A., P. Etheridge, J. Pelham, and W. Emrich. 1999. Fundy Model Forest: Partners in sustainable forest management. The Forestry Chronicle 75:219–227.

Figure Set 7. Rufous hummingbird

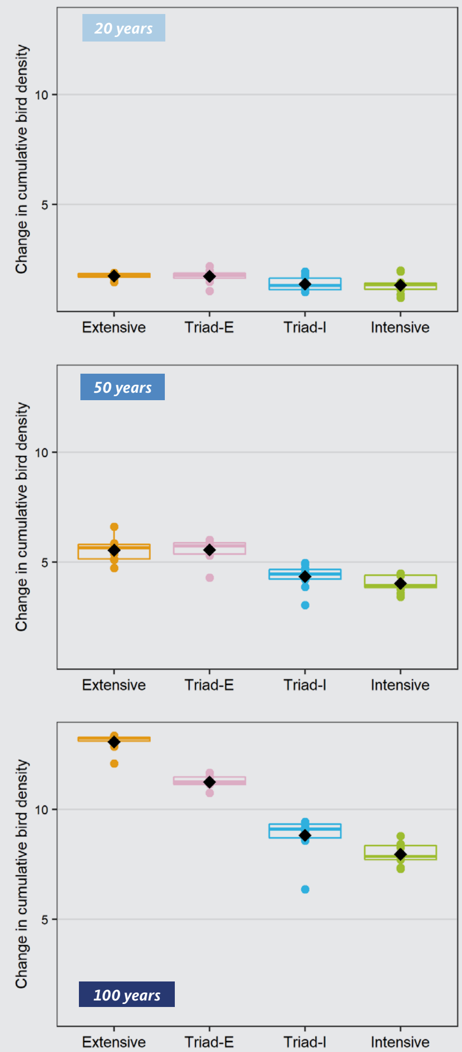


Figure Set 7. Boxplots (above). *Estimates of the change in cumulative density (birds per 10 acres) of rufous hummingbirds between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).*

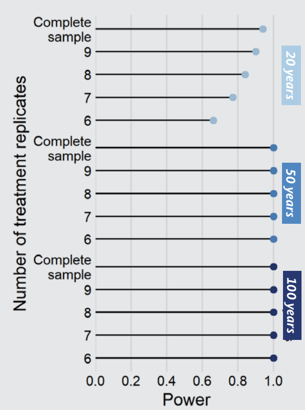


Figure Set 7. Power plot (left). *The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.*

Figure Set 8. Willow flycatcher

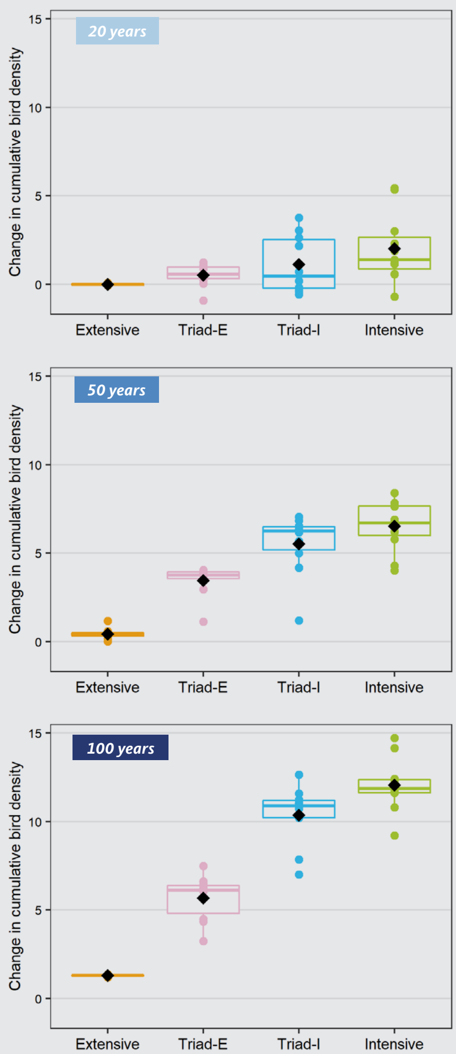


__Figure Set 8. Boxplots (above).__ Estimates of the change in cumulative density (birds per 10 acres) of willow flycatchers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).

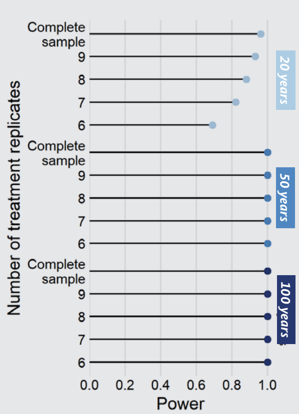


__Figure Set 8. Power plot (left).__ The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.

Figure Set 9. Wilson's warbler

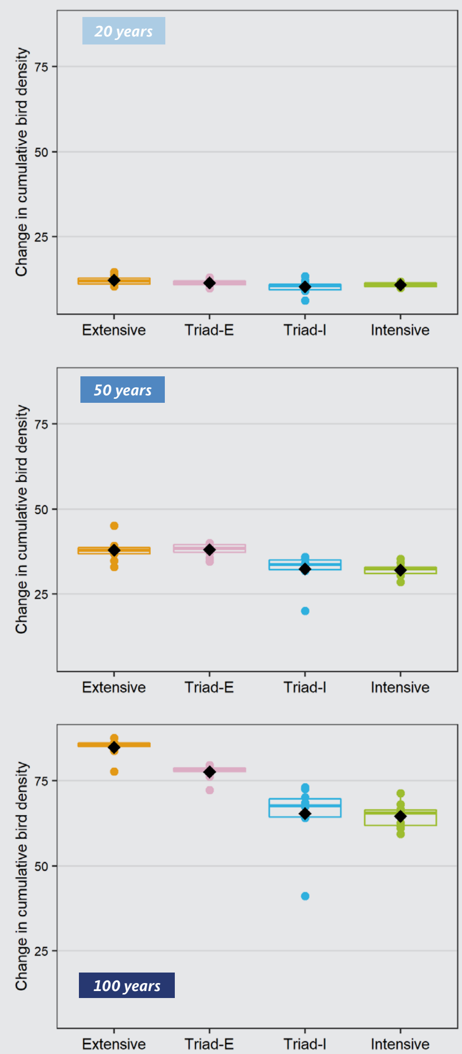


__Figure Set 9. Boxplots (above).__ Estimates of the change in cumulative density (birds per 10 acres) of Wilson's warblers between the specified time and initial density at the beginning of the forest planning model (year 2020), for the complete sample of the four subwatershed treatments, Elliott State Forest Research Design. For example, the "20 years" boxplot is the cumulative density over the first 4 5-year periods minus the initial density. Estimates derived from the Woodstock forest planning model. Mean responses are indicated by the black diamonds. The complete sample is Extensive (n=9), Triad-E (n=10), Triad-I (n=10), and Intensive (n=11).

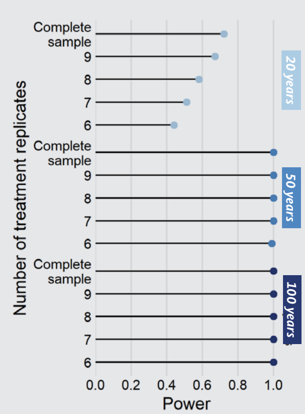


__Figure Set 9. Power plot (left).__ The estimated power to detect a difference among the treatment means, for different sample sizes (number of subwatershed treatment replicates) at 20, 50, and 100 years.

Malt, J. M., and D. B. Lank. 2009. Marbled Murrelet nest predation risk in managed forest landscapes: dynamic fragmentation effects at multiple scales. Ecological Applications 19:1274–1287.

McComb, W. C., M. T. McGrath, T. A. Spies, and D. Vesely. 2002. Models for Mapping Potential Habitat at Landscape Scales: An Example Using Northern Spotted Owls. Forest Science 48:203–216.

McGarigal, K., and W. C. McComb. 1992. Streamside versus Upslope Breeding Bird Communities in the Central Oregon Coast Range. The Journal of Wildlife Management 56:10.

Oregon Dept. of State Lands and Oregon Dept. of Forestry. 2011. Elliott State Forest Management Plan. 406p.

Partners in Flight. 2020a. Avian Conservation Assessment Database, version 2020. Available at http://pif.birdconservancy.org/ACAD.

Partners in Flight. 2020b. Population Estimates Database, version 3.1. Available at http://pif.birdconservancy.org/PopEstimates.

Schlesinger, W.H. (1991). Biogeochemistry, an Analysis of Global Change. New York, USA, Academic Press.

Raphael, M.G., Falxa, G.A., Dugger, K.M., Galleher, B.M., Lynch, D., Miller, S.L., Nelson, S.K., Young, R.D., 2011. Status and Trend of Nesting Habitat for the Marbled Murrelet. PNW-GTR-848. USDA Forest Service Pacific Northwest Research Station.

van Rooyen, J. C., J. M. Malt, and D. B. Lank. 2011. Relating Microclimate to Epiphyte Availability: Edge Effects on Nesting Habitat Availability for the Marbled Murrelet. Northwest Science 85:549–561.

Smith, J. E., L. S. Heath, and J. C. Jenkins. 2003. Forest volume-to-biomass models and estimates of mass for live and standing dead trees of U.S. forests. Page NE-GTR-298. U.S. Department of Agriculture, Forest Service, Northeastern Research Station, Newtown Square, PA.

Spies, T. A., B. C. McComb, R. S. Kennedy, M. T. McGrath, K. Olsen, and R. J. Pabst. 2007. Potential effects of forest policies on terrestrial biodiversity in a multi-ownership province. Ecological Applications 17:48–65.

Ward, C., and T. Erdle. 2015. Evaluation of forest management strategies based on Triad zoning. The Forestry Chronicle 91:40–51.

Welch, B. L. 1951. On the Comparison of Several Mean Values: An Alternative Approach. Biometrika 38:330–336.

APPENDIX 11

Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest

Report prepared by:
Matt Betts, Kim Nelson, Jim Rivers, Dan Roby, Zhiqiang Yang

The purpose of this document is to (1) provide preliminary data and results on Marbled Murrelet occupancy at the Elliott State Research Forest, and (2) provide an outline and suggestions for research on harvest impacts on murrelets.

Our analysis indicates that ~7.8% of 'occupied' Marbled Murrelet habitat at the Elliott State Forest is >65 years old and overlaps with planned extensive ('ecological') forestry (based on murrelet occupancy data provided by Kim Nelson and ODF; Figure 11a, Table 11a). Thus, ~92.2% of identified occupied murrelet habitat will fall into some sort of reserve (either the large Conservation Research Watershed to the west, or the fine-scale reserves (200-800 acres) that form a basis for the proposed Triad design). This estimate assumes that: (1) all 40 Triad replicates will eventually be implemented, (2) historical Marbled Murrelet occupancy data accurately reflect current-day occupancy (i.e., there is strong temporal consistency in nesting habitat and low turnover), and (3) murrelet probability of detection approaches 1 (high detection probability).

It is important to note that these three assumptions are unlikely to hold, hence we should not rely entirely on these historical occupancy data to develop our strategic research plan for the Elliott. First, we are conducting a power analysis to determine the appropriate number of replicates and the timing of implementation of each replicate. It is not logistically possible for all 40 replicates to be implemented simultaneously. Second, murrelets are strongly expected to be site faithful; therefore, changes in occupancy will occur only with disturbance but some sites (currently not known to be occupied) could be colonized (likely by young prospecting birds) over time (Betts et al. 2020). Therefore, results should only be used as an initial proxy for the total area of mature stands that are likely to be occupied. Finally, we know that murrelets are often missed in surveys (there is imperfect detection). Thus, the estimates provided in Table 11a are likely to be an underestimate of the total area of murrelet habitat at the Elliott. To provide a better estimate of the total area of occupied habitat Yang and Betts (unpublished) developed a species distribution model (SDM) using Landsat and LiDAR data

Figure 11a.

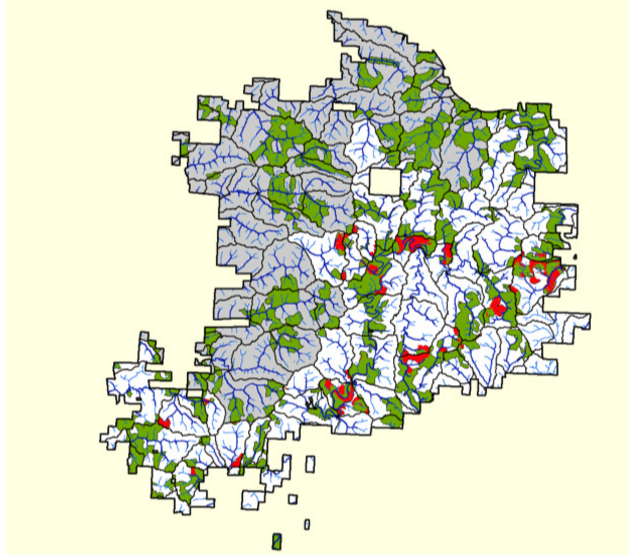


Figure 11a. *Extent of historically occupied stands according to S.K. Nelson and ODF data (green). Occupied stands currently designated as the 'extensive' treatment are highlighted in red. This area totals 1457 acres (7.8% of the historically occupied stands across the entire Elliott State Forest; Table 1). The remaining 92.3% or 17,137 acres >65 years old are in reserves where timber harvesting is prohibited. Total area of occupied habitat = 21,475 (18,594 acres is >65 year-old stands). An additional 2881 acres of murrelet habitat could potentially occur in younger stands (<65 years). Of this 1,444 acres is in the 'intensive management' category (See Table 11b). However, 65% (939 acres) of this shows no initial evidence of residual trees (likely because it has been cut since it was initially surveyed; Table 1). All of the remainder will be surveyed prior to harvest to determine occupancy. If occupied, it will be retained as habitat, at least until the results of the study on murrelet responses to selection cutting are complete and we can quantify potential negative impacts.*

Figure 11b.

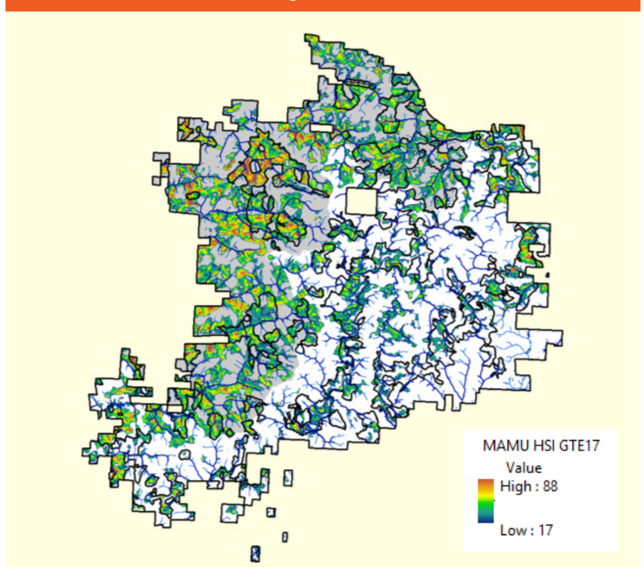


Figure 11b. *Extent of modeled Marbled Murrelet habitat across the Elliott. Occupancy data from Betts et al (2020) [117 points from Nelson and ODF data with known survey dates] were modeled with time-matched 6 visible Landsat TM bands along with 2014 Lidar data. Areas with canopy disturbance were removed. Prediction success on independently held out data was high (AUC=0.89 [out of 1]). The color ramp reflects occupancy likelihood on a scale from 0 to 100. The gray shaded area is in the Conservation Research Watershed (where no harvesting in mature stands would occur).*

that has good prediction success (when tested on independent data; Area Under the Curve = 0.89; Figure 11b, Figure 11c, Appendix 11A).

Conducting some degree of silviculture in >65 year-old murrelet occupied stands is important for two management, conservation, and science-based reasons (1) it upholds the Triad design, which is intended to directly address these hard tradeoffs between the extent and intensity of timber harvest (note that no >65 year-old stands occupied by murrelets would be harvested in the 'intensive treatment' because sufficient timber would be supplied by plantation forestry). (2) Cutting continues to occur on Federal and State lands in young forest (unsuitable murrelet habitat) adjacent to occupied stands, but not currently within known occupied murrelet habitat. It will be critical to understand how murrelets respond to selection cutting over the short and long terms because it is possible that policies protecting murrelet habitat could change, for example in the context of HCPs on State, BLM and private lands. Science should inform such management decisions. We hypothesize that the short-term effects on murrelets of even light harvesting will be negative; nest predation rates are likely to increase due to a higher prevalence of corvids (Marzluff et al. 2004, Cahall et al. 2013) and epiphytes needed for murrelet nesting are likely to decline due to reduced moisture (e.g., van Rooyen et al. 2011). We predict that these potential effects of 'extensive' harvest on murrelets will be compounded by canopy removal in adjacent unoccupied stands, which creates hard habitat edges. To our knowledge, no long-term data exist on the extent of these effects over time. We hypothesize that over the longer term, habitat may recover in light selection harvesting treatments **(i.e., <20% relative density removal; approximately 20% volume harvested)** versus if we were using a clearcut harvest regime.

RECOMMENDATIONS

1 Given the uncertainty involved in identifying the precise locations of future, additional occupied stands (see assumptions #2 and 3 above), and the formal objective of learning about murrelet responses to harvest, OSU would conduct formal murrelet surveys in all potentially occupied habitat stands that are intended for harvest. The exception to this is stands that were identified as being occupied, but have been clearcut harvested since, or had all residual trees removed (according to on-the-ground surveys).

2 As a first approximation from a science perspective, we suggest 10 'treatment' sites (where extensive harvest occurs) and 10 'control' sites (stands with no harvest) be established in stands deemed to be occupied by marbled murrelets. Each pair of treatment and control sites should be 'blocked' (i.e., within ~2 km of each other) and blocks should be spaced sufficiently far apart to ensure statistical independence. A 'site' would likely need to be >50 acres. Therefore, in the first 5 years of implementation, we expect that a total of ~500 acres should be sufficient to detect harvest effects on occupancy (with a paired ~500 acres to serve as controls). Timber harvests in occupied

Figure 11c.

