Rogue Basin Cohesive Forest Restoration Strategy: A Collaborative Vision for Resilient Landscapes and Fire Adapted Communities

June 2017

The Nature Conservancy and
Southern Oregon Forest Restoration Collaborative

Southern Oregon Forest Restoration Collaborative

Funding support

Oregon Department of Forestry Federal Forest Health Program

Oregon Watershed Enhancement Board Forest Collaborative Capacity Grant Program

Jackson County

Josephine County

USDA USFS Rogue River-Siskiyou National Forest

Bureau of Land Management

The Nature Conservancy

Dedication

This assessment is dedicated to Ed Reilly, whose vision, open mind, pragmatism, and inclusive approach was a positive force for change in the Rogue Basin: he will be missed.

Acknowledgements

This assessment builds on a developing vision of collaboratively driven forest management, conceived and nurtured in southwestern Oregon by numerous parties. It relies on contributions of stakeholders and workshop participants as well as the technological capabilities and advice from a wide range of engaged individuals.

Contractors

Don Helmbrecht -- Wildland Fire Analyst, Forest Service, TEAMS Enterprise Unit, Bozeman, MT, for local fuel calibration and large wildfire simulation

Joe Scott -- Pyrologix LLC, Missoula, MT, for risk workshop facilitation and quantitative risk calculations

Julie Gilbertson-Day -- Pyrologix LLC, Missoula, MT, for quantitative risk calculations

Suggested Citation: Metlen, K. L., D. Borgias, B. Kellogg, M. Schindel, A. Jones, G. McKinley, D. Olson, C. Zanger, M. Bennett, B. Moody, and E. Reilly. 2017. Rogue Basin Cohesive Forest Restoration Strategy: A Collaborative Vision for Resilient Landscapes and Fire Adapted Communities. The Nature Conservancy, Portland, OR.

Available online at: https://tnc.box.com/s/k8kel1cww1i3oo4ru55lc1dv7xpyxuob.

* **Corresponding author:** *E-mail:* kmetlen@tnc.org

Cover photo: Ashland Forest Resiliency Stewardship Project © Darren Borgias

The Nature Conservancy, Oregon Forest Team

Mark Stern -- Director, Forest Conservation

Aaron Jones -- Spatial Analyst and Cartographer

Bryce Kellogg -- Oregon Forest Analyst

Chris Zanger -- Oregon Forest Analyst

Darren Borgias -- Southwest Oregon Forest Conservation Director

Derek Olson -- Spatial Analyst

Kerry Metlen, Ph.D. -- Forest Ecologist

Michael Schindel -- Director, Conservation Information Systems

Technical Advisors:

Bill Kuhn – Area Ecologist, R6 Ecology Program, Rogue River-Siskiyou National Forest District Office

Brett Brown -- Fire Ecologist, Siskiyou Mountains Ranger District, Rogue River-Siskiyou Mountains National Forest

Cindy Donegan -- Wildlife Biologist, U.S. Fish and Wildlife Service (retired)

Jena Volpe -- Fire Ecologist, Bureau of Land Management Medford District

Jim Wolf -- Retired ODF, Consultant

Jon Lamb -- Silviculture, Bureau of Land Management Medford

District Shannon Downey -- Environmental Coordinator, USFS Enterprise Program

Matthew P Thompson, PhD -- Research Forester, Forest Service, Human Dimensions Program, Rocky Mountain Research Station, Missoula, MT

Patricia Hochhalter -- Ecologist, USFS, Rogue River-Siskiyou National Forest

Terry Fairbanks -- District Silviculturist, Bureau of Land Management Medford District (retired)

Contents

Executive Summary 6
Introduction 8
Objectives 10
Scope 10
- Inference of the Underlying Data 12
  - Vegetation and Related Fire-Potential Data 13
  - Wildfire Modeling Limitations 13

Quantitative Wildfire Risk Assessment 13
- Fire Behavior Modeling 13
- Current Wildfire Risk 21

Landscape Management Objectives 24
- Local Fire Community Risk 24
- Large Wildfire Community Risk 26
- Landscape Resilience 26
- Northern Spotted Owl Habitat 28
- Climate Resilient Landscapes 29

Restoration Needs by Treatment Theme 30
- Estimation of Restoration Need 31
- Treatment Placement Filters 34
  - Restoration Byproduct Timber 34
  - No-treatment Filters 35

Optimizing Management Scenarios 36
- 20-year Management Scenarios 37
- Wildfire Risk Performance 39
- Landscape Resilience Performance 41
- Complex Forest Habitat Performance 43
- Economic Costs of Implementation 44

Implementation of the Rogue Basin Strategy 47
- Prioritizing Among Potential Planning Areas 47
- Purpose and Need Within a Planning Area 48
- Multiparty Monitoring 50
- Social Engagement 50