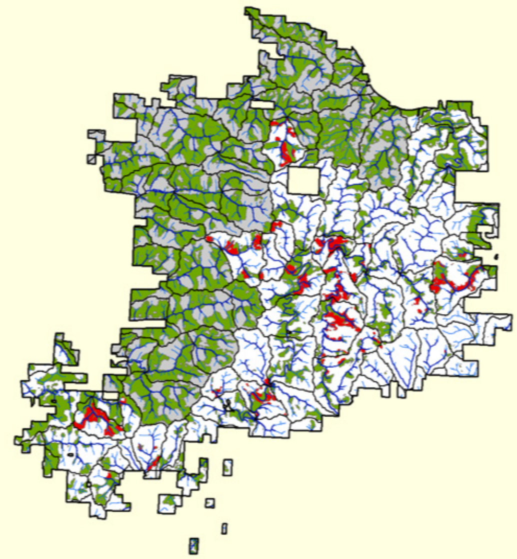


Figure 11c. *Extent of model predicted murrelet occupied stands (green) according to the Yang and Betts (unpublished) species distribution model. Predicted occupied stands currently designated as in the 'extensive' treatment are highlighted in red. This area totals 1676 acres (9% of the historically occupied stands across the entire Elliott State Forest). Note the substantial proportion of predicted occupied stands in the Conservation Research Watershed (CRW).*

Table 11a. Stand Level Research Treatment

Treatment	KN Occupied	ODF Occupied	KN + ODF
CRW	4,355	5,157	7,006
Extensive	1,083	1,220	1,452
Reserve	5,683	6,314	7,593
Reserve 2	121	121	125
GRMA	1,703	1,912	2,410
Total	**12,944**	**14,725**	**18,586**

Table 11a. *Area (in acres) of historically occupied murrelet habitat in proposed different management types at the Elliott State Research Forest. Calculations above are only for stands >65 years old, which are of the greatest conservation significance, and are most likely to be occupied habitat. CRW = Conservation Research Watershed; GRMA = Generic Riparian Management Area; "KN Occupied" indicates murrelet-occupied stands based on survey data supplied by Kim Nelson; "ODF Occupied" indicates murrelet-occupied stands based on survey data supplied by Oregon Department of Forestry. The final column is the union of the two. Note that there is substantial overlap in the two datasets. In total, 1,452 acres of habitat is identified as historically occupied by murrelets, falls into a mature forest category, and would also be available for 'extensive' harvest (low density removal, see above). Note that occupied stands <65 are not included in this table.*

Proportion of total habitat historically occupied by murrelets that would potentially be subject to extensive timber harvest = 7.81%

stands should not reduce tree relative density more than 20%, and retain the overstory as much as possible. Best management practices (BMP) will be developed as part of the sale planning process and will involve provisions to limit predation by corvids and other impacts on murrelets.

3 Surveys will occur each year in both harvest treatment sites and randomly assigned control sites. Surveys should occur only in 'good' ocean years (based on Betts et al. 2020) for a minimum of two years prior to harvest. In addition, we propose that nest searching be conducted in a subset of stands. This will be a non-trivial cost, but will likely be essential to determine harvest effects on murrelet demography. Additional monitoring of Corvids and microclimate will be needed to help determine impacts to harvesting.

LITERATURE CITED

Betts, M.G., J.M. Northrup, J.A. Bailey Guerrero, S.K. Nelson, J.L. Fisher, B.D. Gerber, M-S. Garcia-Heras, Z. Yang, D.D. Roby, J.W. Rivers 2020. Squeezed by a habitat split: Warm ocean conditions and old-forest loss interact to reduce long-term occupancy of a threatened seabird. Conservation Letters 13: e12745.

Cahall, R., J. Hayes, and M.G. Betts. 2013. If you build it will they come? Long-term response by forest birds to experimental thinning supports the "Field of Dreams" hypothesis. Forest Ecology and Management 304: 137–149

Marzluff, J.M., J.J. Millspaugh, P. Hurvitz, and M.S. Handcock. 2004. Relating resources to a probabilistic measure of space use: Forest fragments and Steller's Jays. Ecology 85:1411-1427.

Van Rooyen, J.C., J.M. Malt, and D.B. Lank. 2011. Relating microclimate to epiphyte availability: edge effects on nesting habitat availability for the Marbled Murrelet. Northwest Science. 85: 549–561

Table 11b.

Category	Acres
< 65 yr old stand with no residual trees outside of the riparian area	939
< 65 yr old stand with residual older trees present and should be surveyed before harvest	442
< 65 stand that serves as buffer around an older stand and needs to be reallocated to reserve	63
Balance	**1,444**

Table 11b. *Analysis of stand structure within each of the stands that are a combination of occupied murrelet habitat, <65 year old, and overlap with the intensive harvest allocation. Each of these stands was confirmed to be a former clearcut, and using the 2008 LiDAR imagery examined for the presence of older residual trees. If the harvest was after 2008, the stand was examined in Google Earth to confirm harvest and to determine if residual older trees are present. We propose to use on-the-ground surveys to (a) check for residual trees in the stands identified to have been occupied (by ODF and KN surveys). If residual trees exist, these stands will be surveyed.*

APPENDIX 11A

Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest

BRIEF METHODS FOR OUR MARBLED MURRELET SPECIES DISTRIBUTION MODELING

We used Maxent (https://www.rdocumentation.org/packages/dismo/versions/1.1-4/topics/maxent) to model Marbled Murrelet occupancy data for the Elliott State Forest. Maxent is a machine-learning based presence-only model that is extensively used for modeling species distributions. Our predictor variables included 6 visible Landsat TM bands (Shirley et al. 2013 – Diversity and Distributions), elevation, slope, and tree height (hmean) and tree height stand deviation (hstd) (the latter two were derived from LiDAR).

To process Landsat data, we used harmonic fitting to the spectral data from 1985-2020. Based on MCD12Q2.006 Land Cover Dynamics Yearly Global 500m, the average day of year for greenup and peak greenness were identified for the ESF as 64 and 182, which corresponds to March 4th and Jun 30. All variables summarized at 100, 500, 1000, 2000, 5000 m radii surrounding Marbled Murrelet occupied sites. Results presented here are only for 100 m spatial extent (which produced the best model performance).

We used murrelet occupancy data 2008-2018 (N=117). Data are available at https://figshare.com/articles/dataset/Squeezed_by_a_habitat_split_warm_ocean_conditions_and_old-forest_loss_interact_to_reduce_long-term_occupancy_of_a_threatened_seabird_data_and_code_/12743762. Occupied areas disturbed by harvesting during this period were excluded from analysis.

We modeled murrelet presence as a function of the variables above, the interactions among them, and allowed linear and quadratic features. We randomly assigned 50% of the data for model training and 50% for testing. Note that these test data were therefore independent of those used for model building.

Results

Overall, the model performed well (AUC [independent data] = 0.89; Figure 11d, 11f). This is comparable to previous murrelet models (Hagar et al. 2014, Falxa and Raphael 2016) but

Figure 11d.

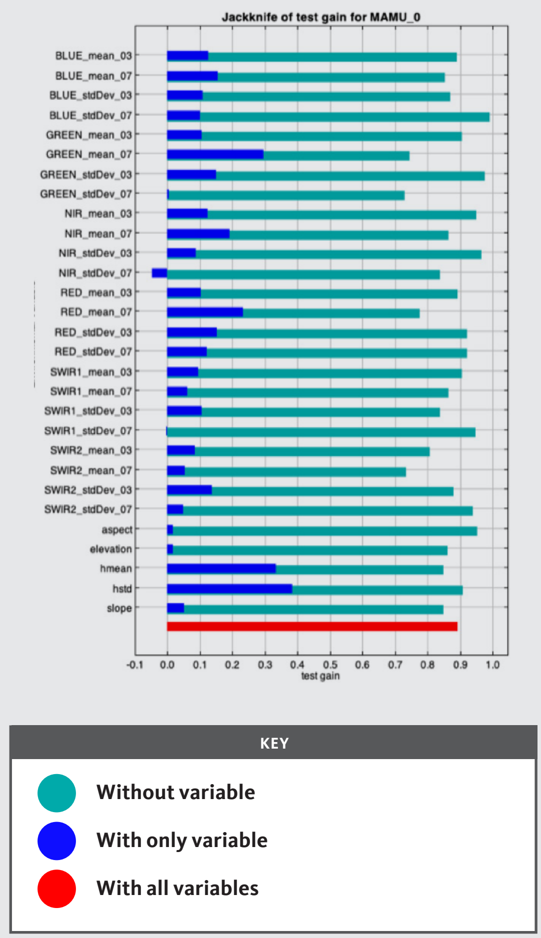


Figure 11d. *Relative performance of predictor variables in Marbled Murrelet Maxent model. Note that the overall model (red) performed well (AUC=0.89). Both Lidar (hmean, hstd) and Landsat data contributed to model performance.*

Figure 11e.

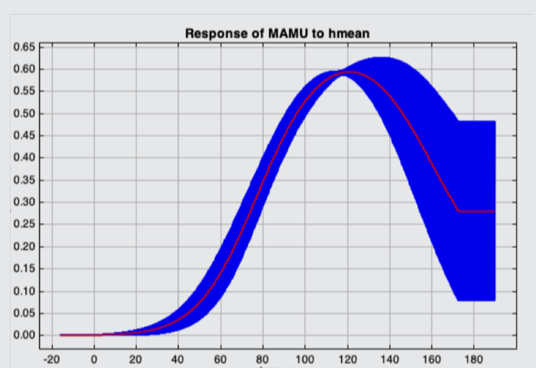


Figure 11e. *Fitted relationship between canopy height (hmean; derived from Lidar) at a 100 m scale and probability of murrelet occupancy. Note high confidence bands at tall tree heights reflect model uncertainty.*

enables fine-scale prediction of murrelets at the Elliott State Forest. Landsat spectral bands were surprisingly effective at predicting distributions, but LiDAR data also contributed. As expected, we found a strong positive effect of canopy height on murrelet occupancy (Figure 11e). Fitted relationships (partial dependence plots), relative influence metrics, and model diagnostics are available on request.

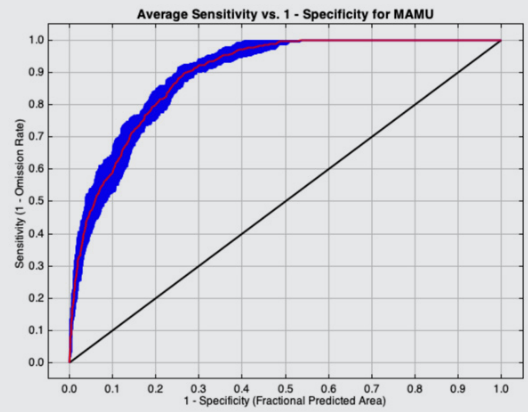
Literature cited

Falxa, G.A., and M. G. Raphael. 2016 Status and trend of Marbled Murrelet populations and nesting habitat. PNW-GTR-933 https://www.fs.fed.us/pnw/pubs/pnw_gtr933.pdf

Hagar, J.C., B.N.I. Eskelson, P.K. Haggerty, S.K. Nelson, and D.G. Vesley. 2014 Modeling Marbled Murrelet (Brachyramphus marmoratus) habitat using LiDAR-derived canopy data. Wildlife Society Bulletin 38(2):237–249

Shirley, S.M., A. Yang, R.A. Hutchinson, J.D. Alexander, K. McGarigal and M.G. Betts, 2013. Species distribution modelling for the people: unclassified landsat TM imagery predicts bird occurrence at fine resolutions. Diversity and Distributions 19: 651-872.

Figure 11f.



KEY

Mean (AUC = 0.894)

Mean +/1 one stddev

Random prediction

Figure 11f. *Receiver Operating Characteristics Curve for Marbled Murrelet Model*

APPENDIX 11B

Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest

SUPPLEMENTARY INFORMATION FOR POTENTIAL MARBLED MURRELET HABITAT DISTRIBUTION AND RESEARCH STRATEGY AT THE ELLIOTT STATE FOREST

Table 11c.

Stand Level Allocation	KN Occupied + ODF MMMA	ODF MMMA	KN Occupied MAMU	MAMU Habitat Suitability Index GTE 17
CRW	7,410	5,358	4,598	15,306
Intensive	1,444	354	1,196	646
Extensive	2,022	1,392	1,562	1,934
Reserve	7,893	6,575	5,881	6,814
GRMA	2,706	2,076	1,914	4,464
Total	**21,475**	**15,756**	**15,151**	**29,164**

Table 11c. *Summary of stand allocations in all analyses of marbled murrelet habitat. This includes stands that are less than and greater than age 65.*

APPENDIX 12

Summary of the Research Design for Peer Review

Summary prepared by:
Matt Betts, Klaus Puettmann, and Katy Kavanagh

RECONCILING MULTIPLE ECOSYSTEM SERVICES AND TIMBER PRODUCTION: AN EXPERIMENTAL TEST OF THE TRIAD APPROACH AT THE ELLIOTT STATE RESEARCH FOREST, OREGON

ABSTRACT

Background: Forests are integral for the health and wellbeing of humanity, as well as to the conservation of biodiversity and ecosystem functions and services. With increasing global demand for forest products and influences from a changing climate, it will be critical to find ways to provide these essential resources without compromising global forest biodiversity, carbon sequestration, and ecosystem services. Along with conservation of aquatic and terrestrial biodiversity, the Elliott state forest has a high potential for carbon sequestration and productivity of wood products making it the ideal place for research on these individual components and for studying the potential for integrating these often competing land uses. We propose that the Elliott State Research Forest (ESRF) be a center – both in Oregon and worldwide – for scientific exploration of sustainable forest management, with the aim of informing future policy and bridging political divides via the application of the scientific method and participatory governance.

The Triad framework: Expansion of high-yielding tree plantations could free up forest land for conservation provided this is implemented in tandem with stronger policies for conserving native forests. Because plantations and other intensively managed forests often support less biodiversity than native forests, a second approach argues for widespread adoption of extensive management, or 'ecological' forestry, which better preserves key forest structural elements and emulates a broad range of disturbance regimes. Extensive management often reduces wood yields and hence there is a need to harvest over a larger area to maintain an equivalent supply of wood. A third, hybrid suggestion involves 'Triad' zoning where the landscape is divided among reserves, extensive management, and intensive management in varying proportions. The overarching objective of the ESRF will be to provide the first landscape-scale experimental test of the Triad as a means to integrate multiple values. Most importantly, the size of the ESRF will enable us to explore and quantify the synergies and tradeoffs associated with different arrangements of these treatments at a landscape scale through time.

Methods: We will experimentally establish four Triad treatments that differ in the proportions of reserves, extensive and intensive forestry, but produce a comparable amount of wood products. The four Triad treatments are: 'intensive-reserve' (50% reserve, 50% intensive), 'Triad-I' (40% reserve, 20% intensive, 40% extensive),'TriadE', (20% reserve, 20% intensive, 60% extensive), and 'extensive' (100% extensive). All treatments will be implemented at the scale of whole subwatershed (which range from 2 ~400-2000 acres) and will be replicated 10 times (N=40 subwatersheds totaling ~52,000 acres). The entire western portion of the Elliott (~30,000 acres) will, following a 15-year period of restoration treatments in established plantations, be designated as a permanent reserve and will serve as a broad-scale control to determine the effect of reserve size and fragmentation on biodiversity, carbon sequestration and socio-ecological processes. In all treatment subwatersheds and the reserve, Elliott principal investigators will collect long-term data on a range of values that are of critical importance to socio-ecological systems. These include (in no order of importance and not an exclusive list): abundances of threatened and endangered (T&E) species (e.g., northern spotted owl, marbled murrelet, Coho salmon), above and belowground carbon pools and fluxes, water flow and quality, timber production, employment, hunting opportunities, total economic production, recreational benefits, biodiversity (e.g., plant, bird, arthropod, mammal abundances and diversity). Because forest management treatments will take decades to fully implement, the landscape-scale aspect of this research will necessarily be long term.

Nested within this broader landscape-scale study, a substantial suite of stand and tree neighborhood-level research will occur. Precise topics will depend on policy needs as well as researcher interest and capacity. These include questions relating to (for example): (1) the most environmentally benign ways to implement intensive forestry, (2) methods to increase fire resistance, (3) quantifying timber production and biodiversity associated with various ecological forestry methods, (4) appropriate buffer sizes to minimize impacts to stream ecosystems, (5) silvicultural methods for restoration of oldgrowth characteristics, and (6) management approaches to maximize carbon sequestration, (7) the long-term effect of selection cutting on the development of marbled murrelet habitat. Given that conclusions from short-term studies often change substantially when examined over the longer term (Cahall et al. 2014, Pabst and Harmon 2018) our aim is for each of these finer-scale studies to be conducted over the long-term.

Outcomes: In addition to delivering rigorous, policy relevant science the Elliott State Research Forest will be designed to provide a number of local and regional societal benefits. These include collaboration with local indigenous tribes in the planning and management process, local economic multipliers from timber harvested and research efforts, recreational opportunities, and the

largest formal forest reserve in the Oregon Coast Range – a region that is under represented in the existing protected areas network.

INTRODUCTION

Forests support the majority (about 70%) of terrestrial biodiversity (International Union for Conservation of Nature 2017), and forest loss and degradation are primary global drivers of biodiversity decline (Betts et al. 2017). The United Nations Convention on Biological Diversity and subsequent Strategic Plan for Biodiversity ("Aichi biodiversity targets", CBD 2011) were significant attempts to address biodiversity loss, but consensus is emerging that the overall objective – halting biodiversity loss by 2020 – has failed (Mehrabi, Ellis, & Ramankutty 2018, Díaz et al. 2019). Given that biodiversity is strongly associated with ecosystem processes (Brokeroff et al. 2017) and services (Nelson et al. 2014, Ricketts et al. 2016), it will be essential to develop management practices that ameliorate biodiversity loss.

Central to the challenge of conserving global biodiversity is an increasingly demanding human population with escalating rates of consumption (Tilman & Clark 2014) and CO2 emissions. The provision and use of forest products is no exception, with current roundwood production equal to 3.7 billion m^3/year and projected growth in wood demand of 30% by 2050 (Kok et al. 2018, FAO 2019). Forests remain of high economic value to humanity, worth over $US 600 billion annually (Duraiappah et al. 2005, Rametsteiner & Whiteman 2014), but wood production potentially threatens other critical values including forest biodiversity and carbon stocks, which are both in rapid decline (Butchart et al. 2010, Saatchi et al. 2011).

To meet the world's wood demand, foresters have often adapted the agricultural model of increasing production through intensive, high-input management practices aimed at increased tree growth and management efficiency by simplifying and homogenizing stand structure (Puettmann, Coates, & Messier 2008). This has been successful at boosting yields – in some cases as much as 40-fold [25-40 m^3/ha/year vs. 1-2 m^3/ha/year in unmanaged natural forests (Sedjo 1999, Wagner et al. 2005)]. Indeed, plantation forest area has increased by over 105 million ha since 1990, with an average annual increase of 3.6 million ha, and planted forests now account for 7% of the world's forests and 33% of roundwood production (Food and Agriculture Organization of the United Nations 2015). If current trends continue, tree plantations – of either native or non-native species – could provide most of global wood by 2050 (Jürgensen, Kollert, & Lebedys 2014).

Closing the wood production 'yield gap' through plantations has two important implications for biodiversity and carbon conservation. First, high-yielding plantations create the potential to reduce harvesting pressure on natural, unmanaged forests (Edwards et al. 2014,Pirard, Dal Secco, & Warman 2016, Runting et al. 2019) and to free up forest land for conservation, provided that appropriate conservation policies are implemented for native forests. Second, however, plantations themselves may have relatively low conservation value (Barlow et al. 2007, Brockerhoff et al. 2008, Swanson et al. 2011, Betts et al. 2013, but see Yamaura et al. 2019). For this and other reasons, researchers and land managers have proposed and developed various local versions of 'ecological forestry' or extensive management techniques (Pommerening & Murphy 2004, Franklin & Johnson 2012, Puettmann et al. 2015, Franklin, Johnson, & Johnson 2018). These techniques typically aim to emulate natural disturbance regimes and vegetation structure, often relying on retention of trees and downed wood and longer harvest rotations (MacLean et al. 2009, Lindenmayer et al. 2012, Root & Betts 2016). However, compared to management of homogeneous plantations, profits and yields of extensive forestry approaches are often substantially lower, in part because of the added complexity of management operations (Newton & Cole 2015, Kormann et al. In review).

THE TRIAD APPROACH

Attempts to reconcile conservation, production, and other objectives have prompted a proposed compromise approach involving forest management in three distinct zones. This 'Triad' zoning divides landscapes into discrete units that emphasize reserves, extensive management, or intensive management (Seymour & Hunter 1992). Reserve areas are managed for biodiversity conservation, which often means little or no intervention. Extensive forestry operations are typically characterized by partial retention, minimal use of external inputs, more time between harvests, and reliance on natural tree regeneration (Franklin & Donato 2020). Practices in the intensive zone can include planting of native or exotic tree species, use of herbicide to control competing vegetation, thinning, and fertilization (Paquette & Messier 2010). Triad provides a framework for assessing the implications for biodiversity and ecosystem services of these approaches. The Triad approach is grounded in the idea that producing wood from intensively managed forests can permit more land to be freed up for conservation (Côté et al. 2010, Tittler, Messier, & Goodman 2016) (Figure 2).

However, the few theoretical (Seymour & Hunter 1992) and modeling (Tittler, Messier, & Fall 2012, Tittler et al. 2015) studies aimed at determining optimal proportions of different management regimes in the Triad approach (Ward & Erdle 2015, Tittler, Messier, & Goodman 2016) are limited in scope due to the absence of sufficient empirical data to formally identify how best to minimize impacts to biodiversity while meeting any given level of demand for wood and providing ecosystem services (Messier et al. 2009, Yoshii et al. 2015, Yamaura et al. 2016). To our knowledge, there are still no empirical tests of how differing proportions of land under the three Triad compartments alter species' populations, wood yield and other ecosystem services across entire landscapes. Instead, the balance of reserves, extensive, and intensive forestry operations at landscape scales is typically determined in an ad hoc manner. This limitation is particularly concerning given that the Triad approach is now being implemented in several jurisdictions in North America and elsewhere (MacLean et al. 2009, Messier et al. 2009, Paquette & Messier 2010, Lahey 2018). This scarcity of scientific information is in stark contrast to the explosion of research on "land sharing" (reflecting a focus on softer, ecological farming) versus "land sparing" (reflecting a focus on strict reserves and intensive farming) in agricultural landscapes (Phalan et al. 2011) which has strong parallels to Triad. At a time when biodiversity continues to decline and the demands of a resource-hungry human population increase, it is critical that wood production strategies are based on science-based evaluations of alternatives (Tallis et al. 2018, Runting et al. 2019).

RATIONALE AND SIGNIFICANCE:

CONTEXT IN THE PACIFIC NORTHWEST AND RELEVANCE TO STAKEHOLDERS

Timber production in the Pacific Northwest has historically been highly controversial, with a range of interests vying for influence over the way forests are managed (Spies et al. 2019, Phalan et al. 2019). Current debates over the most appropriate ways to manage the forest are particularly heated, and focus on three major issues below.

1. **Biodiversity Conservation:** Although the Northwest Forest Plan resulted in the broad-scale conservation of late-successional old-growth forest across Washington, Oregon and California, this forest type and its associated species continue to decline (due to both harvesting and fire; Phalan et al. 2019). This has resulted in repeated legal action by environmental groups to halt logging on state lands (Hall 2019). On the other hand, species associated with complex early seral forest also appear to be declining (Betts et al. 2010, 2013). To address these issues, federal forest managers (particularly the Bureau of Land Management and the Forest Service) have recently experimented with and conducted regeneration harvests following various types of 'ecological' forestry practices.

2. **The role of intensive forest management.** In the Pacific Northwest, herbicides are commonly used in plantations to control competing vegetation and therefore substantially accelerate tree growth (Kroll et al. 2017). The degree to which plantations can support biodiversity and ecosystem services had been poorly understood prior to our AFRI-funded research (e.g., Betts et al. 2013, Stokely et al. 2019). At the stand (local) level, there are strong tradeoffs between timber production, biodiversity (Figure 12a, Kormann et al. In Press) and carbon sequestration (Boutte et al. 2020 Law et al. 2019). However, it remains unclear whether such tradeoffs can be ameliorated at the landscape level via a land-use zoning approach; in other words, certain areas are focused on timber production, while others sustain biodiversity and carbon sequestration with consequently reduced timber yields. Further, it is unknown whether there are landscape-scale thresholds in the amount of plantations before biodiversity in remaining natural forest begins to decline (Betts and Villard 2009) and the entry

Figure 2

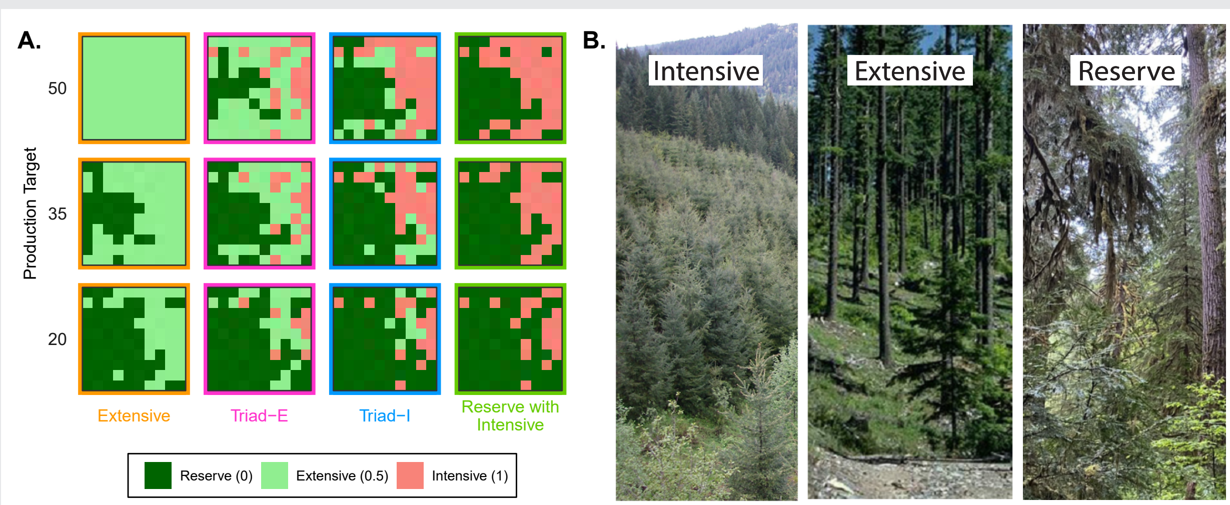


Figure 2. *Conceptual illustration of contrasting approaches to managing landscapes for timber production and biodiversity conservation in mixed-wood yield landscapes along a continuum from where extensive (ecological) forestry dominates to landscapes comprised of reserves and intensive management. In (A), each of the nine panels is a schematic map of a region with unmanaged habitat (also termed 'reserve', dark green; 0 units of production per pixel), ecological forestry (also termed 'extensive management', light green; 0.5 units/pixel), and high-yield forestry (also termed 'intensive management', coral; 1 unit/pixel). Region maps in the same row all produce the same quantity of wood, but use different proportions of forest management approaches to provide the production target. The three rows show results from low (20) to higher production targets (50). Note that even the highest production target depicted here is still only ½ of the total production possible. Due to the reduced per acre production afforded by extensive forestry, 'Extensive' landscapes (left column) necessarily have reduced reserve compared to the 'Reserve with Intensive' landscapes. Intermediate options (Triad-E and Triad-I) will also be examined and represent balanced options where reserves, extensive and intensive management occur in the same landscapes. At the Elliott State Research Forest, we will test the 50% production target (top row). In (B), examples of each type of management are shown: intensive management (Douglas-fir plantation), ecological forestry (variable retention harvesting in native forest), and unmanaged, protected old growth.*

of wood products into the built environment, offsetting fossil fuels, leads to an overall increase or decline of sequestered carbon.

3 Declines in timber production and tax revenue. There have been substantial declines in local timber and tax revenue to rural communities in the wake of substantial declines in timber harvest over the three decades since the Northwest Forest Plan (Spies et al. 2019) and due to other environmental regulations. In response, rural timber-producing counties in Oregon recently sued the state of Oregon and were awarded $1.1 Billion USD in lost revenue (Sickinger 2019).

The Elliott State Research Forest seeks to address these controversial issues by testing the hypothesis that multiple objectives can be better integrated via the Triad zoning approach at the landscape scale. We seek to test a range of scenarios with differing proportions of (1) extensive (ecological) forestry, (2) intensive forestry and (3) reserves to determine a suite of policy options to produce timber, sequester carbon (both ecosystem services) and maintain native biodiversity. Most 6 importantly, the size of the ESRF will enable us to

Figure 12a.

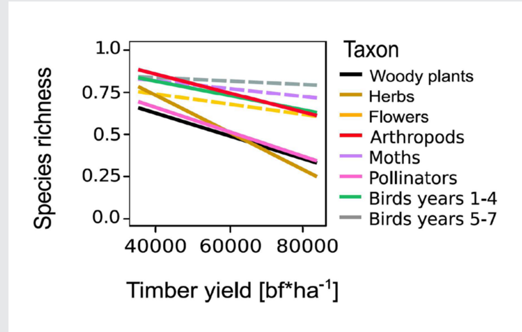


Figure 12a. *Results of a recent study (Kormann et al. In Press) demonstrating tradeoffs between species richness of biodiversity taxa (normalized to 1) and timber production. Statistically significant tradeoffs (solid lines) occur for arthropods, pollinators, woody & herbaceous plants, and birds in the first years of stand development. Our current proposal is to test whether such tradeoffs can be minimized at the landscape scale by implementing 'optimal' amounts of different forest management regimes using the 'Triad' approach.*

Figure 4. Triad Landscape-level (Subwatershed) Treatments

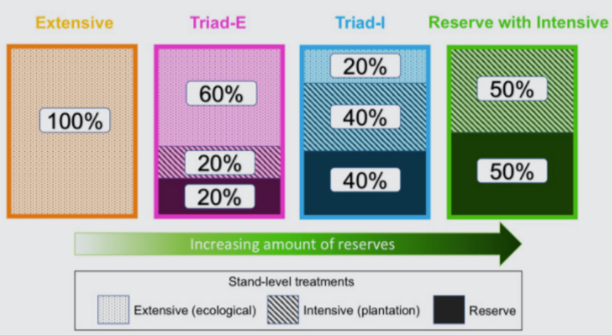


Figure 4. *The four Triad treatments that we will apply at the subwatershed scale at the ESRF. All of the subwatersheds (400-2000 ac) in the Management Research Watersheds will receive one of these four treatments. Treatments are designed to produce approximately equivalent wood yields using different combinations of stand-level treatments: reserves, extensive (ecological forestry) and intensive management (plantations). The 'Extensive' Triad treatment (orange) will be 100% ecological forestry, the 'Reserve with Intensive' Triad treatment (light green) will comprise 50% intensive forestry and 50% reserve. 'Triad-E' and 'Triad-I' contain differing proportions of reserve, ecological and intensive forestry.*

Figure 6. Age class distribution in the Conservation Research Watershed and the Management Research Watershed

KEY

	LTE65	GT65
CRW	36%	%
MRW	60%	%
ALL ELLIOTT	50%	50%

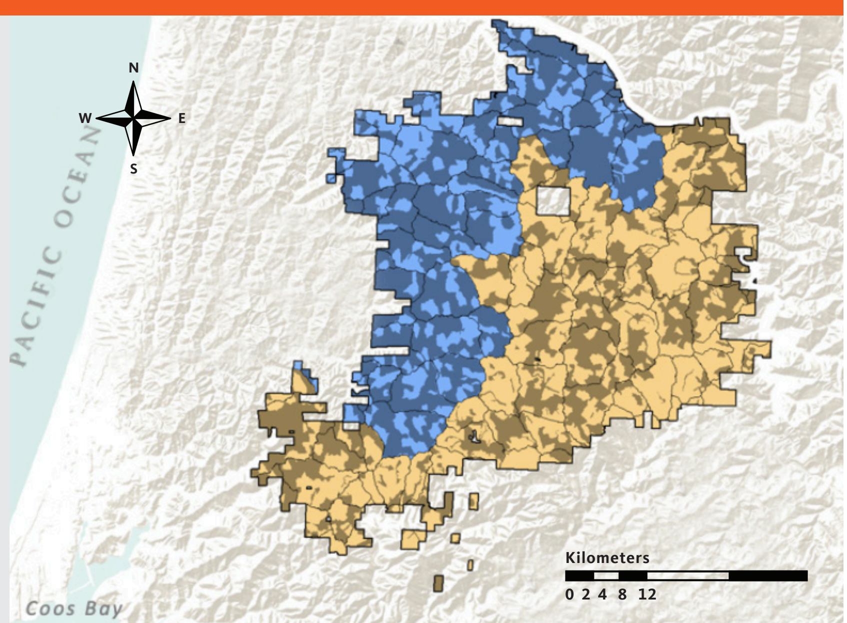


Figure 6. *Subwatersheds of the Elliott State Research Forest color coded by classification into the Conservation Research Watersheds (CRW) and Management Research Watersheds (MRW) and color coded by stand age greater than 65 years (GT65) and less than 65 years (LTE65). Uncolored regions indicate this portion of watershed is not part of the proposed Elliott State Research Forest.*

explore and quantify the synergies and tradeoffs associated with different arrangements of these treatments at a landscape scale through time.

METHODS SUMMARY

Study Area. The Elliott State Research Forest is located in the southern Oregon Coast Range, and lies within 10 km of the Pacific Ocean. The area is 98% forested, and dominated by Douglas-fir, with some western hemlock, western red cedar,and red alder. As a result of timber harvest, ~50% of these forests are Douglas-fir plantations <65 years old. The majority of the remaining forest is <152 years old, originating from a stand-replacing fire in 1868. Approximately 5000 acres escaped this fire and were subsequently harvested so there are a few hundred acres greater than >153 years.

Experimental Units and Sample Size. The experimental unit for implementation of our research design will be at the subwatershed scale. These subwatersheds range from 400 to 2000 acres in size, thereby reflecting a spatial scale relevant to most of the taxa and processes likely to be included in our study. The 66 subwatersheds in the Elliott State Research Forest are designated to be in either the Conservation Research Watersheds (CRW) or Management Research Watersheds (MRW), (Figure 5) with over 9,000 acres in partial watersheds that were either less than 400 acres or not fully contained within the ESRF. Subwatersheds were chosen to provide defined boundaries (ridges) and the ability to use water attributes (e.g., temperature, quality, quantity as an integrator of treatment effects. With 41 subwatersheds, we plan to have at least10 replicates per treatment level. Under this scenario, forty-one watersheds that are wholly contained within the MRW will receive the treatments outlined in Figure 4. Although the exact number of replicates will depend on the results of an ongoing power analysis that is based on simulation models for biodiversity responses to treatments across subwatersheds.

Treatment Assignment. The ESRF has experienced substantial anthropogenic and natural disturbance over the past 150 years. Approximately half of the area has been clearcut – mostly during the 1960-2016 period. As a result of this previous management history, fully random assignment of subwatershed-scale treatments is not socially or logistically feasible. For instance, initial tests of fully random assignment resulted in some subwatersheds with high-quality old forest being assigned substantial intensive forestry (which would result in these stands being clearcut). Similarly, existing young plantations were randomly assigned to 'reserve', which is suboptimal from a conservation perspective – in the short term at least. We therefore assigned treatments non-randomly using the following criteria: (1) ensure that there is no detectable bias among treatments in biophysical factors (i.e., elevation, aspect, site productivity, slope and aspect). (2) prohibit intensive harvest of old forest. Ultimately, no old forest will be clearcut in the current research design, (3) minimize the amount of silviculture conducted in T&E species habitat (i.e., marbled murrelet, spotted owl). The current design results in ~1400 acres of potential murrelet habitat attributed to 'extensive' forest management. Where this occurs, silviculture will be 'light touch' (low proportions of basal area will be removed). Long-term data will be collected on murrelet responses to these treatments (in relation to paired controls).

Non-random treatment allocation. There are several well-known scientific reasons for random allocation of treatments. First, randomization aims to avoid true bias caused by confounding factors. For instance, it might not be by chance that old forest remains where it does (e.g., steep slopes, low productivity forest; Lindenmayer and Laurance 2012); harvests are likely to have occurred in the most productive

Figure 5. Potential Subwatershed Triad Treatment Assignments

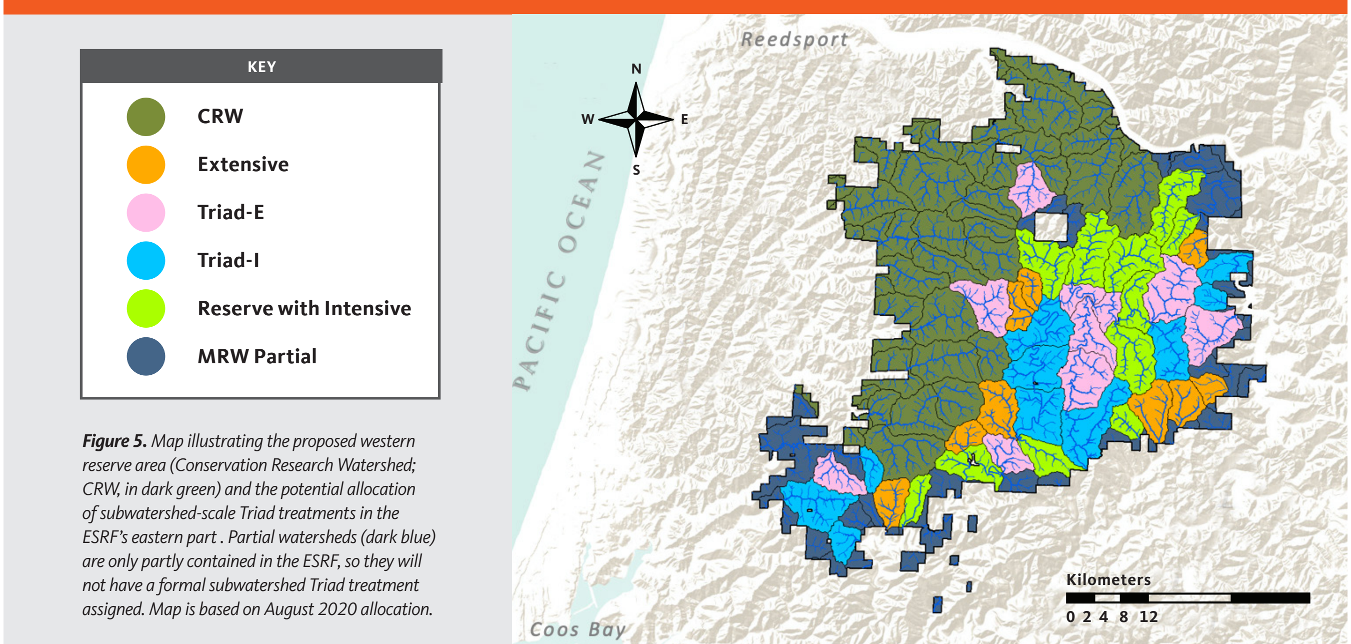


Figure 5. *Map illustrating the proposed western reserve area (Conservation Research Watershed; CRW, in dark green) and the potential allocation of subwatershed-scale Triad treatments in the ESRF's eastern part . Partial watersheds (dark blue) are only partly contained in the ESRF, so they will not have a formal subwatershed Triad treatment assigned. Map is based on August 2020 allocation.*

and easily accessible stands. Ignoring such factors may lead to misinterpretation by erroneously associating results with the Triad treatments. However, we did not find evidence that standscale treatments were biased as a function of such biophysical factors. As noted above, we are conducting a simulation model to serve as the basis for power analysis to determine the appropriate subwatershed-scale replication. We will also use this process to compare modelled scenarios that use a fully random design to the current design. This will provide a quantitative estimate of whether sampling allocations are biased.