References 52
Appendices 58

List of Figures

Figure 1: Nested, interacting stressors impacting forests of the Rogue Basin and potential factors to reduce that stress by restoring landscape resilience and fire adapted communities. 8
Figure 2: Increasing efficiency by integrating regional assessment with project planning, unit scale implementation, and monitoring. 9
Figure 3: The Rogue Basin Cohesive Forest Restoration Strategy analysis area is 4.6 million-ac across many ownerships and land allocations. 11
Figure 4: FSim generated annual probability of a 2-ac pixel burning in a fire >35-ac for the 10 million-ac fire behavior modeling area (see inset) centered on the 4.6 million-ac Rogue Basin Project area. 15
Figure 5: FSim generated probability of fire > 35-ac burning at six fire intensity levels 16
Figure 6: The relative importance of collaboratively identified high value resources and assets (a) as identified in the workshop and (b) after accounting for their relative extent and replacement value. 17
Figure 7: a) Conditional net value change (cNVC) and b) Expected net value change (eNVC) to all mapped high value resources and assets for the Rogue Basin analysis. 21
Figure 8: Expected net value change (eNVC) for a) deer winter range, b) timber value varied by ownership and land allocation (as in Table 4), c) the cumulative eNVC on assets mapped that impact community values, and d) Northern Spotted Owl dispersal, nesting, roosting, and foraging habitat. 22
Figure 9: The relative wildfire risk of high value resources and assets mapped for the Rogue Basin quantitative wildfire risk assessment. 23
Figure 10: Fuel reduction treatments and forest restoration thinning were prioritized across the Rogue Basin project area based on five priorities a) fuel reduction to reduce local fire community risk b) fuel reduction to reduce large wildfire community risk c) thinning to promote landscape resilience d) thinning to promote and protect complex forest habitats e) thinning in settings likely to be resilient to climate change. 25
Figure 11: Landscape scale ecological departure for three of the most abundant biophysical settings in the Rogue Basin. 26
Figure 12: Average existing trees per acre and basal area for each of the treatment themes 32
Figure 13: Average existing trees per acre by diameter class (inches) by treatment theme for the available and accessible portions of the analysis area. 33
Figure 14: Three potential management scenarios for the Rogue Basin showing mechanical treatment priorities of potential treatment units as summed across planning areas. 38
Figure 15: Landscape management scenarios alter cumulative negative and positive modeled wildfire responses. 39
Figure 16: Landscape scale departure for biophysical settings common across the Rogue Basin and performance of three landscape scale management scenarios at returning those vegetation classes to the natural range of variability. 41
Figure 17: Departure from natural range of variability for dry Douglas-fir (Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland) in two exemplar watersheds to illustrate how three management scenarios perform at returning the natural range of variability. 42
Figure 18: Comparison of the Maximum Federal and All Lands management scenarios to the Business as Usual scenario for Northern Spotted Owl nesting, roosting, and foraging habitat extent (ac) and wildfire risk to core nesting, roosting, and foraging habitat. 43
Figure 19: Treated footprint, merchantable timber volume (in millions of board feet; MMBF) removed as restoration byproduct, and net revenue of implementation costs and timber receipts for three landscape-scale restoration scenarios by treatment type. 45

Figure 20: Net revenue per acre by yarding system and density of volume removal under the Maximum Federal scenario where merchantable volume is removed. 46
Figure 21: Prioritized planning areas for the Rogue Basin All Lands scenario, overlaid with existing planning areas and their relative performance on five landscape scale objectives, assuming the full treatable and accessible footprint is treated....... 48
Figure 22: Example factsheet for planning area #1, which happens to be centered on the Ashland municipal watershed and site of the Ashland Forest All Lands Restoration project. 49

List of Tables

Table 1: Analysis area characteristics, from forested to non-forested with significant developed areas not exposed to wildland fire and other non-burnable substrates. 12
Table 2: Annual fire year parameters for the 10 million-ac fire modeling analysis area for the years 1992-2013 and for 10,000 modeled fire year iterations....... 15
Table 3: Five classes of assets (HVRA) were identified and mapped as 18 individual sub-HVRAs.. 18
Table 4: Four of the seven classes of resources (HVRA) identified and mapped as 27 covaried sub-HVRAs (of 48 total). 19
Table 5: Three of seven classes of resources (HVRA) identified and mapped as 21 covaried sub-HVRAs (of 48 total)....... 20
Table 6: The Rogue Basin Cohesive Forest Restoration Strategy provides a framework for understanding how proposed planning areas can achieve five landscape objectives, all of which tier to key elements of the National Cohesive Wildland Fire Management Strategy National Action Plan....... 24
Table 7: Priority for thinning forests to promote landscape resilience was limited to closed seral classes (s-classes) and favored in appropriate topographic positions (facets)....... 28
Table 8: Northern Spotted Owl (NSO) existing habitat and relative habitat suitability (RHS) classes used to prioritize active management 29
Table 9: Accessibility by ownership and vegetation type under the existing road network (acres) 34
Table 10: Cost to remove merchantable product, determined by yarding system and density of restoration byproduct volume....... 35
Table 11: Filters used (acres) to determine where treatments could potentially be placed. The portions of the landscape unavailable for treatment often substantially overlap. 36

Executive Summary

The forests of western North America have innate ecological value, provide diverse wildlife habitats, underpin the global carbon and water cycles, and provide human communities with clean water, recreation, and other benefits. Landscape-scale forest restoration is needed to mitigate threats to these forests and surrounding communities from uncharacteristically destructive fires catalyzed by a century of fire exclusion, past destructive logging practices, and climate change. This report describes the collaboratively-derived Rogue Basin Cohesive Forest Restoration Strategy (Strategy), which integrates resource assessments conducted by the Southern Oregon Forest Restoration Collaborative and partners to clarify the potential costs and benefits of landscape-scale forest restoration in the Rogue Basin.

This document integrates four foundational parts. First, we conducted a **wildfire risk assessment** to quantify current wildfire risk and provide indicators for evaluating alternative management scenarios. Second, we identified a suite of **five landscape-scale management objectives** and the relative value of mechanical treatments to achieve those objectives. Third, we generated **mechanical treatment themes** and their potential extents and **derived outputs** for the entire landscape, should mechanical treatments be implemented. Fourth, we compare three contrasting **management scenarios** of increasing treatment footprint across the Rogue Basin and estimate their performance on key indicators. Finally, we discuss how these assessments could be used to **inform project development and evaluation**.