Second, randomization is more likely to result in spatial interspersion of treatments. It was of initial concern to us that our treatments seemed quite clumped as initially implemented (Figure 5; e.g., more 'extensive' watersheds occurred adjacent to each other than you would hope). However, when we tried a fully randomized design, spatial clumping occurred frequently by chance alone. Given the size of the Elliott, and the large scale of the experimental units, full interspersion of treatments is unattainable – even with a randomized design. We will address spatial autocorrelation by taking proximity of treatments into account during statistical analysis (via including spatial terms in the error structure).

Treatment Scheduling. Due to the large spatial extent of experimental treatments, it will not be logistically possible, or economically beneficial to local communities to implement all silvicultural activities simultaneously. We therefore propose to concentrate initial treatments on a subset of 16 subwatersheds (4 replicates). These watersheds will enable us to apply an adaptive management approach, wherein we will be able to test (a) the feasibility of current proposed treatments, and (b) the degree to which our initial estimates of necessary replication (from power analysis) were correct. This 'phased' implementation of the design also subverts the concern that our results are dependent on the climatic conditions of the treatment years (the range of inference will be expanded). We plan to account for temporal autocorrelation and yearly weather patterns in the statistical analysis. This treatment schedule will also give us the opportunity to collect long-term pretreatment data on the untreated subwatersheds.

Fragmentation and Spatial Effects: The sizes of the individual treatment areas, including reserves, will range from 80-1000 acres, depending on the percentage of the subwatershed in reserve and the size of the subwatershed. We acknowledge that this may be too small to serve as effective patch sizes for some of the species and processes in our study – however, such fragmentation effects have not been extensively studied in the Pacific Northwest (McGarigal and McComb 1995). We will therefore maintain one large reserve (35,000 acres) to serve as a 'benchmark' to which smaller reserves can be compared. Ultimately, the current design with a gradient in reserve size will enable us to test the effect of reserve size on biodiversity and ecological processes. Similar information could be gained by comparing how species and processes develop on neighboring land where larger areas received intensive management or extensive treatments.

Stand-level silvicultural treatments. One of our research goals is to explore the most effective ways to implement 'extensive' and 'intensive' forestry. Thus, we expect the exact specifications of 'intensive' and 'extensive' silvicultural approaches to vary within subwatersheds, and ultimately follow principles of adaptive management (see Appendix 2; see 'Nested Design' below).

A **Reserves:** This treatment will have very, very limited intervention and management. Natural processes including disturbance would be unmanaged and allowed to create disturbances and seral stages (with the exception of fire).

B **Intensive treatments** will maximize wood productivity per acre. Research treatments in these forests will allow us to investigate management options that primarily emphasize the production of wood fiber at rotations of 60 years or longer. At the same time, we can assess methods to reduce the impact of this harvest regime on other attributes such as biodiversity, habitat, carbon cycling, recreation, and rural well-being.

C **Extensive treatments** will be to explore the implementation of a new set of alternatives to intensive plantation management and unmanaged reserves. Research on "extensive" alternatives will aim to accomplish diverse forest characteristics to meet a broad set of objectives and ecosystem services. This will be done by retaining structural complexity while ensuring conditions exist to obtain regeneration and sustain the complex forest structure through time.

D **Riparian conservation areas:** The aquatic and riparian conservation component of the system-based research strategy will rely on a set of designated RCAs. These RCAs design will maintain and restore vital ecological processes that influence the aquatic ecosystem in the intensively managed and extensively managed treatments.

Biodiversity, Timber, and Ecosystem Monitoring Data. In each subwatershed, Elliott principal investigators will collect long-term data on a range of values that are of critical importance to socioecological systems. An initial set of thematic research areas have been identified by stakeholders and included in the ESRF Research Charter. These include:

- **Biodiversity and At-Risk Species:** As the Elliott contains a number of potentially at-risk and sensitive species (e.g., northern spotted owl, marbled murrelet, Coho salmon) research needs to address the most pressing of issues associated with sustaining and enhancing terrestrial and aquatic species in the context of managed forested landscapes.
- **Timber production:** The Triad design will enable us to track the quality and quantity of timber removed across treatments and the fate of the carbon in this timber as it moves into the manufacturing and built environments.
- **Carbon sequestration in reserves and managed forests:** We will monitor below and above ground carbon through

space and time under a variety of management scenarios. We will develop a database on carbon concentrations, mortality, and decay rates. We will use the results of these observational and manipulative studies to parameterize and test biogeochemical process models that will serve the Elliott and other forests.

- **Local and Regional Economic Benefits:** We will track not only direct employment in silvicultural and recreational activities, but also the 'multiplier effects' resulting from timber and non-timber benefits.
- **Climate Change Adaptation:** Forest and ecosystem health related to climate change impacts; research to identify potential suite of management approaches to help mitigate impacts with a goal of forest resiliency and reduced vulnerability.
- **Natural and Human-Caused Disturbance:** Disturbances such as landslides, debris flows, fires, different types of harvest regimes and recreation all play a crucial role in forested landscapes. The Elliott has and will continue to be the site of significant disturbances – whether natural or human-caused. Research conducted on the forest will be tailored to account for this important opportunity.
- **Stand Structure and Composition:** The Elliott has demonstrated inherent potential for older, larger trees to dominate as well as complex early seral that can potentially dominate the northwest forests associated with our region. Research will explore management options that provide for a variety of stand structures and composition, including late-successional conditions, and associated range of biodiversity, wood products and ecosystem services
- **Water Quantity and Quality in Relation to Forest Management:** The Elliott provides excellent opportunities to develop better scientific understanding of the effects and biological responses of natural and human-caused disturbances in forest landscapes on water quality and quantity.
- **Landscape and Scale Issues:** Opportunities to investigate the role of adjacency (source-sink relationship), fragmentation, and connectivity.
- **Socio-economic and cultural impacts:** Opportunities to investigate the human dimensions of a Triad design.

Additional response variables include, but are not limited to: above and belowground carbon, mortality rates, decay rates, water flow and quality, timber production, employment, hunting opportunities, total economic production, recreational benefits, biodiversity (e.g., plant, bird, arthropod, mammal abundances and diversity). Because forest management treatments will take decades to fully implement, the landscape-scale aspect of this research will necessarily be long term.

A NESTED DESIGN:

OPPORTUNITIES FOR STAND-LEVEL EXPERIMENTS WITHIN THE TRIAD FRAMEWORK

It is important to realize that although the unifying 'grand vision' for the Elliott is the question of how to meet society's wood demands while maintaining biodiversity, carbon sequestration and other socioecosystem processes, this in no way precludes many stand-level studies that only tangentially fit within this vision. For instance, it is certainly of policy relevance to find out how biodiversity responds to different approaches of "ecological forestry" (very little work has been done on this, despite the fact that it is being applied to 1000s of acres of Bureau of Land Management holdings). Nested within this broader landscape-scale study, a substantial suite of stand-or tree neighborhood level research will occur. Precise topics will depend on policy need and researcher interest and capacity. These include questions relating to, for example: (1) the most environmentally benign ways to implement intensive forestry, (2) methods to increase fire resistance or resilience, (3) quantifying timber and biodiversity yields from various ecological forestry methods, (4) appropriate riparian configuration to minimize impacts of harvesting to stream ecosystems, (5) silvicultural methods for restoration of old-growth characteristics, and (6) management approaches to maximize carbon sequestration. We provide a list of additional research opportunities that could nest within the broader Triad design in Appendix 2.

AN ADAPTIVE MANAGEMENT APPROACH:

Our goal is to implement Triad treatments in the context of adaptive management. Our intention is not to be held to a single "silviculture du jour" for the next 50-100 years, but we will learn by doing – both with extensive and intensive silviculture. For example, we will examine whether it is possible to conduct highly productive intensive management while minimizing herbicides, and in ways that conserve early seral biodiversity? We will also test whether there are innovative approaches to ecological forestry that will not reduce wood supply substantially.

Appendices 3, 5, and 7 were included along with this summary of the research design for reviewers.

LITERATURE CITED:

Balmford, A., K. J. Gaston, S. Blyth, A. James, and V. Kapos. 2003. Global variation in terrestrial conservation costs, conservation benefits, and unmet conservation needs. Proceedings of the National Academy of Sciences 100:1046–1050.

Barlow, J., T. A. Gardner, I. S. Araujo, T. C. Ávila-Pires, A. B. Bonaldo, J. E. Costa, M. C. Esposito, L. V.

Ferreira, J. Hawes, M. I. Hernandez, and others. 2007. Quantifying the biodiversity value of tropical primary, secondary, and plantation forests. Proceedings of the National Academy of Sciences 104:18555–18560.

Betts, M., and G. Forbes (eds). 2005. Forest management guidelines to protect native biodiversity in the Greater Fundy Ecosystem, 2nd edition. New Brunswick Cooperative Fish and Wildlife Research Unit. University of New Brunswick.

Betts, M. G., G. J. Forbes, and A. W. Diamond. 2007. Thresholds in Songbird Occurrence in Relation to Landscape Structure. Conservation Biology 21:1046–1058.

Betts, M. G., N. L. Rodenhouse, T. Scott Sillett, P. J. Doran, and R. T. Holmes. 2008. Dynamic occupancy models reveal within-breeding season movement up a habitat quality gradient by a migratory songbird. Ecography 31:592–600.

Betts, M. G., and M.-A. Villard. 2009. Landscape thresholds in species occurrence as quantitative targets in forest management: generality in space and time? Pages 185–206 Setting conservation targets for managed forest landscapes, ed. MA Villard, and BG Jonsson. Cambridge University Press.

Betts, M. G., J. C. Hagar, J. W. Rivers, J. D. Alexander, K. McGarigal, and B. C. McComb. 2010. Thresholds in forest bird occurrence as a function of the amount of early-seral broadleaf forest at landscape scales. Ecological Applications 20:2116–2130.

Betts, M. G., J. Verschuyl, J. Giovanini, T. Stokely, and A. J. Kroll. 2013. Initial experimental effects of intensive forest management on avian abundance. Forest Ecology and Management 310:1036–1044.

Betts, M. G., C. Wolf, W. J. Ripple, B. Phalan, K. A. Millers, A. Duarte, S. H. M. Butchart, and T. Levi. 2017. Global forest loss disproportionately erodes biodiversity in intact landscapes. Nature 547:441–444.

Betts, M. G., Christopher Wolf, Marion Pfeifer, Cristina Banks-Leite, Victor Arroyo-Rodríguez, Danilo Bandini Ribeiro, Jos Barlow, Felix Eigenbrod, Deborah Faria, Robert J. Fletcher Jr., Adam S. Hadley, Joseph E. Hawes, Robert D. Holt, Brian Klingbeil, Urs Kormann, Luc Lens, Taal Levi, Guido. F. Medina-Rangel, Stephanie L. Melles, Dirk Mezger, José Carlos Morante-Filho, David Orme, Carlos A. Peres, Benjamin T. Phalan, Anna Pidgeon, Hugh Possingham, William J. Ripple, Elenor M. Slade, Eduardo Somarriba, Joseph Tobias, Jason M. Tylianakis, J. Nicolás Urbina-Cardona, Jonathon J. Valente, James I. Watling, Konstans Wells, Oliver R. Wearn, Eric Wood, Richard Young, and Robert M. Ewers. 2019a. Extinction filters mediate the global effects of habitat fragmentation on animals. Science 366:1236–1239.

Betts, M. G., J. Gutiérrez Illán, Z. Yang, S. M. Shirley, and C. D. Thomas. 2019b. Synergistic effects of climate and land-cover change on long-term bird population trends of the western USA: A test of modeled predictions. Frontiers in Ecology and Evolution 7:186.

Betts, M. G., B. T. Phalan, C. Wolf, S. C. Baker, C. Messier, K. J. Puettmann, R. Green, S. H. Harris, D. B. Lindenmayer, and A. Balmford. 2020. Producing wood at least cost to biodiversity: integrating Triad and sharing-sparing approaches to inform forest management. Submitted to Biological Reviews.

Brockerhoff, E. G., H. Jactel, J. A. Parrotta, C. P. Quine, and J. Sayer. 2008. Plantation forests and biodiversity: oxymoron or opportunity? Biodiversity and Conservation 17:925–951.

Brockerhoff, E. G., L. Barbaro, B. Castagneyrol, D. I. Forrester, B. Gardiner, J. R. González-Olabarria, P. O. Lyver, N. Meurisse, A. Oxbrough, H. Taki, I. D. Thompson, F. van der Plas, and H. Jactel. 2017. Forest biodiversity, ecosystem functioning and the provision of ecosystem services. Biodiversity and Conservation 26:3005–3035.

Brower, J. E., J. H. Zar, and C. N. von Ende. 1998. Field and Laboratory Methods for General Ecology, 4th Edition. WCB McGraw-Hill, Boston, MA.

Brown, E. R. 1985. Management of wildlife and fish habitats in forests of western Oregon and Washington. Pages 192–1985. U.S. Department of Agriculture.

Butchart, S. H., M. Walpole, B. Collen, A. Van Strien, J. P. Scharlemann, R. E. Almond, J. E. Baillie, B.

Bomhard, C. Brown, J. Bruno, and others. 2010. Global biodiversity: indicators of recent declines. Science 328:1164–1168.

Cahall, R. E., J. P. Hayes, and M. G. Betts. 2013. Will they come? Long-term response by forest birds to experimental thinning supports the “Field of Dreams” hypothesis. Forest Ecology and Management 304:137–149.

Ceballos, G., P. R. Ehrlich, A. D. Barnosky, A. García, R. M. Pringle, and T. M. Palmer. 2015. Accelerated modern human–induced species losses: Entering the sixth mass extinction. Science Advances 1:e1400253.

CIPS. 2020. CIPSANON User’s Manual, version 4.0. Center for Intensive Planted-forest Silviculture. http://cips.forestry.oregonstate.edu/cipsanon.

Convention on Biological Diversity. 2010. The strategic plan for biodiversity 2011– 2020 and the Aichi biodiversity targets. UNEP/CBD/COP/DEC/X/2. Secretariat of the Convention on Biological Diversity, Nagoya, Japan.

Côté, P., R. Tittler, C. Messier, D. D. Kneeshaw, A. Fall, and M.-J. Fortin. 2010. Comparing different forest zoning options for landscape-scale management of the boreal forest: possible benefits of the Triad. Forest Ecology and Management 259:418–427.

Crookston, N. L., and G. E. Dixon. 2005. The forest vegetation simulator: a review of its structure, content, and applications. Computers and Electronics in Agriculture 49:60–80.

Cushman, S. A., and K. McGarigal. 2004. Hierarchical analysis of forest bird species–environment relationships in the Oregon coast range. Ecological Applications 14:1090–1105.

Díaz, S., J. Settele, E. S. Brondízio, H. T. Ngo, J. Agard, A. Arneth, P. Balvanera, K. A. Brauman, S. H. M. Butchart, K. M. A. Chan, L. A. Garibaldi, K. Ichii, J. Liu, S. M. Subramanian, G. F. Midgley, P. Miloslavich, Z. Molnár, D. Obura, A. Pfaff, S. Polasky, A. Purvis, J. Razzaque, B. Reyers, R. R. Chowdhury, Y.-J. Shin, I. Visseren-Hamakers, K. J. Willis, and C. N. Zayas. 2019. Pervasive human-driven decline of life on Earth points to the need for transformative change. Science 366:1-10.

Dooley E., and S. Fairweather. 2016. Elliott State Forest cruise report for Oregon Department of State Lands. Prepared for Oregon Department of State Lands by Mason, Bruce, and Girard. Portland, Oregon. March 9, 2016. 39 pp.

Duraiappah, A. K., S. Naeem, T. Agardy, N. Ash, H. Cooper, S. Diaz, and et al. 2005. Ecosystems and human well-being: biodiversity synthesis; a report of the Millennium Ecosystem Assessment. World Resources Institute.

Edwards, D. P., J. J. Gilroy, P. Woodcock, F. A. Edwards, T. H. Larsen, D. J. Andrews, M. A. Derhé, T. D.

Docherty, W. W. Hsu, S. L. Mitchell, and others. 2014. Land-sharing versus land-sparing logging: reconciling timber extraction with biodiversity conservation. Global change biology 20:183–191.

Ellis, T. M., and M. G. Betts. 2011. Bird abundance and diversity across a hardwood gradient within early seral plantation forest. Forest Ecology and Management 261:1372–1381.

Ellis, T. M., A. J. Kroll, and M. G. Betts. 2012. Early seral hardwood vegetation increases adult and fledgling bird abundance in Douglas-fir plantations of the Oregon Coast Range, USA. Canadian Journal of Forest Research 42:918–933.

Fahrig, L. 1998. When does fragmentation of breeding habitat affect population survival? Ecological Modelling 105:273–292.

Fahrig, L. 2003. Effects of Habitat Fragmentation on Biodiversity. Annual Review of Ecology, Evolution, and Systematics 34:487–515. Food and Agriculture Organization of the United Nations. 2015. Global Forest Resources Assessment 2015: How are the World's Forests Changing?. Food and Agriculture Organization of the United Nations. 2019. FAOSTAT Statistical Database. Rome, Italy.

Franklin, J. F., and D. C. Donato. 2020. Variable retention harvesting in the Douglas-fir region. Ecological Processes 9:1–10.

Franklin, J. F., and K. N. Johnson. 2012. A restoration framework for federal forests in the Pacific Northwest. Journal of Forestry 110:429–439.

Franklin, J. F., K. N. Johnson, and D. L. Johnson. 2018. Ecological forest management.

Gray, A. N., T. R. Whittier, and M. E. Harmon. 2016. Carbon stocks and accumulation rates in Pacific Northwest forests: role of stand age, plant community, and productivity. Ecosphere 7.

Greenfield, P., N. Tran-Dinh, and D. Midgley. 2019. Kelpie: generating full-length 'amplicons' from wholemetagenome datasets. PeerJ 6:e6174.

Gunn, J. S., M. J. Ducey, T. Buchholz, and E. P. Belair. 2020. Forest carbon resilience of Eastern Spruce Budworm (Choristoneura fumiferana) salvage harvesting in the northeastern United States. Frontiers in Forests and Global Change 3:14.

Hagar, J. C. 2007. Wildlife species associated with non-coniferous vegetation in Pacific Northwest conifer forests: A review. Forest Ecology and Management 246:108–122.

Hall, B. 2019, May 19. The fight for a forest: OSU's bid to manage Elliott for research still faces questions. Corvallis Gazette Times.

Hall, M. 2018. Blue and yellow vane traps differ in their sampling effectiveness for wild bees in both open and wooded habitats: Blue vane traps better for bee sampling. Agricultural and Forest Entomology 20:487–495.

Hansen, A. J., W. C. McComb, R. Vega, M. G. Raphael, and M. Hunter. 1995. Bird Habitat Relationships in Natural and Managed Forests in the West Cascades of Oregon. Ecological Applications 5:555–569.

Harris, S. H., U. G. Kormann, T. D. Stokely, J. Verschuyl, A. J. Kroll, and M. G. Betts. 2020. Do birds help trees grow? An experimental study of the effect of land-use intensification on avian trophic cascades. Ecology. In press.

Hayes, J. P., S. P. Cross, and McIntire, P.W. (n.d.). Seasonal variation in mycophagy by the western redbacked vole, Clethrionomys californicus, in southwestern Oregon. Northwest Science 60:250–257.

Helm, D. J., and B. R. Mead. 2004. Reproducibility of vegetation cover estimates in south-central Alaska forests. Journal of Vegetation Science 15:33–40.

Homan, R. N., B. S. Windmiller, and J. M. Reed. 2004. Critical thresholds associated with habitat loss for two vernal pool-breeding amphibians. Ecological Applications 14:1547–1553.

International Union for Conservation of Nature. 2017. The IUCN Red List of Threatened Species. Version 2016.3.

Jones, J. E., A. J. Kroll, J. Giovanini, S. D. Duke, T. M. Ellis, and M. G. Betts. 2012. Avian Species Richness in Relation to Intensive Forest Management Practices in Early Seral Tree Plantations. PLoS ONE 7:e43290.

Jürgensen, C., W. Kollert, and A. Lebedys. 2014. Assessment of industrial roundwood production from planted forests. Planted Forests and Trees Working Papers (FAO) eng no. FP/48/E.

Kelly, R. M., J. Kitzes, H. Wilson, and A. Merenlender. 2016. Habitat diversity promotes bat activity in a vineyard landscape. Agriculture, Ecosystems & Environment 223:175–181.

Kéry, M., and J. A. Royle. 2016. Applied Heirarchical Modeling in Ecology, Vol. 1. Elsevier, New York, NY.

Kéry, M., J. A. Royle, and H. Schmid. 2005. Modeling Avian Abundance from Replictated Counts Using Binomial Mixture Models. Ecological Applications 15:1450–1461.

Kimmins, J. P. 1997. Balancing Act. UBC Press, Vancouver, British Columbia, Canada.

Kok, M. T. J., R. Alkemade, M. Bakkenes, M. van Eerdt, J. Janse, M. Mandryk, T. Kram, T. Lazarova, J. Meijer, M. van Oorschot, H. Westhoek, R. van der Zagt, M. van der Berg, S. van der Esch, A.-G. Prins, and D. P. van Vuuren. 2018. Pathways for agriculture and forestry to contribute to terrestrial biodiversity conservation: A global scenario-study. Biological Conservation 221:137–150.

Kormann, U. G., T. D. Stokely, J. Verschuyl, A. J. Kroll, S. H. Harris, D. A. Maguire, D. B. Mainwaring, J. W. Rivers, and M. G. Betts. In Press. Reconciling biodiversity with timber production and revenue. Ecological Applications.

Kroll, A. J., J. Verschuyl, J. Giovanini, and M. G. Betts. 2017. Assembly dynamics of a forest bird community depend on disturbance intensity and foraging guild. Journal of Applied Ecology 54:784–793.

Lahey, W. 2018. An Independent Review of Forest Practices in Nova Scotia. Halifax, Nova Scotia.

Law, B. E., T. W. Hudiburg, L. T. Berner, J. J. Kent, P. C. Buotte, and M. E. Harmon. 2018. Land use strategies to mitigate climate change in carbon dense temperate forests. Proceedings of the National Academy of Sciences 115:3663–3668.

Lindenmayer, D.B. & Laurance, W.F. 2012. A history of hubris–Cautionary lessons in ecologically sustainable forest management. Biological Conservation 151: 11–16.

Lindenmayer, D., J. Franklin, A. Lõhmus, S. Baker, J. Bauhus, W. Beese, A. Brodie, B. Kiehl, J. Kouki, G. M. Pastur, and others. 2012. A major shift to the retention approach for forestry can help resolve some global forest sustainability issues. Conservation Letters 5:421–431.

MacKenzie, D. I. 2005. What are the issues with presence-absence data for wildlife managers? Journal of Wildlife Management 69:849–860.

MacLean, D. A., P. Etheridge, J. Pelham, and W. Emrich. 1999. Fundy Model Forest: Partners in sustainable forest management. The Forestry Chronicle 75:219–227.

MacLean, D., R. Seymour, M. Montigny, and C. Messier. 2009. Allocation of conservation efforts over the landscape: the Triad approach. Pages 283–303 Setting conservation targets for managed forest landscapes, ed. MA Villard, and BG Jonsson. Cambridge University Press.

Matthews, G. 1993. The carbon content of trees. Forestry Commission Technical Paper 4. Forestry commission, Edinburgh, Scotland.

Mehrabi, Z., E. C. Ellis, and N. Ramankutty. 2018. The challenge of feeding the world while conserving half the planet. Nature Sustainability 1:409–412.

Messier, C., R. Tittler, D. D. Kneeshaw, N. Gélinas, A. Paquette, K. Berninger, H. Rheault, P. Meek, and N. Beaulieu. 2009. Triad zoning in Quebec: Experiences and results after 5 years. The forestry chronicle 85:885–896.

Muggeo, V. M. R. 2003. Estimating regression models with unknown break-points. Statistics in Medicine 22:3055–3071.

Nelson, E., G. Mendoza, J. Regetz, S. Polasky, H. Tallis, Dr. Cameron, K. M. Chan, G. C. Daily, J. Goldstein, P. M. Kareiva, E. Lonsdorf, R. Naidoo, T. H. Ricketts, and Mr. Shaw. 2009. Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales. Frontiers in Ecology and the Environment 7:4–11.

Newton, M., and L. Cole. 2015. Overstory development in Douglas-fir-dominant forests thinned to enhance late-seral features. Forest Science 61:809–816.

Ohmann, J. L., and M. J. Gregory. 2002. Predictive mapping of forest composition and structure with direct gradient analysis and nearest- neighbor imputation in coastal Oregon, U.S.A. Canadian Journal of Forest Research 32:725–741.

Oregon Forest Practices Act. 2017. Page ORS 197.277.

Paquette, A., and C. Messier. 2010. The role of plantations in managing the world's forests in the Anthropocene. Frontiers in Ecology and the Environment 8:27–34.

Parrish, M. C., S. Demarais, T. B. Wigley, P. D. Jones, A. W. Ezell, and S. K. Riffell. 2017. Breeding bird communities associated with land cover in intensively managed pine forests of the southeastern U.S. Forest Ecology and Management 406:112–124.

Pasari, J. R., T. Levi, E. S. Zavaleta, and D. Tilman. 2013. Several scales of biodiversity affect ecosystem multifunctionality. Proceedings of the National Academy of Sciences 110:10219–10222.

Phalan, B., M. Onial, A. Balmford, and R. E. Green. 2011. Reconciling food production and biodiversity conservation: land sharing and land sparing compared. Science 333:1289–1291.

Phalan, B. T., J. M. Northrup, Z. Yang, R. L. Deal, J. S. Rousseau, T. A. Spies, and M. G. Betts. 2019. Impacts of the Northwest Forest Plan on forest composition and bird populations. Proceedings of the National Academy of Sciences of the United States of America: 116 (8) 3322-3327.

Pirard, R., L. Dal Secco, and R. Warman. 2016. Do timber plantations contribute to forest conservation? Environmental Science & Policy 57:122–130.

Pommerening, A., and S. Murphy. 2004. A review of the history, definitions and methods of continuous cover forestry with special attention to afforestation and restocking. Forestry 77:27–44.

Puettmann, K. J., K. D. Coates, and C. C. Messier. 2008. A Critique of Silviculture: Managing for Complexity. First edition.

Puettmann, K. J., S. M. Wilson, S. C. Baker, P. J. Donoso, L. Drössler, G. Amente, B. D. Harvey, T.

Knoke, Y. Lu, S. Nocentini, and others. 2015. Silvicultural alternatives to conventional even-aged forest management-what limits global adoption? Forest Ecosystems 2:8.

Radford, J. Q., and A. F. Bennett. 2004. Thresholds in landscape parameters: occurrence of the whitebrowed treecreeper Climacteris affinis in Victoria, Australia. Biological Conservation 117:375–391.

Ralph, C. J., S. Droege, and J. S. Sauer. 1995. Monitoring Bird Populations by Point Counts. Page 191. General Technical Report, U.S. Department of Agriculture, Forest Service, Albany, CA, USA.

Rametsteiner, E., and A. Whiteman. 2014. State of the world's forests; enhancing the socio-economic benefits from forests. Food and Agriculture Organization of the United Nations, Rome, Italy.

Ricketts, T. H., K. B. Watson, I. Koh, A. M. Ellis, C. C. Nicholson, S. Posner, L. L. Richardson, and L. J. Sonter. 2016. Disaggregating the evidence linking biodiversity and ecosystem services. Nature Communications 7:1-8.

Rivers, J. W., A. L. Liebl, J. C. Owen, L. B. Martin, and M. G. Betts. 2012. Baseline corticosterone is positively related to juvenile survival in a migrant passerine bird. Functional Ecology 26:1127–1134.

Rivers, J. W. 2014. The intensive forest management study: avian demography crewbook. Page 106.

Rivers, J. W., C. L. Mathis, A. R. Moldenke, and M. G. Betts. 2018. Wild bee diversity is enhanced by experimental removal of timber harvest residue within intensively managed conifer forest. GCB Bioenergy 10:766–781.

Rivers, J. W., J. Verschuyl, C. J. Schwarz, A. J. Kroll, and M. G. Betts. 2019. No evidence of a demographic response to experimental herbicide treatments by the White-crowned Sparrow, an early successional forest songbird. The Condor 121:duz004.

Root, H. T., and M. G. Betts. 2016. Managing Moist Temperate Forests for Bioenergy and Biodiversity. Journal of Forestry 114:66–74.

Root, H. T., J. Verschuyl, T. Stokely, P. Hammond, M. A. Scherr, and M. G. Betts. 2016. Plant diversity enhances moth diversity in an intensive forest management experiment. Ecological Applications 27: 134–142.

Rota, C. T., R. J. Fletcher Jr, R. M. Dorazio, and M. G. Betts. 2009. Occupancy estimation and the closure assumption. Journal of Applied Ecology.

Royle, J. A. 2004. N-Mixture Models for Estimating Population Size from Spatially Replicated Counts. Biometrics 60:108–115.

Runting, R. K., B. W. Griscom, M. J. Struebig, M. Satar, E. Meijaard, Z. Burivalova, S. M. Cheyne, N. J. Deere, E. T. Game, F. Putz, and others. 2019. Larger gains from improved management over sparing–sharing for tropical forests. Nature Sustainability 2:53.

Saatchi, S. S., N. L. Harris, S. Brown, M. Lefsky, E. T. Mitchard, W. Salas, B. R. Zutta, W. Buermann, S. L. Lewis, S. Hagen, and others. 2011. Benchmark map of forest carbon stocks in tropical regions across three continents. Proceedings of the national academy of sciences 108:9899–9904.

Sedjo, R. A. 1999. Planted Forests: Contribution to the Quest for Sustainable Societies. New Forests 17:339–359.

Seymour, R. S., and M. L. Hunter. 1992. New forestry in eastern spruce-fir forests: principles and applications to Maine.

Sickinger, T. 2019, November 20. Oregon loses $1 billion timber lawsuit to rural counties. The Oregonian.

Spies, T. A., J. W. Long, S. Charnley, P. F. Hessburg, B. G. Marcot, G. H. Reeves, D. B. Lesmeister, M. J. Reilly, L. K. Cerveny, P. A. Stine, and M. G. Raphael. 2019. Twenty-five years of the Northwest Forest Plan: what have we learned? Frontiers in Ecology and the Environment 17:511–520.

Stan Development Team. 2015. 2015. Stan Modeling Language User's Guide and Reference Manual, Version 2.9.0.

Stokely, T. D. 2014. Interactive effects of silvicultural herbicides and cervid herbivory on early seral plant communities of the northern Oregon Coast Range. Oregon State University.

Stokely, T. D., and M. G. Betts. 2019. Deer-mediated ecosystem service versus disservice depends on forest management intensity. Journal of Applied Ecology 57:31-42.

Stokely, T. D., U. G. Kormann, and M. G. Betts. 2020. Synergistic effects of wild ungulates and management intensification suppress native plants and promote exotics. Forest Ecology and Management 460: 117772.

Stokely, T. D., J. Verschuyl, J. C. Hagar, and M. G. Betts. 2018. Herbicides and herbivory interact to drive plant community and crop-tree establishment. Ecological Applications 28: 2011–2023.

Swanson, M. E., J. F. Franklin, R. L. Beschta, C. M. Crisafulli, D. A. DellaSala, R. L. Hutto, D. B. Lindenmayer, and F. J. Swanson. 2011. The forgotten stage of forest succession: earlysuccessional ecosystems on forest sites. Frontiers in Ecology and the Environment 9:117–125.

Tallis, H. M., P. L. Hawthorne, S. Polasky, J. Reid, M. W. Beck, K. Brauman, J. M. Bielicki, S. Binder, M. G. Burgess, E. Cassidy, and others. 2018. An attainable global vision for conservation and human well-being. Frontiers in Ecology and the Environment 16:563–570.

Tang, M., C. J. Hardman, Y. Ji, G. Meng, S. Liu, M. Tan, S. Yang, E. D. Moss, J. Wang, C. Yang and C. Bruce. 2015. High-throughput monitoring of wild bee diversity and abundance via mitogenomics. Methods in Ecology and Evolution 6(9):1034-1043.

Tilman, D., and M. Clark. 2014. Global diets link environmental sustainability and human health. Nature 515:518–522.

Tittler, R., E. Filotas, J. Kroese, and C. Messier. 2015. Maximizing conservation and production with intensive forest management: it's all about location. Environmental management 56:1104–1117.

Tittler, R., C. Messier, and A. Fall. 2012. Concentrating anthropogenic disturbance to balance ecological and economic values: applications to forest management. Ecological Applications 22:1268–1277.

Tittler, R., C. Messier, and R. C. Goodman. 2016. Triad forest management: local fix or global solution. Pages 33–45 Ecological Forest Management Handbook.

Ung, C.H., P. Bernier, and X.J. Guo. 2008. Canadian national biomass equations: new parameter estimates that include British Columbia data. Canadian Journal of Forest Research 38: 1123-1132.

Ure, D. C., and C. Maser. 1982. Mycophagy of red-backed voles in Oregon and Washington. Canadian Journal of Zoology 60:3307–3315.

USFWS (US Fish and Wildlife Service). 2012. Endangered and threatened wildlife and plants; designation of revised critical habitat for the Northern Spotted Owl: final rule. Pages 71876–72068.

Villard, M.-A., and B. G. Jonsson. 2009. Tolerance of focal species to forest management intensity as a guide in the development of conservation targets. Forest Ecology and Management 258:S142–S145.

Wagner, R. G., K. M. Little, B. Richardson, and K. Mcnabb. 2005. The role of vegetation management for enhancing productivity of the world's forests. Forestry 79:57–79.

Walters, K. R., U. Feunekes, A. Cogswell, and E. Cox. 1999. A forest planning system for solving spatial harvest scheduling problems. Page 8. Remsoft.

Ward, C., and T. Erdle. 2015. Evaluation of forest management strategies based on Triad zoning. The Forestry Chronicle 91:40–51.

Wiens, J. A. 1989. Spatial Scaling in Ecology. Functional Ecology 3:385–397.

Wilsey, B. J., and C. Potvin. 2000. Biodiversity and ecosystem functioning: importance of species evenness in an old field. Ecology 81:887–892.

Wilson, B. T., C. W. Woodall, and D. M. Griffith. 2013. Imputing forest carbon stock estimates from inventory plots to a nationally continuous coverage. Carbon Balance and Management 8:15.

With, K. A., and T. O. Crist. 1995. Critical thresholds in species' responses to landscape structure. Ecology 76:2446–2459.

Yamaura, Y., D. Lindenmayer, Y. Yamada, H. Gong, T. Matsuura, Y. Mitsuda, and T. Masaki. 2019. A spatially explicit empirical model of structural development processes in natural forests based on climate and topography. Conservation Biology.

Yamaura, Y., Y. Shoji, Y. Mitsuda, H. Utsugi, T. Tsuge, K. Kuriyama, and F. Nakamura. 2016. How many broadleaved trees are enough in conifer plantations? The economy of land sharing, land sparing and quantitative targets. Journal of applied ecology 53:1117–1126.

Yegorova, S., M. G. Betts, J. Hagar, and K. J. Puettmann. 2013. Bird-vegetation associations in thinned and unthinned young Douglas-fir forests 10years after thinning. Forest Ecology and Management 310:1057–1070.

Yoshii, C., Y. Yamaura, M. Soga, M. Shibuya, and F. Nakamura. 2015. Comparable benefits of land sparing and sharing indicated by bird responses to stand-level plantation intensity in Hokkaido, northern Japan. Journal of forest research 20:167–174.

APPENDIX 13

Summary of Peer Reviews

A summary of the proposed Triad research design for the ESRF (Appendix 12) and an invitation to review the research forest proposal was distributed to select regional and international research scientists. Included below is a list of reviewers and an overview of the feedback received. It should be noted that this was not a 'blind review' meaning that these individuals were selected for review as a result of their relevant expertise in related fields and in research design. The purpose of seeking this external peer review was as a check on the quality of science being proposed, to determine if there were fundamental flaws in our logic, and to solicit additional ideas for research at the Elliott. Therefore, some of the recommendations were incorporated as changes in our current proposal, and some of the more operational attributes will be considered in more detail, if the Land Board approves moving forward with the Elliott State Forest being conveyed to Oregon State University College of Forestry as the Elliott State Research Forest.

REVIEWERS

- **David Lindenmayer**
  Professor, Australian Laureate Fellow, Fenner School of Environment and Society, Australian National University
- **John M. Marzluff**
  Professor of Wildlife Science, School of Environmental and Forest Sciences, University of Washington
- **Bernard T. Bormann**
  Professor of Forest Ecosystems and Director, Olympic Natural Resources Center, School of Environmental and Forest Sciences, College of the Environment, University of Washington
- **Christian Messier**
  Professor and Scientific Director, Center of Forest Research, University of Quebec in Montreal and in Outaouais
- **Andrew Balmford**
  Professor, Department of Zoology, University of Cambridge, Fellow of the Royal Society of London
- **Jerry Franklin**
  Emeritus Professor of Forest Ecology, University of Washington
- **Sue Baker**
  Professor, School of Natural Sciences, University of Tasmania, Australia

STATEMENTS OF SUPPORT

The following represents a few statements of support provided in review documents and letters of support from Dr. John Marzluff, Dr. Chrstian Messier, Dr. David Lindemeyer, and Dr. Andrew Balmford.