The Strategy outlines approaches and scenarios for implementing ecologically-informed forest thinning with mechanical treatments, conceived and constructed within a framework of conservation, proposing no new system roads and only modeling mechanical treatments outside of wilderness, core Northern Spotted Owl habitat, and riparian reserves. Mechanical treatments are designed to increase landscape resilience, reduce wildfire risks, protect complex forest, increase fire management options and fire fighter safety, and generate economic activity for local communities. Conservation-oriented management designations were included in modeling for mechanical treatment, but solely for accomplishing ecological objectives.

The wildfire risk assessment under current conditions identified homes and Northern Spotted Owl habitats as particularly at risk of damaging fire. Conversely, tanoak, deer and elk winter range, and oak woodland were most likely to be benefitted by fire. We used the risk assessment to identify the portions of the landscape where ignitions are most likely to damage communities, and packaged the data to promote integration of risk-based approaches into ongoing project planning.

Five landscape scale objectives were modeled: 1) mitigating **risk of local fire to communities**, 2) reducing **risk of large wildfire to communities**, 3) restoring **landscape resilience** through restoration of open forest, 4) protecting existing and promoting future **complex forest habitat** for Northern Spotted Owl and related species, and 5) promoting fire resistance in **climate resilient settings**. Data were provided to allow prioritization of projects that best achieve all five landscape objectives together, or individual objectives, depending on stakeholder values.

To achieve these objectives, the Strategy applied prescriptions to four mechanical treatment themes: **ecological resilience, fuel management, long-range complex habitat,** and **near-range complex habitat**. Prescriptions for each treatment theme set target densities and stand structures specified by objective, forest type, and seral state. These prescriptions were applied in a model to generate estimates of mechanical treatment outputs.

We contrasted three 20-year mechanical treatment scenarios that primarily evaluate increasing treatment footprint area: 1) **Business as Usual** treating 150,000-ac of federal land, 2) **Maximum Federal**, treating 0.9 million-ac, which is the entire treatable and accessible footprint with forest vegetation on the Rogue River-Siskiyou Mountains National Forest and the Medford District Bureau of Land Management in need of thinning, 3) **All Lands**, treating 1.1 million-ac by adding to the Maximum Federal footprint additional treated acres on additional ownerships within the Community at Risk.

Modeled results of implementing the full All Lands scenario best reduced wildfire risk to all high value resources and assets; notably **reducing expected net value change by 70%** and **wildfire risk to homes by 50%** relative to the Business as Usual Scenario. The All Lands scenario **reduced wildfire risk to high quality Northern Spotted Owl habitat by 47%**, achieved by a modest reduction of Northern Spotted

Owl nesting, roosting, and foraging habitat *on ridges and warm midslopes* where resilience objectives call for restoring more open stands, which still provide dispersal habitat.

Landscape resilience improved modestly, even under the most widespread treatment footprint. At local scales thinning excess mid- and late-closed stands improved the balance of mid- and late-open forests. However, across the basin time is needed so that mid-seral forests can grow and develop to reduce the deficit of late seral forests. This process is accelerated in the strategy with ecologically based thinning to improve growth rates and forest successional processes.

The economic dynamics of the Strategy and possible offsets from selling timber calculated on implementation of the Maximum Federal strategy over 20 years are significant. The Maximum Federal scenario would treat **0.9 million acres** and require **$30 million per year** to implement, including pile burning of associated fuels. The return on investment includes a **37% reduction in overall wildfire risk** and a byproduct of **66 million board feet of merchantable timber every year**, consistent with the current volume targets of the Federal agencies. Further return on investment is a more fire resilient landscape and significant economic activity annually with **1,700 direct and indirect jobs** that produce **$65 million in local wages**, and generate over **$260 million in local economic output**.

Consistent with the National Cohesive Wildland Fire Management Strategy, the Rogue Basin Strategy All Lands scenario best achieved landscape scale objectives. The Strategy framework can be used to structure manager decision-making and has already been used to engage stakeholder and the public in conversations about management of southwestern Oregon forests. Strategy treatments should promote conditions to enable managed fire that will improve landscape resilience, climate resilience, and community safety at a reduced cost over the long-term. Continued implementation of the Strategy on federal lands could encourage related work on all lands, and result in a more resilient landscape where people and nature thrive.

Photo: Applegate valley from Boaz mountain © The Nature Conservancy (Anna Vandervlugt)

Introduction

Fire regime disruption, harmful logging practices, and climate change are primary factors resulting in western North American forests that are highly departed from historically resilient conditions (Sensenig et al. 2013, Stephens et al. 2013, Hessburg et al. 2016). Nested stressors continue impacting these forests, threatening landscape resilience, community safety, and sustainability of the services forests provide, but those stressors can be diminished through a mix of managed fire, strategic protections, and active forest restoration (Figure 1). Proactive management may be needed to help forests respond to these stressors and allow the landscape to adapt to future climates in ways that maintain ecosystem services (Stephens et al. 2013, Millar and Stephenson 2015). Strategic placement of mechanical treatments and prescribed fire are central to enabling the safe return of beneficial fire to fire dependent ecosystems and managed fire is increasingly acknowledged as a critical agent in adapting forests to climate change (Hessburg et al. 2016, Schoennagel et al. 2017).

The Southern Oregon Forest Restoration Collaborative (SOFRC) formed to address these issues regionally by participating in demonstration restoration projects and collaborative planning with local land management agencies and stakeholders. The SOFRC developed this cohesive Rogue Basin Forest Restoration Strategy (Strategy) to understand the tradeoffs of scenarios that accelerate mechanical forest restoration and prescribed fire, increasing the probability of favorable wildfire outcomes. Inherent in increasing treatment pace and scale is the need to plan, implement, and monitor in a strategic and cohesive way that is tiered to regional assessments, such as the wildfire risk assessment, and meets local needs, including mechanisms for adaptive management (Figure 2). The Strategy data, approaches, and dialogue generated can lead to this integrated approach.