"I think the Elliott State Research Forest Plan represents an extraordinary opportunity for globally significant research across meaningful spatial and temporal scales. ...The Elliott Plan promises to address that critical data shortfall for the first time, with state-of-the-art measurement of all core outcomes, sensible time horizons, and sufficient replication of a broad swathe of real-world management practices. As such it is very likely to inform forest management across the Pacific Northwest for much of this century, as well as to serve as a paradigm for research into sustainable forest management worldwide." ***– Balmford***

"The Elliot Experimental Forest will enable managers and policy makers to research the critical tradeoffs between the services forests provide to nature and people; crucial information for Oregonians and all Northwesterners that wrestle with how to sustain our wonderful natural resources in a rapidly changing world." ***– Marzluff***

"Ideas of trade-offs has been well conceptualized in initiatives like the Triad program and land sharing-land sparing in agriculture, they have never been formally tested with empirical data in long-term experiments. This is a critical knowledge gap in ecologically sustainable forest management – and a gap that urgently needs to be closed because of the immense challenges facing the forest estate globally." ***– Lindenmayer***

"As you know, I have been very active in researching and implementing the Triad approach in Canada, but this research plan constitutes a major step toward testing the Triad approach in an innovative way. I particularly appreciate the fact that this approach will be tested in a large area over the long-term with true replicates for each of the four treatments being compared." ***– Messier***

Letters of support from Drs. Christian Messier, David Lindenmayer, and Andrew Balmford available upon request.

FEEDBACK FROM REVIEWERS AND OSU RESPONSES TO COMMENTS FROM REVIEWERS

Review by Dr. Sue Baker

- Main criticism is the language having such a strong focus on Triad rather than framing it as a Triad trial, it might be better to frame it as a sparing/Triad/sharing trial.
- Suggested Triad-I treatments have 30% reserve, 30% intensive and 40 % extensive.
- Suggested incorporating frequently neglected considerations for ecologically sustainable forestry, habitat for saproxylic species and ecological advantages of regeneration burning over mechanical/herbicide site preparation.

RESPONSES TO PROF. BAKER'S COMMENTS

Yes, we agree that it might be better to frame the proposed Elliott research as something other than 'Triad' – especially given that two of the four subwatershed treatments have one or two stand-level treatments (i.e., 'Extensive' = only extensive, ecological forestry, *'Intensive with Reserve' = only intensive management and reserve). We avoided 'Sharing/Sparing' due to the baggage this general concept has in the conservation biology literature.*

Yes, it would be excellent to have an additional treatment with 30/30/40 in addition to 20/20/60. Our concern was that the former would not enable an equal wood supply across subwatershed treatments. However, we will examine forest productivity carefully to determine if the 30/30/40 mix could be attainable.

It is a good point that we consider beetles as a biodiversity component. We have budgeted for DNA barcoding, and this should enable the deployment of pitfall traps for this taxon, and subsequent identification. Also, we do intend to test a variety of alternatives to herbicides as a means to intensify management. Post-harvest burning is one example of such an option.

Review by Prof. David Lindenmayer

- Impressed with the depth of thinking and planning that has been injected into the development of the research program for the forest.
- Supportive of long-term ecological experiments - relevant to forest management and are extremely rare worldwide.
- Ideas of trade-offs has been well conceptualized in initiatives like the Triad program and land sharing-land sparing in agriculture, they have never been formally tested with empirical data in long-term experiments. This is a critical knowledge gap in ecologically sustainable forest management – and a gap that urgently needs to be closed because of the immense challenges facing the forest estate globally.

RESPONSE TO PROF. LINDENMAYER'S COMMENTS

Thank you for these positive reviews.

Review by Prof. Christian Messier

- Nothing mentioned that the Triad will consider adaptation strategy to make the landscape more resilient to global changes and climate uncertainty.
    - Another question beside only biodiversity would be what of the 4 experimental treatments more appropriate to make the landscape more resilient to global change, of which biodiversity is an important aspect.
- Is intensive here is ONLY Douglas fir plantation or it includes other tree species depending on the site and if mixed tree species plantation could even be considered?
- Could OSU divide the 10 replicates into 5 where the treatments will tend to be homogenous and 5 where they will be more heterogenous to see how homogenous vs heterogenous landscape within each subwatershed treatment would work. This idea come from a recent study from agricultural landscape (e.g. Hass et al. 2018) that suggests that landscape diversity is as important as crop diversity at the farm scale in maintaining key ecosystem services. So could this be also tested with this site?

RESPONSE TO PROFESSOR MESSIER'S COMMENTS

The letter of support and thoughtful recommendations from Dr. Messier are greatly appreciated. We have tried to better highlight the adaptive management underpinning of the proposal recognizing that we are applying treatments in a highly variable and changing environment. We agree that this will make the proposal and the landscape to which the treatments are applied that much more resilient. We believe that the Extensive treatments which accommodate the greatest degree of structural complexity and species diversity is where we will see the greatest resilience to the impacts of climate change (whether that is manifest as insect, disease, or fire). At this point, the vast majority if not all of the plantations on the Elliott are Douglas-fir plantations. We envision broadening the species diversity as a nested study within the intensive treatments and assessing the influence of that diversity on productivity, disease occurrence, carbon and species diversity. With regard to the dividing replicates into homogeneous and heterogeneous, the answer is yes, that is a possibility. At this point we can only infer what conditions will be like for laying out experimental units, but once we have conducted a full forest inventory we will be in a position to assess whether such a split watershed approach might be appropriate.

Review by Dr. Bernard Bormann

- Need a clear definition of extensive, as it is referred to in different places in different ways. I suggest it should be defined as the space between max. NPV plantations and no-touch reserves. A number of places suggests at least some authors are thinking it's Jerry and Norm's ecological forestry, which needs to be broadened to include, at a minimum the following:
    - Engagement with rural communities and tribes to identify elements important to them, designed in from the beginning, not as a socio-economic analysis after the fact. This has been the single largest error in PNW forest policy in my view. If you do this, you will hear about fear of fire, road and other access, hunting and recreation, and culturally important plants diminished by past management (one in your case will be huckleberries on ridges managed by fire). These concerns can be designed into extensive approaches. Keeping extensive open to this is vital.
    - Early-seral biodiversity and ecological process (as well as structure) are not adequately handled in the current draft. The "complex early seral" story is not the whole story. The long-term ecosystem productivity program has been studying this since 1990, and recognizes the need to extend the time/space of pioneering species, nitrogen fixers, browse, mineral soil organic matter effects of shrubs, insect, pollinator, and fish food chains—all of which could be included in slightly longer rotations with conifers establish and well maintained at wide (near final-harvest) spacings. This is an active, managed early seral approach—quite different from the natural regen model. This could be an extensive model with few (or

really any) live-conifer residuals. Also consider crop rotations as another example. Mound-and-pit topography is another. The narrow complex-early-seral model also suffers from a key largely incorrect assumption, that whatever comes back is natural. When we looked at the 1880s GLO records from just south of the Elliott, the most common condition was "brush with a scattering of fir;" well-stocked fir stands were a small percent of the landscape. The demise of tribal people, fire exclusion, and site prep and planting are largely responsible for the huge expansion of conifer seed stores that alter natural succession. This requires active management to restore any similarity to past patterns. The active early seral model is also a great way to bring in needs of rural communities and tribes. Please refer to Bormann et al. 2015 (which I attach).

- Need a very precise definition of old forest. The WA DNR uses structure alone, not age. This allows them to consider (at least in theory) managing in mature stands with large but not that old trees.
- Make fire a much stronger element to the study (or at least allow this as it unfolds). The patterns driven by the current design might actually be a good fire strategy, but you will need to think about underburning and managing along ridge roads (or ridge burning [maybe for huckleberries] as prep for fire attack response.
- Depending on how constraining MM/NSO regulations are it might be worth a try to get a research HCP (like OESF).
- Emphasize more active management of the previously unmanaged 100-150 yr old stands. They are at a height now where major wind events will soon affect them as well as subject to possible total or partial loss from fire. I think of added questions such as:
    - How do you protect MM and NSOs from massive fire and wind?
    - How do you extract some timber and other human benefits from these as they fall apart in an accelerated fashion given climate and other changes?
- I'd make revenue a key focus. Efficiency of harvest/roads dictates the majority of remaining net revenue that can go to "restoration", research, or beneficiaries if there are any. You've got a great group (Woodam etc.. to do this).
- There are a few areas that could be strengthened:
    - Needs more on other ecological goals beyond ESA;
    - Should use ecosystem services correctly (includes timber production);
    - Aquatic goals should focus on biotic responses, not indicator thereof at this scale;
    - The 60 yr minimum rotation seems wrong—you might even think about adding an industry control treatment (if the questions is whether these ideas are better).

RESPONSE TO COMMENTS FROM PROF. BERNARD BORMANN

We as authors appreciate the detailed comments and recommendations provided by Professor Bormann. We have directly incorporated a number of these comments with edits to the text in an attempt to improve clarity. We completely agree that the definition of Extensive has been a source of confusion for some readers. We have taken your advice and tried to expand that definition to include some of the suggestions that you make above. While not explicitly presented in the section where we define "Extensive" we emphasize our commitment to working with our various partners and stakeholders and specifically tribal representatives to ensure that "Extensive" meets a broad set of interests. We specifically chose to not use the term "ecological forestry" to avoid defining the approach too narrowly or to a specific school of thought. It is not that we disagree with the tenets of ecological forestry, it is just that we wish to retain as much flexibility to accommodate the largest number of values/ecosystem services in this set of treatments.

The actively managed early seral approach described in your comments is highly appealing and is definitely something that we can incorporate into this study design. Currently, we do not provide much detail on how early seral habitat will be managed, but we have added some text to reflect some of the thinking that you provide here.

We appreciate the recommendation regarding needing a precise definition of "old forest." We do not actually use the term "old forest" in the proposal, but do refer to mature forests and naturally regenerated forests. We have attempted to emphasize stand complexity rather than age of trees as tree age is not as simple to estimate in the field as one might imagine and because beyond a certain point structure of the stand is far more ecologically meaningful than age. In working with different stakeholders we were asked to manage by age, but I think we have come to a general agreement on linking natural regeneration, habitat and structural complexity into a single package that is described as naturally regenerated mature stands.

We have added some acknowledgement of the importance of fire and fire as a management tool in the research opportunities section. We appreciate the suggestion that we should emphasize more active management of the previously unmanaged 100-150 yr old stands and specifically the questions around how we will protect murrelets from large crown fires or wind storms. However, this has been an area of particular concern raised by numerous stakeholders as well as in other research comments that push back against any active management in olders tands. The extensive treatments do include management strategies that include timber harvest with high rates of retention in mature stands, but we have also committed to avoiding the oldest, naturally regenerated, most structurally complex stands as a result of deliberations with stakeholders. Shortening rotation lengths on intensive harvest units goes against our intent to maximize wood production rather than revenue.

Review by Dr. John M. Marzluff

- The Elliot Experimental Forest will enable managers and policy makers to research the critical tradeoffs between the services forests provide to nature and people; crucial information for Oregonians and all Northwesterners that wrestle with how to sustain our wonderful natural resources in a rapidly changing world.

- You say the 4 main treatments will yield approximately equal amounts of wood, but I see no way that the 100% intensive and the 50:50 treatments can do that. Won't all treatments with some reservation or ecological forestry produce less wood than the 100% intensive?
- A critical feature of sparing vs. sharing debates is the extent to which sparing actually leads to land put into conservation. In the Midwest, for example, this does not happen because as the value of the crop (corn there) increases so to does the plowing of marginal lands that were initially spared. Can you build in a way to work on policies that would go with your treatments to assure conservationists that if land is intensively worked, then an equal amount will be reserved? This in specific, but in general involving social scientists looking at policy and governance necessary to implement your strategies on a wider PNW landscape would be a good addition.
- Can you measure how many jobs are created or maintained in each treatment as well?
- You mention owls and murrelets, but you aren't going to be able to study these well at the scale of your treatments. I suggest you focus on nest predator changes for mamu and barred owl changes for now. Those are the drivers of forest value for the species, so measure them directly rather than trying to say something about a rare species (though you might at least survey every 5-10 years for owls and murrelets).
- You should make an argument as to why this is needed given the HJ Andrews experimental forest nearby. What do we gain over the Andrews effort with the Elliot?
- You mention the ability to study landscape effects beyond the plots. You might add to that the aspect of recreation in the landscape and proxy to development. Both are frequent in the Elliot and spatially variable, so they might affect your replicates.

RESPONSE TO PROFESSOR MARZLUFF'S COMMENTS

We greatly appreciate the positive support and critical input from Professor Marzluff. We have attempted to integrate his comments into the text or we provide a brief response below. Within the Triad design, the intensive treatments are applied to 50% of the land area of extensive with the remaining 50% going into reserve. On the extensive treatments, a fraction of the timber is harvested in a given unit, but there are no reserves within these watersheds, it always totals to 50% of the maximum volume taken on the intensive harvest units. In the case of the Elliott, we are proposing to place 65% of the forest into reserve with only 17% going into Intensive and 16% in extensive treatments. We also commit to all intensive harvest units being matched in acreage by reserve units. It is also important to note that even under intensive, the forest conditions achieved from years 30 - 60 are not equivalent to intensive agricultural production, but accommodating a diversity of species, soil organic matter accumulation, and a diversity of recreational values.

Job creation as a result of stand management, harvest and milling will be assessed as part of the rural economy values that are described as one of the values influenced and studied in this set of experiments. We appreciate the suggestion with regard to murrelets and owls, we will certainly study predators and we intend to have regularly scheduled monitoring of endangered species throughout the study area.

The HJ Andrews is an ideal location to study the ecology and hydrology of natural forest systems. There are no longer any intensive or really any large scale extensive forest management experimentation on the Andrews. The Elliott allows us to study and demonstrate alternative forest management approaches and how they influence forest ecosystem processes, productivity, biodiversity, habitat, and recreational opportunities to name a frew. This is not and cannot be studied at the HJ Andrews. We intend to study recreational opportunities, impacts and potential throughout the forest. These possible studies are addressed in the research opportunities in Appendices 3 and 6.

Review by Dr. Jerry Franklin

Full text of emails from Jerry Franklin to members of the Elliott project team are included at the end of this section with his permission for reference. Because of the extensive nature of Dr. Franklin's comments, responses to key comments are provided by members of the OSU Exploratory Committee: Matt Betts, Klaus Puettmann, Ashley D'Antonio, Meg Krawchuk, Shannon Murray, John Session, and Ben Leshchinsky.

COMMENTS FROM JERRY FRANKLIN

"First, I find the concept of conducting an experiment that essentially involves the entire property at the outset of OSU's stewardship to be inappropriate. There is no way that any of us can possibly anticipate the critical forest conservation issues that we are going to be needing to address one, two or three decades from now. I don't believe that the most important challenge is going to be how to divide up amongst the different management philosophies though I may be wrong. Our track record at figuring out the most important issue(s) has been very poor in academia. We are going to be surprised. That being the case, taking what will be your major research property and committing it all to an experiment of any kind along with committing all of the financial resources necessary to sustain it is not – to use a kind word – prudent. All of the verbiage in the proposal about being able to superimpose many research projects on the current design may be true – but almost certainly there will be important research that needs to be done that will have been locked out or grossly compromised by the treatments imposed on the entire property. Thank God we in FS research did not do to the H. J. Andrews what many of us thought we should do – i.e., make it (the entire Andrews) a model of modern forest practices circa the 1960s and 1970s. I will make only one more comment about this – forest academics have an abominable record of identifying and conducting fundamentally important forest science projects."

COMMITTEE MEMBER RESPONSE

When the Dean formed the Elliott State Research Forest Exploratory Committee in 2019 he charged the group with developing a 'grand *vision' that warranted OSU taking on the massive responsibility of an 85,000 ac research forest. In our view, implementing a test of a single silvicultural approach (e.g., "ecological forestry") was insufficient to warrant such a step. Rather, we chose to address the most pressing problem facing humanity: how to provide for the carbon, timber, ecosystem services needs of a global population of nearly 8 billion people without compromising the conservation of biological diversity and ecosystem health.*

Although this is the 'grand vision' for the Elliott, this in no way precludes many stand-level studies that only tangentially fit within this vision. Here are some examples of the "nested" research projects:

1. *It is certainly of policy relevance to find out how biodiversity responds to different sorts of "ecological forestry" (very little work has been done on this in the PNW, despite BLM's intent to implement it widely).*
2. *How do Coho salmon respond to differing degrees of canopy removal adjacent to streams? This question could still be very effectively addressed within the rubric of Triad.*
3. *Can we generate high timber yields in plantations with reduced or no herbicides?*
4. *Over the long term, do mixed species plantations result in higher yield than single species plantations?*

Figures 13a and 13b show how such studies could be implemented within Triad using randomized block, replicated designs. All of these questions are central forest management questions that are of great interest to the people of Oregon, and can be implemented within the Triad design as "nested studies".earch program on the Elliott that will push us to bridge disciplines and develop a more systemic, integrative view of forestry. We'll be tracking numerous response variables including: timber yield, revenue, employment, data on a myriad of biodiversity and ecosystem processes, carbon storage, recreational benefits and use, among many other response variables. We agree that a major challenge will be to ensure that we not only analyze these variables separately and need to ensure that logistical and funding support plans specifically emphasizes integrative work.

Further, we plan to implement Triad silviculture in the context of adaptive management. So, we will not be married to a single "silviculture du jour" for the next 50-100 years, but we will learn by doing – for both extensive and intensive management. We will ask questions such as: Are there ways to do highly productive intensive management without herbicides, and in ways that conserve early seral biodiversity? Are there are ways to do ecological forestry without reducing wood supply substantially? Our descendants will likely look back at our current practices and be in awe of how simplistic and misplaced they are.

The adaptive management approach also allows us to cut an important balance between flexibility and the sort of "ongoing inspiration" questions/program that you describe, and a very important other element to the ESRF: trust-building and the development of the HCP supporting this work. In order to develop the Elliott's potential as a research forest, OSU recognizes the importance of collaboration, community building, and input that signals a desire to share governance and respect community perspectives. This trust-building requires some basic architecture that helps the broader community understand what is, and what is not, going to happen on the Elliott. The Triad approach provides that architecture. The Triad approach also provides the architecture to support a HCP that is critical to the Elliott. These two important elements are critical to the Elliott's success.

COMMENT FROM JERRY FRANKLIN

"Second, despite your efforts to find a way around it, I do not find that the design meets the high standards that are required for a statistically valid and, perhaps more important, a socially convincing outcome at some future date. The treatments are not randomly assigned and all of the manipulations and rationalizations that are created will not produce a definitive outcome on the questions posed. You don't like the aggregation that takes place with a random assignment? Then do a stratified random assignment where environmentally comparable watersheds are clustered in groups of four and randomly assign within those clusters. What you have done requires far too much explanation, manipulation, and rationalization to be a clean experiment. And if that isn't enough, you don't have any true controls! You need to have untreated controls right along with the treatments. Considering the big reserve to be a control is not credible. You need control "treatments" if you are going to be able to assess changes in biota, for example."

COMMITTEE MEMBER RESPONSE

First, given the natural disturbance and forest management history at the Elliott, it would not be politically feasible, ethical, nor strategic from a conservation standpoint to implement a fully random design at the Elliott. A fully random design would result in many old stands being clearcut and turned into intensive management. Similarly, it would result in large areas of plantations being set aside as reserves. These scenarios were completely unpalatable to the Exploratory, Advisory and Stakeholder Committees.

How to ameliorate this lack of randomization problem? There are several important scientific reasons for random allocation of treatments. First, randomization avoids true bias. For instance, it might not be by chance that old forest remains where it does (e.g., steep slopes, low productivity forest; Lindenmayer and Laurance 2012 – Biol. Cons.). To explore this possibility, we tested whether the particular watershed-scale treatments tended to fall on steeper slopes than others, or were characterized by higher site-quality ground. We found no evidence for such biases, except that our "extensive" treatment watersheds tend to be smaller, on average (Figure 9a).

A second reason for randomization is that it is more likely to result in spatial interspersion of treatments. Indeed, it was of concern to our group that our treatments seemed quite clumped as initially implemented (e.g., more 'extensive' watersheds occurred adjacent to each other than you would hope). However, when we tried a fully randomized design, it turns out that by chance alone substantial

***Figure 13a.* Nested study question: Does wildlife respond differently to ecological forestry conducted in young versus older stands?**

Question: Does wildlife respond differently to ecological forestry conducted in young versus older stands? In other words, does variable retention cutting in 40-year plantations provide the same quality of habitat as , the same treatment in older stands, that have large legacy elements (large residual green trees, large snags, downed wood)?

Relevance: BLM is in the process of implementing 1000s of acres of 'ecological forestry' treatments, and USFS may follow. Small private owners are also interested in implementing ecological forestry techniques. One might hypothesize that a number of taxa are dependent on large wood elements (e.g., beetles, lichens, fungi) in early seral systems and will be less prevalent in early seral forests that originated from 40-50 year old plantations.

Example nested design: Within subwatersheds (green) where any form of ecological forestry is permissible.

Ecological forestry (e.g., high retention with no herbicides) is implemented in either plantations (red) or natural (<150 year) stands. In this case, it would be impossible to attribute stand age randomly, but one could compare both treatments to untreated forest.

Species abundances are quantified (beetles, lichens, fungi, birds, small mammals)
NOTE: Again, this requires no deviation from the overall Triad framework because Extensive forestry would be implemented across age classes.

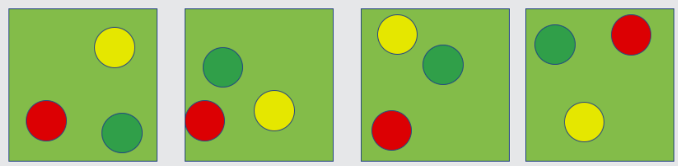


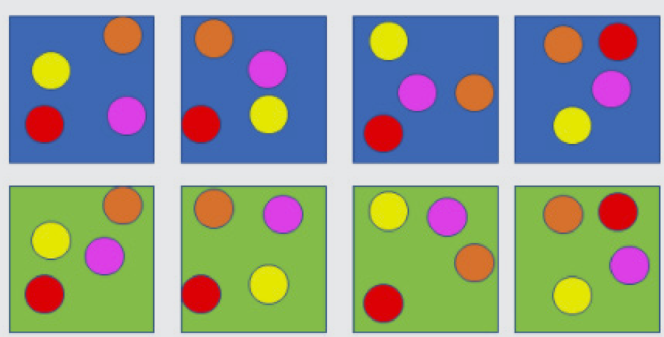
***Figure 13a.** Nested study design for the question of whether ecological forestry techniques result in similar habitat quality in old versus young stands, both in relation to unharvested controls. This research is relevant because ecological forestry is being implemented on BLM land in stands up to 150 years old with an upper diameter limit of 40 inches. To our knowledge, little or no formal research has been done on these treatments.*

***Figure 13b.* Nested study question: What is the effect of planting species mixtures on "ecosystem stability"? (sensu Tilman 2006 – Nature)**

Relevance: It has been hypothesized that species mixtures might reduce disease vulnerability, result in "over-yielding", be more resilient in the face of climate change. Below and above-ground interactions could be examined at finer scales (among tree). Another hypothesis is that the effect of species mixtures could be contingent on stand and landscape context. For instance, monocultures embedded within a landscape of intensive management might be particularly vulnerable to disease-induced mortality. Multiple land-owners would benefit from knowing the answers to these questions. Also, such an experiment could be nested within broader, global-scale experiments asking similar questions: https://treedivnet.ugent.be

Example nested design: Within subwatersheds where Triad is implemented, randomly allocated experimental stands are attributed to a range of species mixtures (red=1, orange=2, yellow=3, pink=4). This is a randomized block design. In total, we could have up to 10 blocks in each Triad treatment (so total blocks = 40, or within a single Triad treatment N=10).

At the landscape (subwatershed scale) these four treatments are nested in a landscape of reserve/intensive (blue) or ecological forestry ("extensive"; green). This enables testing the question of whether the context of planting in mixtures matters.



NOTE: Such a design would not compromise the overall Triad question because the same stand-level treatments would be applied across watersheds.

***Figure 13b.** Nested study design for the examination of how plantations of different tree species diversity effects yield. These sorts of experiments are of particular importance over the long term to determine whether the current prevalent approach of Douglas-fir monocultures is a risky strategy in the face of climate change and potential disease outbreaks.*

clumping occurs. Given the size of the Elliott, and the large scale of the experimental units, full interspersion of treatments is unattainable – even with a randomized design. So, the best way to handle this issue is post-hoc, by taking spatial autocorrelation into account during statistical analysis, and by examining/integrating a wide suite of covariates that could contribute to variability.

All of this said, it is a fundamental principle of inferential statistics that to make inference to a broader population, treatments be randomized (this is primarily for the reasons above). One promising way forward is to model different research design scenarios using a landscape-scale harvest/ biodiversity simulation model (e.g., Woodstock). We will run different design scenarios for 50, 100 years etc. to test whether the outcomes of random allocation versus our current allocation differ. If changes need to be made, this can occur within the adaptive management process and supported using the full input and governance structure we establish for the Elliott. For example, if the finding is "extensive/ecological forestry results in a greater density of early seral associated birds for a given harvest level over the duration of the study", does this conclusion differ if we implement a fully random design versus the one currently proposed? Although a number of assumptions about yields, wildlife responses etc. are required for such modeling, this will be one effective way to ameliorate reviewer concerns about the effects of randomization.

Finally, randomization is essential for statistical inference but it could be argued that the Elliott experiments will be valuable even in the absence of statistical inference. For example, Hubbard Brook – one of the best-known forest management experiments in the world – was not randomly assigned as a watershed. Nor was there any replication at all. This has not precluded its value to the forest ecology and policy community. It is worth noting that highly cited empirical papers from the PNW (van Mantgem et al. 2009, Chen et al. 1995, Spies et al. 1990) all do not have randomized design. A random design would have been either inappropriate or impossible in any of these studies. For instance, Chen et al. examined the influence of forest edge in (a) old-growth and (b) plantations on microclimate. It would not have been possible to randomly attribute "old growth" as a treatment. One of the highest profile studies in forests in the PNW in recent decades has been the Donato et al. (2005) Science paper on post-fire salvage logging. Of course, in this study, fire was not randomly attributed, but neither was the salvage logging treatment. Finally, the experimental watershed treatments at the HJ Andrews were not randomly assigned. This is not to argue that random designs aren't critical, or ideal. The only point is that sometimes in ecology random designs are simply not feasible. This is particularly the case for landscape-scale studies. In these cases, ethical researchers will at least formally test, and report on, potential confounding factors (as we have at the Elliott).

Figure 9a.

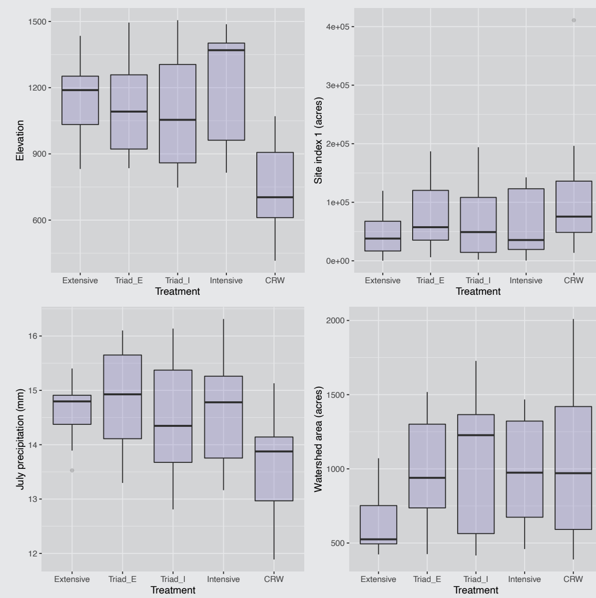


Figure 9a. *Tests for whether lack of fully random subwatershed-scale treatments at the Elliott resulted in any substantial confounding between treatments and other underlying features at the Elliott State Forest. If this were the case, it would be possible to misattribute treatment effects when in fact other features were the cause. Neither elevation, site index, precipitation showed substantial differences among treatments. Only watershed areas in the Extensive treatment tended to be smaller than the other treatments. Note that the CRW (Conservation Research Watershed) is not a formal treatment, so the differences above are not detrimental to the overall Triad design.*

COMMENT FROM JERRY FRANKLIN

"Third, I see a lot about impacts of management on water yields, quality, biota but I see nothing in the plan about how you are going to assess those impacts. Watershed level studies require extended calibration periods (including on control watersheds) so that you can statistically assess changes following treatments. That kind of work requires incredible investments in time and money (and controls). We can see from the Andrews the incredible value of such calibrated watershed experiments but I don't see where that is built into this research plan – which could make inferences about aquatic systems should we say – difficult?! Unless you are really prepared to do watershed level assessments of impacts there really is no reason for you to be doing treatments at the levels of watersheds – is there?"

COMMITTEE MEMBER RESPONSE

Our plan is to implement such calibration, and funding has been budgeted to do so. The treatments roll out over multiple decades (both a pro and a con of the design), which provides opportunity for long-term pre-treatment monitoring for many sites.

COMMENT FROM JERRY FRANKLIN

"Fourth, the whole notion that you are doing a meaningful test of the

TRIAD concept is nonsense. You are trying to test it at the wrong scale. TRIAD in the PNW forests is occurring at the level of large landscapes, not small watersheds. The production emphasis element of TRIAD are the fiber farms of the REITs and TIMOs and are being done on a very short rotation. The integrated element of TRIAD are represented by the federal forests (BLManyway), trust forests managed by WA DNR, and many private forest lands, where ecological and economic goals are being integrated through ecologically-based management that includes recognition of special management areas (e.g., riparian habitats) and various forms and intensities of retention. The hard-core conservation element of TRIAD are the large reserved forest areas like the Late Successional Reserves on federal lands, national parks, wilderness areas, private reserves and trusts, etc. I do not find this experiment to be a credible test of what I understood as the Maine folks' version of TRIAD."

And, as I noted initially, I don't consider an experiment about how to divide forest landscapes at any scale among production and conservation goals to be a high priority in our current world; that probably has a much higher social than technical element to it anyway. There are so many important things to be done and this is not one of them. A comprehensive test of alternative approaches to preparing our managed forest landscapes to meet the challenges of climate change is one of them – great that you are aware of the continental-wide collaboration that is going on in this regard, but your current experiment does not fit the design. Some credible silvicultural experimentation to begin better quantifying the tradeoffs between ecological and economic goals in ecological forestry treatments would be another one."

COMMITTEE MEMBER RESPONSE

Differences in opinion are valuable, and your comments will help to refine elements of the proposal. This diversity of perspectives is the core of the critical review process. We now have external comments and reviews from a number of leading conservation biologists and forest ecologists worldwide, and they disagree with you that the research design is inappropriate. These scientists include: Prof. Andrew Balmford (University of Cambridge, UK), Prof. Sue Baker (U. Tasmania, Aus), Prof. Christian Messier (Université du Montreal, Canada), Prof. David Lindenmayer (Australian National University), Prof. John Marzluff (University of Washington). All reviewers had some important and valuable comments that we will incorporate into the proposal, but overall, the reception was highly enthusiastic.

Your point above about the spatial scale is important. Of course, it would be ideal to have an experiment that covered the entire western part of Oregon, but such region-wide experiments are clearly logistically and politically impossible. Although our experiment will not be useful for some wide-ranging species (e.g., mountain lion), it will be relevant to species and processes operating at finer spatial scales (e.g., songbirds, pollinators, murrelets, water quality, landslides, recreation opportunities, fine-scale deer and elk habitat selection).

We do wish that monitoring of multiple facets of social and ecological systems were being systematically carried out on the portfolio of management strategies that exist across the region, in a way that would help build our understanding of trade-offs in forest management. But they aren't. Accordingly, the ESRF provides a unique function, and an opportunity to test ideas of sustainability relevant (and necessary) to the region as a whole. This is somewhat of a mesocosm experiment, but a very large one.

COMMENT FROM JERRY FRANKLIN

"...I think that the quality of SOF's proposal for the Elliott – in terms of vision, creativity, relevance, practicality, among other things – is critical. And at the level of the School itself, it needs to be able to engage and excite a majority of the faculty, staff, and student body. The current proposal, in my view, falls far short."

COMMITTEE MEMBER RESPONSE

We have pushed for a high degree of faculty involvement in this process. Many might be under the impression that this has been a top-down process, but this is far from the case. The interim Dean asked for faculty volunteers and nominations to help come up with a "bold" vision for research at the Elliott. This formed the Exploratory Committee – which is made up of social scientists (Ashley D'Antonio), ecologists (Meg Krawchuk, Matt Betts, Klaus Puttemann), a geotechnical engineer (Ben Leshchinsky), a forest operations modeler (John Sessions), forest stream ecologists (Dana Warren and Gordie Reeves). The Exploratory Committee also organized a suite of meetings in 2019 to solicit ideas from other faculty in CoF and these formed the basis for a long list of interesting research questions. We also have an external science advisory panel composed of social and natural scientists outside of OSU. In short, despite the relatively short time line in putting the proposal together this has been a participatory, largely bottom-up process driven by researchers. There will be many further opportunities for other members of CoF, other faculty from OSU, UO, PSU and hopefully from other universities as well to be involved and develop their own nested experiments within the Triad design (see below). Also, we should note that the hope is that the research design is sufficiently interesting that we will attract researchers from far beyond OSU. Indeed, we've had enthusiastic responses from professors at the University of Washington, University of Cambridge, Australian National University, University of Tasmania, and University of Montreal.

COMMENT FROM JERRY FRANKLIN

"...A second tendency on the part of foresters (especially silviculturists) is to develop confounded designs. What I mean by that is that they simultaneously vary several variables with the result that you never get a clean test of any of the variables. They are all confounded together."

"...Credible large, long-term research projects are very costly in terms of both time and money. These are major investments that have very long-term consequences for the organizations that undertake them, in terms of administrative time, funds, and personnel. They have a tendency to take on a life of their own. The most successful of these kinds of efforts (as illustrated by Hubbard Brook, Coweeta, and Andrews) involve collaborations between institutions, particularly academic institutions and federal agencies."

"The first thing I would do is to develop a more meaningful vision for SOF's program on the Elliott. For example, as a starting point: To develop, quantify, and demonstrate approaches to forest management that integrate ecological, economic, and cultural objectives and that reduce risks to disturbances and climate change. Whether something like this works or not – some kind of over-riding guiding vision is needed. What is the general purpose/goal of SOF in undertaking research at Elliott?"

COMMITTEE MEMBER RESPONSE

Our group agrees that we should avoid confounds, study ecological responses over the long term, and that such experiments will be expensive.

COMMENT FROM JERRY FRANKLIN

"I believe some significant changes in what is proposed is imperative but that this could be done in a relatively short time, if you chose to do it. The current proposal would not get a pass on peer review at NSF and probably not in the court of public opinion, either.

COMMITTEE MEMBER RESPONSE

It is fairly well known that it is difficult at best to get forestry studies funded by NSF and it is generally accepted that it is highly unlikely that any applied management research would be funded. For the Elliott project to be NSF funded, we would need to have a clear basic research angle that tests exciting ecological theory. Our faculty have served on many NSF panels and have led a number of funded NSF grants and can attest to this notion. It is more likely that the Elliott might attract funding from large foundations or applied funders such as USDA-AFRI. For these, a substantial, bold vision is necessary (not fine-scale stand-level studies examining micro changes to silvicultural practices). As for public opinion, time will tell, but the CoF Elliott group has been in extensive conversations with an integrated group of environmentalists (Audubon, Wild Salmon Center, Nature Conservancy), members of the forest products sector (Douglas Timber Operators, Barnes & Associates, and others) Confederated Tribes of Grand Ronde, Confederated Tribes of the Coos, Lower Umpqua and Siuslaw Indians, Confederated Tribes of Siletz Indians, members of the recreation community and others. Although things can be rocky, the group has moved to a surprising degree of consensus on the current ideas and design. The Elliott process seems to be a rare example of environmentalists and loggers working closely together to advocate for important research and conservation measures. There is a real opportunity here for a substantial research, conservation and social win.

COMMENT FROM JERRY FRANKLIN

"One real issue that needs to be addressed relates to integration of ecological, economic, and cultural goals in managed forests. Most forest owners/managers in the PNW are seeking that balance in their management and we have little information on how to do it. The second real issue is climate change and how to manage forests to increase resistance and resilience; the issue of wildfire I see as a part of this."

COMMITTEE MEMBER RESPONSE

The discussions among the various members in the Exploratory Committee have strongly emphasized developing a research program on the Elliott that will push us to bridge disciplines and develop a more systemic, integrative view of forestry. We'll be tracking numerous response variables including: timber yield, revenue, employment, data on a myriad of biodiversity and ecosystem processes, carbon storage, recreational benefits and use, among many other response variables. We will be tracking: timber yield, revenue, employment, data on a myriad of biodiversity and ecosystem processes, carbon storage, recreational benefits and use, among many other response variables. In our view, such an approach is highly "integrated". We agree that a major challenge will be to ensure that we not only analyze these variables separately and need to ensure that logistical and funding support plans specifically emphasize integrative work.

NOTE: The full text of emails from Dr. Jerry Franklin are provided in sequence below for reference.

"I have (admittedly quickly) gone through the document that you provided as an attachment. I tried to be as objective as I could in looking at it. I very much want OSU and the College of Forestry and all of you to be as successful as you can possibly be in taking responsibility for the management of this controversial property and I want the science to be highly credible and relevant given the investment that is going to be made.

That said, the changes that have been made in the research proposal I find to be minor in terms of what I view as basic major flaws in the concepts underlying the proposal and in its proposed implementation. I scarcely know where to start but let me give it a try – once again.