The Strategy is grounded in seven collaboratively derived principles (right) and at its

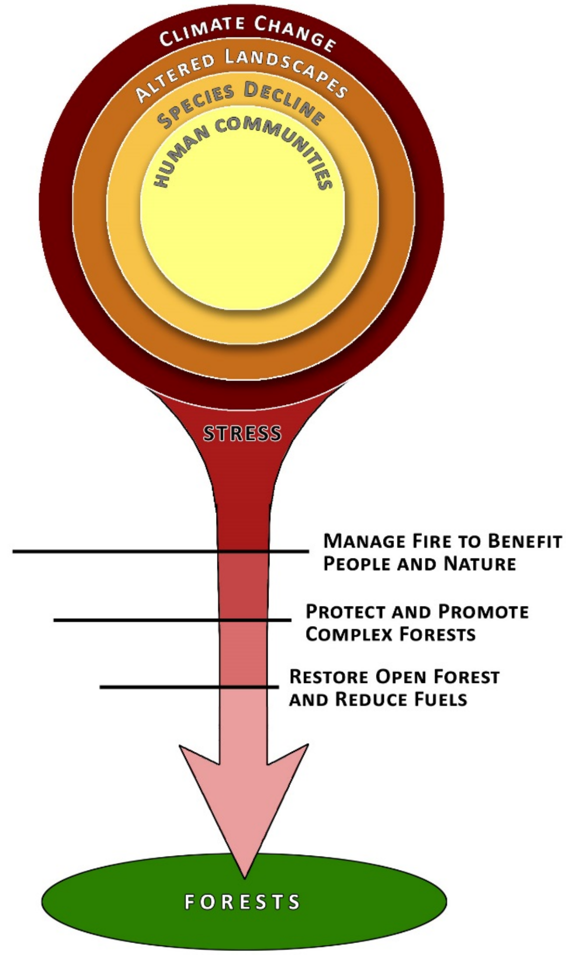


Figure 1: Nested, interacting stressors impacting forests of the Rogue Basin and potential factors to reduce that stress by restoring landscape resilience and fire adapted communities.

Forest Restoration Principles

i. *Inform management with historical fire return intervals and site productivity*
ii. *Plan and monitor at multiple scales*
iii. *Integrate protection and restoration*
iv. *Restore and maintain with thinning and fire*
v. *Support fire adapted communities*
vi. *Ensure enduring viability of critical habitats and species*
vii. *Promote regional economic and workforce viability*

core has placed protection of critical complex forest. Key tools for identifying where to place treatments and evaluate outcomes are wildfire risk and restoration needs assessments that support the National Cohesive Wildland Fire Management Strategy (Jewell and Vilsack 2014), and key recovery actions identified in the Recovery Plan for the Northern Spotted Owl (U.S. Fish & Wildlife Service 2011). Ecologically driven needs for forest thinning are balanced with protection of complex forest and fuel reduction needs to abate wildfire threats. The Strategy allows structured decision making (sensu Thompson et al. 2013a) to drive prioritization among planning areas and to guide development and evaluation of existing planning areas.

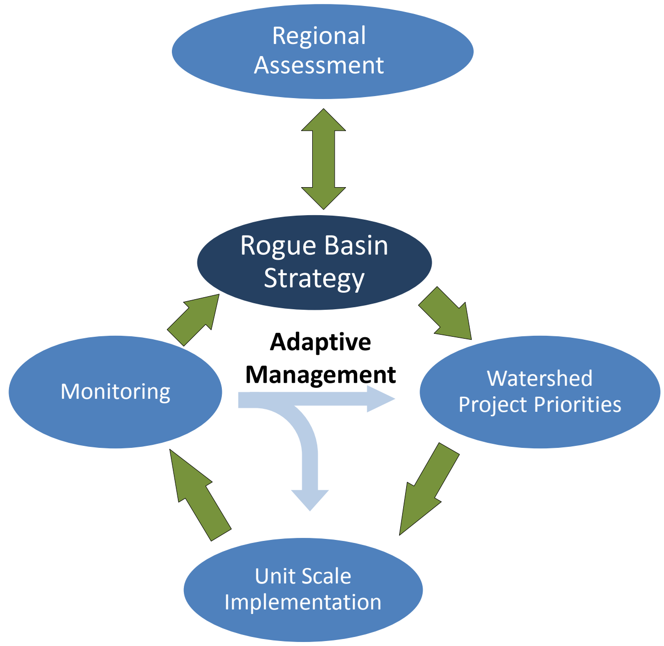


Figure 2: Increasing efficiency by integrating regional assessment with project planning, unit scale

The Strategy is designed to inform and support the federal land management agencies, the State of Oregon, and private landowners in planning integrative and cohesive active management. The Strategy and its integrated quantitative wildfire risk assessment (risk assessment) was convened by SOFRC following the methods of Scott et al. (2013). The risk assessment guides effective treatment placement and project prioritization and provides a metric for how management scenarios perform. Further, it is being used to update the Jackson and Josephine County Fire Plans and regional Community Wildfire Protection Plans with identification of high-risk areas and priorities for fuel reduction.

The Strategy allows prioritization among project areas based on their ability to achieve five critical landscape management objectives: 1) mitigating risk of local fires to communities, 2) mitigating risk of large wildfire to communities, 3) promoting landscape resilience by restoring open forest, 4) protecting existing and promoting near- and long-range future habitat for the Northern Spotted Owl and other complex forest habitat dependent species, and 5) promoting landscapes resilient to climate change. Priorities among project areas were determined based on their relative performance on these objectives.

Within project areas, the SOFRC collaboratively developed forest restoration principles to guide restoration approaches and designed prescriptive actions for treatment themes that include: 1) *fuel management* to ameliorate fire intensity and improve fire management options to protect the Community at Risk, 2) *complex habitat management* to protect and promote complex habitats for Northern Spotted Owl (NSO) and other species, and 3) *ecological resilience and climate adaptation* to re-balance the landscape of open and closed forest. The work described by each treatment theme was then used to calculate restoration byproduct timber volume to facilitate budgeting and a predictable, even workflow. Collaboration, community engagement, and generation of products, employment, and economic activity are important to the resilience of the local communities and critical for the success of all treatment themes.

It is anticipated that the Strategy and related data (Appendix 1; available here) will be used to provide context and rationale for restoration efforts on federal land and - with willing private landowner participation - on all lands. Operating within the robust protections built-in for species dependent on complex habitats, the active management proposed in this Strategy can generate ecosystem benefits, forest products and associated economic outputs, as well as attendant social benefits while preparing the landscape for more effective wildfire management. The Strategy intends to reduce the risk and hazards of high intensity fires, allowing managers the flexibility to use both prescribed fire and managed wildfire to return the forests to a fire regime of frequent low to mixed severity fires, and equally as important, to reduce the need to suppress fires.

Achieving these goals will require an increase in federal and state support under various programs, including but not limited to the Oregon Watershed Enhancement Board Focused Investment Partnerships, National Fire Plan of 2000, Collaborative Forest Landscape Restoration Program initiated in 2008, and Joint Chiefs' Landscape Restoration Partnership Program. These data can be used to evaluate those potential investments.

Objectives

1. Conduct a **quantitative wildfire risk assessment** that allows strategic placement of treatments to reduce wildfire risk, as well as a metric for evaluating potential management scenarios
2. Identify and map an array of **landscape scale objectives** to clarify the most important parts of the landscape to focus fuels reduction and restoration treatments
3. Predict how much work is needed by evaluating the trees per acre to be removed and restoration byproduct timber volume available under potential management scenarios by conducting a **structural restoration needs assessment**
4. Develop three **20-year management scenarios** to allow articulation of the costs and benefits of increasing the pace and scale of forest restoration
5. Facilitate **implementation of a cohesive forest restoration strategy for the Rogue Basin** by providing data, an intellectual framework, and social context for achieving meaningful change to increase landscape resilience and support human communities

Scope

The 4.6 million-ac project area (Figure 3) encompasses the Rogue River Basin of southwest Oregon and overlaps with several of the driest forest regions in the range of the Northern Spotted Owl (*Strix occidentalis caurina*) as identified in the Northwest Forest Plan (NWFP) including parts of the West Cascades, East Cascades, and the Klamath Mountains. The streams of the Klamath, Siskiyou and Cascade Mountain ranges support salmonid and other species and populations of considerable conservation significance, including federally listed species. This report supplements, but does not replace, the important conservation opportunity areas identified for this region by several entities including The Nature Conservancy (Vander Schaaf et al. 2004) and the Oregon Department of Fish and Wildlife (Oregon Department of Fish and Wildlife 2016).

Diverse floras from several western US floristic provinces intermingle and thrive in the complex environmental and geomorphological gradients that characterize the landscape and which allowed it to function as a climate refuge in the past. Dry forest types in the analysis area are largely dominated by Douglas-fir but include white fir, pacific madrone, Jeffery pine, and ponderosa pine dominated forests. Oak woodlands, comprised largely of tanoak coastally and Oregon white oak in the inland valleys, with California black oak increasing in the mountains, are abundant and incredibly diverse.

Dominant low-mixed severity fire regimes shaped the dry forests and woodlands of the northern Klamath, Siskiyou, and southern slopes of the Cascade Mountains for thousands of years; fires influenced by steep topographic gradients, a strong mediterranean climate with abundant lightning, and

Native Americans (Taylor and Skinner 1998, 2003, Halofsky et al. 2011, Perry et al. 2011). Native Americans have been a key component of the landscape for at least 9,000 years (Connolly 1988). Ending in the mid-1800s they lived in and managed these forests with fire: with diverse Athabaskan groups ranging from the coast (Coquille, Chetco, Tolowa, and bands of the Tututni) to further inland (Chasta Costa, Umpqua, Galice and Applegate), with the Takelma and Shasta language groups in the interior Rogue Valley (Pullen 1996, Long et al. 2016). Native American fire use was widespread and for diverse purposes but focused around villages and camps, travel routes, prairies and meadows, and at higher elevations. Tribes used fire for maintaining oak woodlands, basketry materials, foods, hunting grounds, and a multitude of other socioeconomic and ecological objectives (Pullen 1996, Long et al. 2016).

Modern residential development is concentrated in the lowland prairie and river valleys, while woodland and forested systems and associated timber resource management generally increases with elevation and productivity except where there are access limitations or where federal protections exist (e.g. wilderness, national park and national monuments). In 2010, 300 thousand people live in the analytical area, with 203 thousand in Jackson county, 82 thousand in Josephine county, and 22 thousand in Curry county (United States Census Bureau 2010).