First, I find the concept of conducting an experiment that essentially involves the entire property at the outset of OSU's stewardship to be inappropriate. There is no way that any of us can possibly anticipate the critical forest conservation issues that we are going to be needing to address one, two or three decades from now. I don't believe that the most important challenge is going to be how to divide up the amongst different management philosophies though I may be wrong. Our track record at figuring out the most important issue(s) has been very poor in academia. We are going to be surprised. That being the case, taking what will be your major research property and committing it all to an experiment of any kind along with committing all of the financial resources necessary to sustain it is not – to use a kind word – prudent. All of the verbiage in the proposal about being able to superimpose many research projects on the current design may be true – but almost certainly there will be important research that needs to be done that will have been locked out or grossly compromised by the treatments imposed on the entire property. Thank God we in FS research did not do to the H. J. Andrews what many of us thought we should do – i.e., make it (the entire Andrews) a model of modern forest practices circa the 1960s and 1970s. I will make only one more comment about this – forest academics have an abominable record of identifying and conducting fundamentally important forest science projects.

Second, despite your efforts to find a way around it, I do not find that the design meets the high standards that are required for a statistically valid and, perhaps more important, a socially convincing outcome at some future date. The treatments are not randomly assigned and all of the manipulations and rationalizations that are created will not produce a definitive outcome on the questions posed. You don't like the aggregation that takes place with a random assignment? Then do a stratified random assignment where environmentally comparable watersheds are clustered in groups of four and randomly assign within those clusters. What you have done requires far too much explanation, manipulation, and rationalization to be a clean experiment. And if that isn't enough, you don't have any true controls! You need to have untreated controls right along with the treatments. Considering the big reserve to be a control is not credible. You need control "treatments" if you are going to be able to assess changes in biota, for example.

Third, I see a lot about impacts of management on water yields, quality, biota but I see nothing in the plan about how you are going to assess those impacts. Watershed level studies require extended calibration periods (including on control watersheds) so that you can statistically assess changes following treatments. That kind of work requires incredible investments in time and money (and controls). We can see from the Andrews the incredible value of such calibrated watershed experiments but I don't see where that is built into this research plan – which could make inferences about aquatic systems should we say – difficult?! Unless you are really prepared to do watershed level assessments of impacts there really is no reason for you to be doing treatments at the levels of watersheds – is there?

Fourth, the whole notion that you are doing a meaningful test of the Triad concept is nonsense. You are trying to test it at the wrong scale. Triad in the PNW forests is occurring at the level of large landscapes, not small watersheds. The production emphasis element of Triad are the fiber farms of the REITs and TIMOs and are being done on a very short rotation. The integrated element of Triad are represented by the federal forests (BLM anyway), trust forests managed by WA DNR, and many private forest lands, where ecological and economic goals are being integrated through ecologically-based management that includes recognition of special management areas (e.g., riparian habitats) and various forms and intensities of retention. The hard-core conservation element of Triad are the large reserved forest areas like the Late Successional Reserves on federal lands, national parks, wilderness areas, private reserves and trusts, etc. I do not find this experiment to be a credible test of what I understood as the Maine folks' version of Triad.

And, as I noted initially, I don't consider an experiment about how to divide forest landscapes at any scale among production and conservation goals to be a high priority in our current world; that probably has a much high social then technical element to it anyway. There are so many important things to be done and this is not one of them. A comprehensive test of alternative approaches to preparing our managed forest landscapes to meet the challenges of climate change is one of them – great that you are aware of the continental-wide collaboration that is going on in this regard, but your current experiment does not fit the design. Some credible silvicultural experimentation to begin better quantifying the tradeoffs between ecological and economic goals in ecological forestry treatments would be another one.

I have probably said more than I needed to at this point. It is your proposal. I do not think that it does credit to the institution or yourselves; you can do much better than this. Personally, I think you need to start all over beginning with a truly long-term perspective on the potential of the property and an examination of what research will benefit the people (and forests) of the PNW both in the short and long term."

–Full text from follow up email–

"After my initial response to your early email (attached below) I had an exchange with Brett (also attached below). After a long phone conversation further discussing these points with Brett and Norm, we concluded that the exchange should be shared with you folks, as well. It reflected my continued thinking about the current proposal and what some of the alternatives might be. Since then, I have continued to think broadly (often in the middle of the night) about what the Elliott Forest connection could mean to the OSU SOF as well as in more detail about alternatives to the current research proposal and deficiencies in the same. This is a truly profound opportunity for SOF that could have either an enormously important positive outcome or could be disastrous for SOF. I don't believe that in my lifetime SOF has had such an opportunity to be significantly engaged with such a broad array of stakeholders, including the state's social leaders. The SOF's previous involvements have all been with much smaller groups of folks that were more immediately impacted by program's that it proposed and carried out. At Elliott, SOF and its vision of itself and its future are on stage. This may be one of those rare and often unrecognized turning points that occasionally happen. I have an uncomfortable feeling that the previous Dean did not fully recognize its importance and ensure that it got the attention that it deserved. But, in any case, this may be where SOF defines for the citizens of Oregon its vision of its future role in management of natural resources in the region.

Which is to say I think that the quality of SOF's proposal for the Elliott – in terms of vision, creativity, relevance, practicality, among other things – is critical. And at the level of the School itself, it needs to be able to engage and excite a majority of the faculty, staff, and student body. The current proposal, in my view, falls far short.

Initially, I had not intended to get involved in the Elliott in any way, other than with Norm to try to warn SOF away from developing a proposal that would involve significant programmed harvest of older, naturally regenerated forest. We believed and still believe that, based on our experience, this would ultimately doom the proposal and have bad long-term consequences for SOF's reputation. But I have obviously gotten a lot more deeply engaged as I have learned more about the planned research, found it to be deficient in so many regards, and continue to imagine what the consequences might be for the school.

With this background as preface, read the exchange between Brett and I and then the following comments and suggestions.

Some key things I have learned about large long-term research projects

I have a lot of experience in planning and implementing long-term research projects. One principle that I learned very early on is the KISS principle – Keep It Simple Stupid. There is an incredible tendency on the part of foresters (and I am sure many others) to develop complex experiments with many variables. The successful long-term experiments that I know about have been simple designs with one or two very clear questions/variables that are addressed in a very robust fashion. Foresters tend to develop designs that are like Christmas trees, perhaps starting with a simple concept but then adding on more and more variables, diluting the clarity of original design. The large, longer, and more important the experiment the more important it is to keep it simple and to select treatments that truly offer a contrast – not small increments of variation in the key variables but significant contrasts. I will illustrate them in a minute with what was done with the DEMO experiment.

A second tendency on the part of foresters (especially silviculturists) is to develop confounded designs. What I mean by that is that they simultaneous vary several variables with the result that you never get a clean test of any of the variables. They are all confounded together. Let me illustrate with what happened with DEMO, which was a congressionally mandated experiment on alternatives to clearcut harvesting Douglas-fir. Logan Norris and I were the ones that talked the congressional committee into mandating this so we had a major interest in how the FS responded to it. PNW was given the responsibility to design the experiment and they had two silvicultural researchers put together the initial design (which did include random assignment of treatments and controls!). Their design was a nice series of treatments that involved increasing numbers of retained trees; however, each increment of tree retention involved a different spatial arrangement – i.e., of how the retention was distributed. So retention levels and spatial pattern of retention were confounded and no conclusion could be reached about either retention level or spatial arrangement. When the plan underwent review, I challenged it, as logical as it all seemed to the silviculturalists who had developed it. We ended up with a big meeting of researchers and management folks in Portland, to which I brought David Ford, an outstanding quantitative forester. The group concluded that they wanted DEMO to produce a credible statistical test of both retention level (15 and 40%) and pattern of retention (dispersed or aggregated). The confounded design was thrown out and replaced with what was basically a 2 X 2 factorial design.

Credible large, long-term research projects are very costly in terms of both time and money. These are major investments that have very long-term consequences for the organizations that undertake them, in terms of administrative time, funds, and personnel. They have a tendency to take on a life of their own. The most successful of these kinds of efforts (as illustrated by Hubbard Brook, Coweeta, and Andrews) involve collaborations between institutions, particularly academic institutions and federal agencies.

Strong, inspired leadership is critical to conceive and establish successful long-term research projects and, once established, successful transitions in leaderships are critical to their continuation. I have seen both successes and failures in this regard.

How would I approach the Elliott?

The first thing I would do is to develop a more meaningful vision for SOF's program on the Elliott. For example, as a starting point: To develop, quantify, and demonstrate approaches to forest management that integrate ecological, economic, and cultural objectives and that reduce risks to disturbances and climate change. Whether something like this works or not – some kind of over-riding guiding vision is needed. What is the general purpose/goal of SOF in undertaking research at Elliott?

I would engage more of the faculty and student body in planning the actual experiments.

I would not propose to use all of the Elliott in a single experiment but, rather, do a series of experiments on various topics (climate change adaptation, ecological-economic tradeoffs, etc.) in the younger forests, where the areas for replication were selected on comparability in terms of site and stand conditions. I imagine these experiments having treatment areas of 40-50 acres so that small mammal, songbird and other small vertebrate populations could be studied. Of course, with control areas as part of the treatments. I would do some smaller scale exploratory work before actually undertaking the longer-term experiments. I would select and begin calibrating a series of selected watersheds for future experiments.

I would do at least a back of the envelope calculation of the cost of whatever it is that is proposed in the final research proposal.

Closing Comments

I am momentarily running out of ideas and energy but want to get this off to you rather than just sit on it.

I believe some significant changes in what is proposed is imperative but that this could be done in a relatively short time, if you chose to do it. The current proposal would not get a pass on peer review at NSF and probably not in the court of public opinion, either.

I believe that the Triad theme is indefensible as a basis for the research program. One real issue that needs to be addressed relates to integration of ecological, economic, and cultural goals in managed forests. Most forest owners/managers in the PNW are seeking that balance in their management and we have little information on how to do it. The second real issue is climate change and how to manage forests to increase resistance and resilience; the issue of wildfire I see as a part of this.

I would be willing to talk with you further about revising the proposal, if it would be helpful to you and I suspect Norm would be willing, as well.

- Jerry F. Franklin"

APPENDIX 14

Summary of Science Advisory Panel Engagement and Feedback

Starting in May 2020, OSU College of Forestry convened an external Science Advisory Panel (SAP) to support the College in developing an inclusive vision for the Elliott State Research Forest that emphasizes long-term discovery and transformation of research capacity in forest ecosystems. The Panel members were explicitly selected for their expertise across a range of topical areas (forestry, forest ecology, wildlife biology, social science, policy) and work in various settings, including university, agency, industry and NGOs. Panel members served by advising the Dean of the College of Forestry on the scientific and operational opportunities and challenges associated with developing a comprehensive proposal.

SCIENCE ADVISORY PANEL MEMBERS

- **Jennifer Allen**
  Portland State University (Chair)
- **Gwen Busby**
  GreenWood Resources, Inc.
- **Ryan Haugo**
  The Nature Conservancy
- **Serra Hoagland**
  USDA Forest Service, Salish Kootenai College
- **Cass Moseley**
  University of Oregon
- **Linda Nagle**
  Colorado State University
- **Matt Sloat**
  Wild Salmon Center
- **Mark Swanson**
  Washington State University
- **Eric White**
  USDA Forest Service

The following is a summary of points of discussion at SAP meetings during 2020. OSU addresses the topics of discussion in the draft proposal as edits or modifications of existing text or additions to the document. We provide some detail below about how the comments were addressed for each section. SAP meeting materials are available online.

JULY 2020 - REVIEW OF THE DRAFT VISION STATEMENT AND RESEARCH PLATFORM DOCUMENTS

The SAP reviewed the draft vision statement from OSU College of Forestry Dean Tom DeLuca, the 2019 research charter (Appendix 1), the overview of the research design, and descriptions of intensive, extensive, and reserve research treatments (Appendix 5).

The SAP members present provided their reflections during the discussion, some of which include, but are not limited to:

- Provide consensus and positive feedback on the scale of research design at the watershed/landscape level.
- OSU could better communicate the larger and longer-term research objectives to a broader set of stakeholders and could do a better job explaining the project's temporal nature and adaptive approach.
- OSU could incorporate more details on reserve management objectives.
- Members were interested in seeing more information on governance and collaboration with stakeholders. Current documents lack information on what mechanisms will create feedback in the adaptive management approach and a decision-making framework about what research happens on the ESRF.
- OSU should bolster social science research considerations.
- SAP recommended broadening the discussions to include more scientists from U of O, PSU, OSU in other disciplines.
- SAP noted OSU should integrate resilience and resistance across treatments.
- There was broad agreement this exploratory time is the time to think big. These plans will require a lot of operational support, research infrastructure and funding to execute.
- SAP noted the integrity of the research is paramount (comes through in documents in areas that mentioned unbiased treatment selection). OSU should make this statement more boldly and earlier in the document.
- SAP suggested the design needs to speak more clearly to road and trail management as an essential part of ecological and social research.
- SAP members expressed concerns regarding older cohorts in extensive treatment. Is that learning worth the pressure and costs from a social perspective?
- SAP noted it would be beneficial to have a group that does iterative brainstorming of ideas for high impact questions and should be balanced and composed of multiple stakeholders.
- There was general feedback around the terminology used to describe the research design elements, including input the platform is jargon heavy. It could benefit from communications staff translating ideas for public consumption. There was a discussion of the confusion caused by Triad treatments and research treatments using the same names.

OSU incorporated this feedback into the proposal sections on adaptive management, governance, and OSU commitments to public values that were not developed when the SAP provided their thoughts on the initial research treatment documents. Additional text describing potential research projects, programs, and collaborations has also been generated and included in the proposal, in part, to respond to SAP suggestions to improve communication regarding potential research opportunities within the Triad design (Appendix 2 and 3). We address concerns about limited social science by including social science research in the lists of nested research and example research programs (Appendix 2 and 3) and social science research costs in the ESRF budget. OSU conducted a power analysis (Appendix 10) for inclusion in the final proposal to address comments about the importance of research integrity and unbiased treatment selection. We did not immediately address a few of the comments in the draft proposal. We did not address requests for more information on the HCP and decoupling and more details on monitoring mechanisms that create the feedback in the adaptive management approach in the proposal. They will be a part of future planning and development of research monitoring protocols and a forest management plan.

SEPTEMBER 2020 - GOVERNANCE STRUCTURE AND OSU COMMITMENTS TO PUBLIC VALUES

SAP members discussed the proposed Governance Structure (Section 6) of the Elliott State Research Forest, the draft proposal section on Guiding Principles and OSU's Commitments to Public Values (Section 3).

The SAP members present provided their reflections during the discussion, some of which include, but are not limited to:

- A recommendation that OSU develops a process map to show how decisions occur within the governance structure.
- There was an emphasis placed on developing metrics for tracking and transparency of the OSU Commitments to public values. As currently stated in the proposal, there is no concise way to measure them.
- Refinement is needed to the current values appendix, with further definition to some values and overall adjustment to make the language more accessible and less academic. Also noted, it was not enough to address social science through the values domains appendix.
- Regarding the governance structure, some wondered whether there might be opportunities to utilize existing governance structures within the university system and cautioned against creating overly complicated designs.

We address feedback on governance and OSU Commitments to public values where possible. The development of a governance structure for the ESRF was directly influenced by existing and similar governance structures from within OSU and other university forests, stakeholder input, and university legal counsel input. OSU has strived to keep the structure as straightforward as possible while affording necessary decision-making authority to implement research and operational activities and provide adequate accountability of the College and University to the commitments, proposed activities, and values in the ESRF proposal. We have only made commitments that we can meet and are necessary to meet our diverse set of stakeholders' needs. OSU agrees that we should develop metrics for tracking commitments in the next phases of planning.

OCTOBER 2020 - FINANCIALS AND RIPARIAN RESEARCH STRATEGY

The SAP members reviewed a preliminary report on projected research program expenses developed to better understand some of the associated costs of transforming the Elliott into a research forest. SAP members also reviewed the draft riparian research strategy (Appendices 8, 9, 10).

The SAP members present provided their reflections during the discussion, some of which include, but are not limited to:

- SAP suggested it could help to lay out costs in a progression of years and by category to provide a better expense profile over time.
- SAP noted the current document mainly reflects biophysical research costs. Costs are often composed of expensive physical equipment, and there was a lack of social science costs (i.e., permanent traffic counters, surveys, interviews, and analysis).
- SAP noted the personnel section did not indicate positions outside of academic/research positions. SAP inquired about how this budget reflects OSU's interests in supporting the local community with job opportunities. This could be an opportunity to add trainee positions, under technicians, or somewhere for an entry-level position.
- There was broad support amongst SAP members for an outcomes-based riparian research framework and the ability to study riparian buffer design, especially given recent conversations and policy focus around stream buffer widths in Oregon and opportunities to measure ecosystem services with flexible treatments.
- SAP suggested more explicitly incorporating climate risk/hazard management acknowledgment, which relates to disturbances.

As a result of SAP input, we added social science costs and additional personnel costs to the preliminary budget for research program costs. SAP members also vetted the numbers estimated for research/monitoring equipment in key areas (carbon, aquatic, and wildlife/biodiversity), leading to some initial research and start-up budget changes. Support for the outcomes-based riparian research strategy helped solidify the direction for riparian research on the ESRF.

NOVEMBER 2020 - FINAL PROPOSAL REVIEW

SAP members reviewed the final draft iteration of the proposal posted to the DSL website for public review. The discussion focused on updated sections of the proposal, including Financing Research and Management of the ESRF, Governance Structure, Appendix 10 Power Analysis of the Elliott State Forest Research Design, and Appendix 11 Potential Marbled Murrelet Habitat Distribution and Research Strategy at the Elliott State Forest.

The SAP members present provided their reflections during the discussion, some of which include, but are not limited to:

- There is an excellent reason to have the Governor appoint the Advisory Committee membership, but rather than the committee creating their by-laws, they should receive a charge from the Dean.
- Rather than having mediation and decisions flow through the Board of Trustees, that role should be at an appropriately high level.
- There was a suggestion to reserve that academic judgment not be subject to the public appeals process. A risk to academic freedom and integrity would be the reality of different stakeholders wanting different outcomes. To that end, OSU should list the topics or situations that would not be subject to appeal and what would be, rather than leaving that determination so broad.
- Recognizing that the proposal's 'commitments' are what OSU would be held accountable to, there could be a secondary annual report (from the ESRF Executive Director to the public) that reports on OSU's performance of accountability of those commitments.
- There was a lack of clarity around the scientific advisory body and who decides what research is conducted.
- SAP recommended making a cash flow profile with capital revenues mapped out (like timber, carbon, etc.) over time and investments clearly outlined. If so, we could conduct a more comprehensive sensitivity analysis to account for vulnerability and variability factors, like mill closures, timber prices, carbon prices, etc.
- There was conversation around engagement in the carbon market and generating revenue overtime. One SAP member noted that voluntary carbon markets have been performing well this past year and are expected to continue to perform well. Part of the long-term ESRF research goal is to understand soil-carbon dynamics better, and research could play a role in developing new components for carbon market credits.
- There was a discussion of the effort involved in ascertaining Murrelet occupancy, and SAP members expressed interest in research that would inform marbled murrelet response to varying levels of management.

The thoughtful input provided at the final SAP meeting allowed OSU to refine and finalize the proposal submitted to the State Land Board.