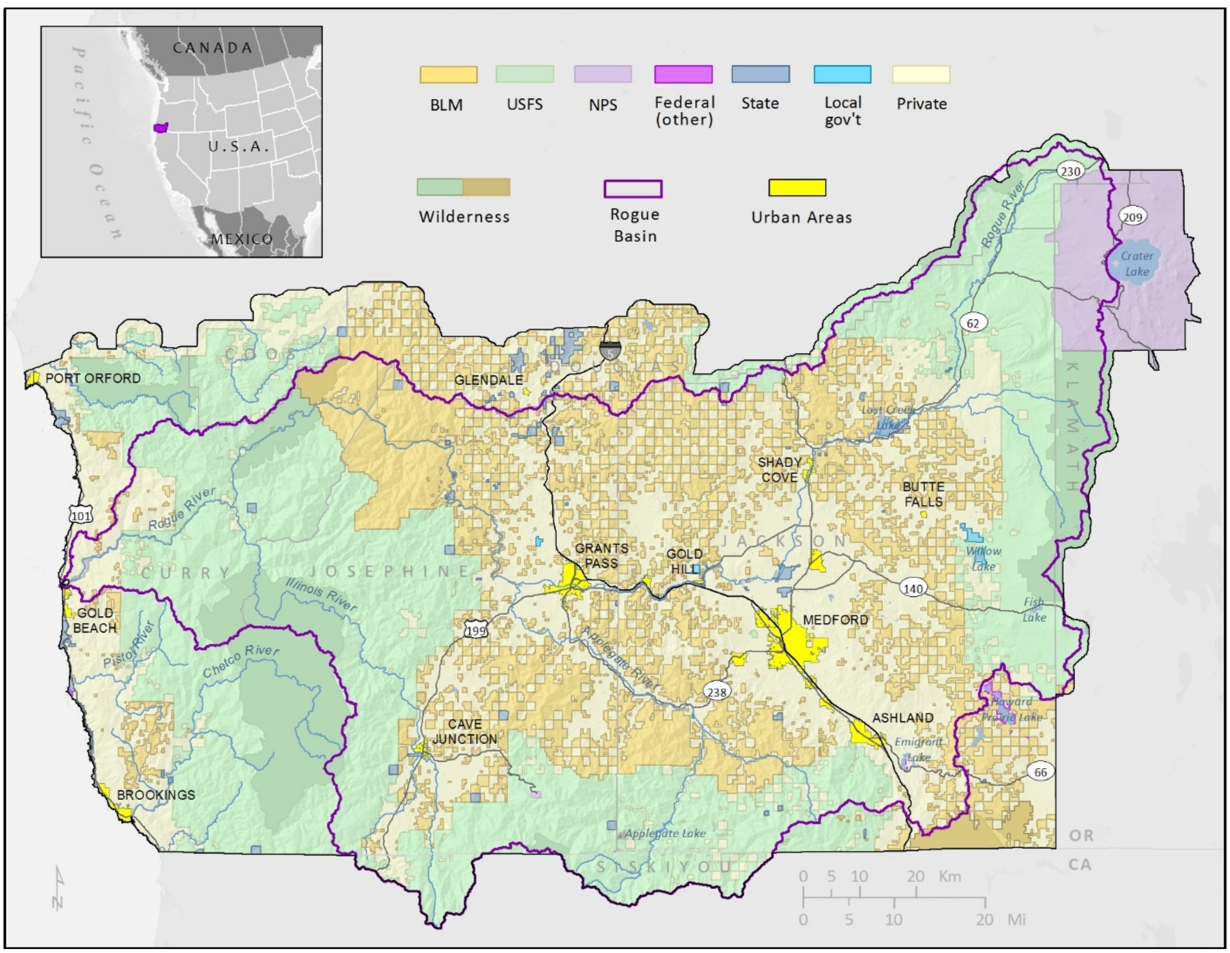


Figure 3: The Rogue Basin Cohesive Forest Restoration Strategy analysis area is 4.6 million-ac across many ownerships and land allocations.

The analysis area is centered on the Rogue River Basin but subsumes the full extent of federal lands managed by the Rogue River-Siskiyou National Forest (RRS), the Medford District Bureau of Land Management (MBLM), and the National Park Service, along with the coastal watersheds south of the

Rogue River (Figure 3). Within the assessment area, 4.2 million-ac are forested and federal ownership covers 2.7 million-ac, of which 2.6 million are managed by the RRS and the MBLM (Table 1). Across this analytical area, Haugo et al. (2015) compared current to historic forest conditions and concluded that a combination of mechanical treatments and fire would be required on 2.1 million acres of predominantly dry forest types to restore the landscape to a historical range of variability.

Table 1: Analysis area characteristics, from forested to non-forested with significant developed areas not exposed to wildland fire and other non-burnable substrates. Bureau of Land Management (BLM) and US Forest Service (FS) lands are predominately Medford District BLM or Rogue River Siskiyou National Forest but include 117,000-ac of neighboring agency lands.

Characteristics	BLM	USFS	Other	Total
Forest	883,804	1,768,273	1,506,637	**4,158,714**
Non-Forest Vegetation	10,652	13,480	68,381	**92,512**
Developed	22,907	37,735	260,641	**321,282**
Total	**917,363**	**1,819,488**	**1,835,658**	**4,572,508**

Globally, mediterranean forests and woodlands are of high conservation importance due to habitat conversion and lack of protection (Hoekstra et al. 2005). Fire regimes have been significantly disrupted for the last 100 years across the mediterranean forests and woodlands of the Rogue Basin (McNeil and Zobel 1980, Agee 1991, Colombaroli and Gavin 2010, Sensenig et al. 2013), including lowland and mixed conifer riparian forests (Messier et al. 2012). Fire regime disruption, combined with extensive even-aged forest stand management and other land-uses, has resulted in forests that are at high risk to wildfire, insects, and disease, issues exacerbated by climate change (Sensenig et al. 2013, Stephens et al. 2013, Hessburg et al. 2015, Hessburg et al. 2016). These risks threaten both complex forested habitats, the oldest most structurally important trees, and also the development of younger stands.

Heavily fragmented ownerships (see Figure 3) complicate land management decisions and increase fire suppression costs. This region is known for past land management conflicts over timber and conservation. Integrating collaboration with project development has emerged with the growing awareness of fire risks to forest values and communities in southwestern Oregon, as elsewhere, and is critically important for building shared understanding and community support for restoration to promote forest health and resilience. The SOFRC has actively supported collaboratively designed projects in the region, including the Medford District Secretarial Pilot, Friese Camp Forest Management, Ashland Forest Resiliency Stewardship, Biomass Utilization, and South Fork Little Butte Creek. This wildfire risk assessment, Cohesive Forest Restoration Strategy, and other ongoing work are advances to continue to improve public dialogue and understanding and broaden support for collaboratively developed, ecologically-based restorative land management.

Inference of the Underlying Data

The Strategy relies on data that vary in the breadth of their inference, thus the scope and scale at which the data are interpreted is a critical consideration for applying the Strategy to on-the-ground action. Individual projects will have many local considerations that change the importance of work in every geography, such as groves of sugar pine in the High Cascades. The Strategy provides a tool for evaluating what work can be achieved in a planning area in the context of the much larger Rogue Basin landscape.

The base data underlying the assessment are quite fine in resolution (down to 0.22-ac), but many of the input data sources are most appropriately interpreted at a scale >10,000-ac. Additionally, the data are aggregated at multiple spatial resolutions for different aspects of the analysis. The coarsest resolution, 27-ac, was utilized for the optimization and economic calculations. Because these units of aggregation were square, they do not perfectly reflect ownership or ecological boundaries and long skinny attributes are less well represented than blocky attributes. The data aggregated for this assessment are excellent for identifying project areas, clarifying the objectives behind those projects, and ranking among projects; however, site specific data and analysis for planning and monitoring individual projects is critical.

Vegetation and Related Fire-Potential Data

The data used in this assessment infer existing vegetation and fuels remotely. The relationships between imagery and known plots are correlations and thus imprecise. Our primary sources, GNN (Landscape Ecology Modeling Mapping and Analysis (LEMMA) 2014) and LANDFIRE (LANDFIRE 2010) both provide error metrics with their data products. We used extensive field reviews and a local fuels calibration workshop to refine the best available data. However, all such data should be evaluated, refined, and augmented at the project scale with local field data as appropriate. One of the key metrics, proportions of seral states, relies on mapping of successional class (s-class) using the data and methodology of Haugo et al. (2015). Ground verification of these data has generally been favorable, but has revealed potential over-prediction of late-seral stands nearer to the coast and under-prediction of late-seral stands further inland.

Wildfire Modeling Limitations

Wildfire is a complex and highly stochastic process. State-of-the-art wildfire modeling was employed for the quantitative risk assessment. This modeling relies on the quality of the underlying fuel data (see above), 20-years of historical fire occurrences, and many informed decisions made by the fire modeling specialist from the Forest Service Enterprise TEAMS unit. Fire modeling results are best interpreted as relative wildfire probabilities and effects between and among scenarios/landscapes within this assessment and not as absolute prediction of future fire behavior. In order to evaluate treatment effects on modifying fire behavior significant assumptions were made about how treatments change fuel characteristics.

Quantitative Wildfire Risk Assessment

The Southern Oregon Forest Restoration Collaborative conducted the Rogue Basin Wildfire Hazard and Risk Assessment in 2015, a quantitative risk assessment using the methods of Scott et al. (2013), to inform fuels and fire management and to provide an indicator for evaluating landscape management scenarios. The risk assessment incorporated fire behavior modeling to characterize large wildfire likelihood and intensity as well as a stakeholder/expert driven process to identify high value resources and assets (HVRAs) and their wildfire susceptibility. This approach overlays likely fire behavior with the susceptibility of HVRAs to identify where risk is greatest on the landscape. This risk assessment was unique in the level of collaborative development and ownership. Three workshops were held to ensure rigorous and broad-based input, understanding, and support for the risk assessment; the participants of those workshops are listed in Appendix 2. Ultimately, we use this approach to model current wildfire risk, as well as wildfire risk under three management scenarios.

Fire Behavior Modeling

We modeled wildfire behavior and likely changes to anticipated fire behavior based on proposed treatments, in conjunction with the Forest Service TEAMS Enterprise Unit. Large wildfire (defined as

>35-ac) fire behavior was modeled for a 10 million-ac project area that buffered the Rogue Basin analytical area by ~15 miles. Vegetation fuel data from the national LANDFIRE (LANDFIRE 2010) were obtained and reviewed on extensive field tours and workshops. The team of professionals applied direct knowledge of the landscape, its vegetation, and how fire interacts with the vegetation, with the objective of refining a landscape fuels product useful to the fire managers of the RRS, the MBLM, ODF and local fire districts. Details are available in Appendix 3 (available here) but key outcomes of the workshop were:

1. Addressed known concerns about homogeneous surface fuel models representing most forests in the analysis area
2. Developed more nuanced models of vegetation types, including oaks
3. Assembled up-to-date spatial data on the extents of mechanical and fire disturbances
4. Defined rules for how mechanical and fire disturbances impact fuels

A 22-year fire occurrence database (1992-2013) was assembled for the 10 million-ac modeling area and used to build probability distributions of ignition locations and weather conditions under which the fires burned. To account for climate-influenced drivers of fire occurrence, the landscape was split into two fire occurrence areas (FOA): a coastal and an interior fire modeling zone. We used Remote Automatic Weather Station (RAWS) weather data from the National Weather Service gathered at Bald 2 RAWS for the coastal FOA and Onion 2 RAWS for the inland FOA. We determined the characteristic size of contemporary wildfires using the "balanced fires-acres percentiles" and Lorenz curve methods (Scott 2014) to determine that 98 percent of the area burned by wildfires was burned by fires >35-ac in the Coastal FOA and >36-ac in the inland FOA. Based on this we settled on 35-ac as the large fire size threshold for the analysis. See Appendix 3 (available here) for further maps and fire modeling details.

The large fire simulation system, FSim, was used to run 10,000 iterations, each representing a "fire year", with ignition points distributed and burn weather determined by historically informed probability distributions. This produced an annual burn probability (Figure 4) and probability of burning at each of six fire intensity levels based on likely flame length (Figure 5). Modeled fire occurrence, size and frequency were evaluated against the past 20-years of regional fire to refine model inputs (as in Scott et al. 2015) with satisfactory results. The final FSim run better reflected the 20-year historical median fire years than the mean and had a much greater standard deviation than the 20-year record, as one could expect from 10,000 iterations, which would have multiple 500,000-ac fire events, compared to 20 annual observations with a single 500,000-ac event (Table 2).

Wildfire burn probabilities varied markedly across the 10 million-ac project area, consistent with the recent historical observations, with the highest probabilities in the southwest corner and the lowest probabilities in the Cascade Mountains (Figure 4). The parts of the landscape with lower burn probabilities, such as the high Cascades, had the highest probability of either very low or very intense fire when they burned; where fire was more likely, intensity tended to be moderate, consistent with observations of a mixed severity fire regime (Figure 4 and Figure 5). These probabilities are best interpreted as relative values and not as a prediction of annual fire frequency. For further methods and analysis of the large fire simulations, see (Appendix 3; available here).

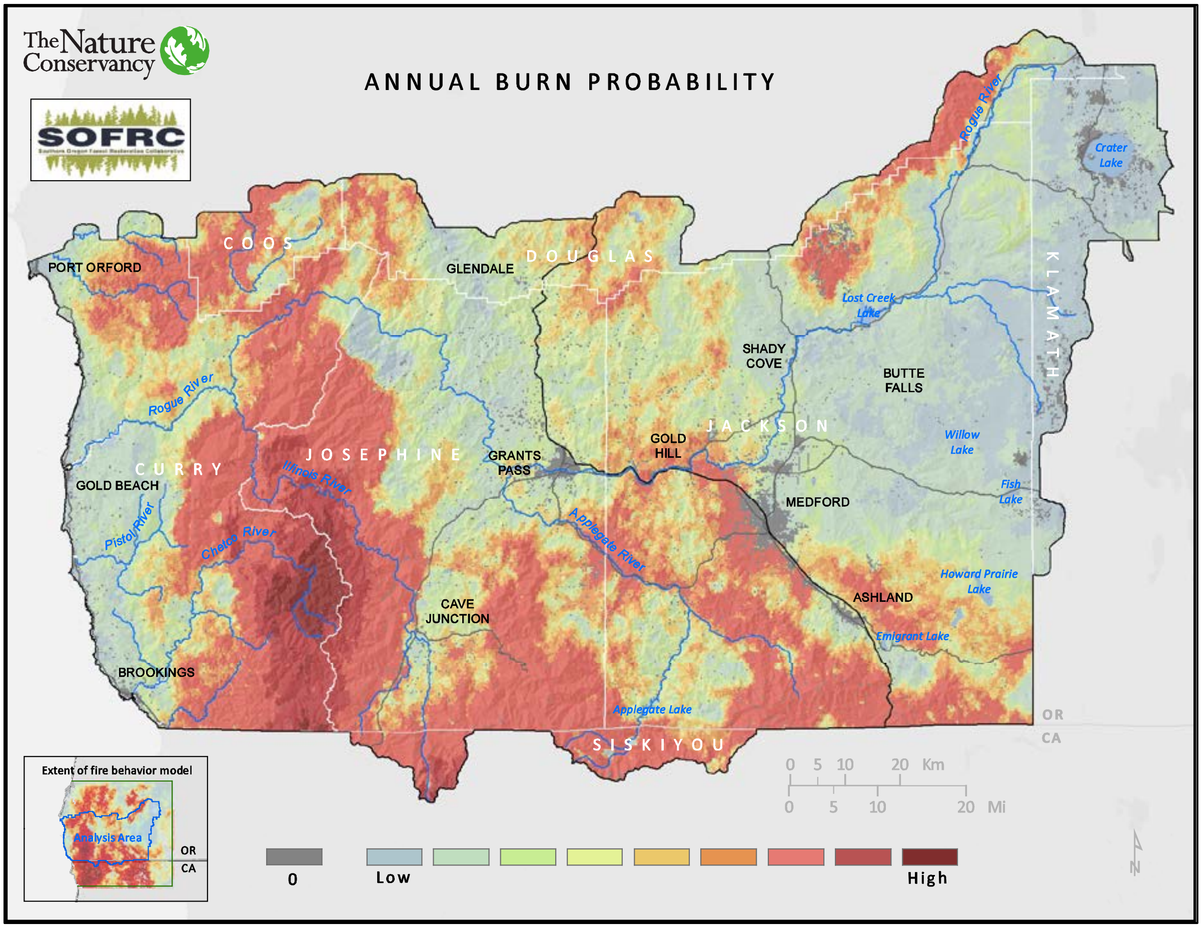


Figure 4: FSim generated annual probability of a 2-ac pixel burning in a fire >35-ac for the 10 million-ac fire behavior modeling area (see inset) centered on the 4.6 million-ac Rogue Basin Project area.

Table 2: Annual fire year parameters for the 10 million-ac fire modeling analysis area for the years 1992-2013 and for 10,000 modeled fire year iterations.

Source	Parameters	Mean	Median	Standard Deviation
20-year record	Acres Burned	26,352	9,282	42,576
	Fire Size	1,415	959	1,493
	Fire Number	15	11	9
Modeled fires	Acres Burned	69,092	14,777	165,601
	Fire Size	2,645	826	4,943
	Fire Number	19	18	11

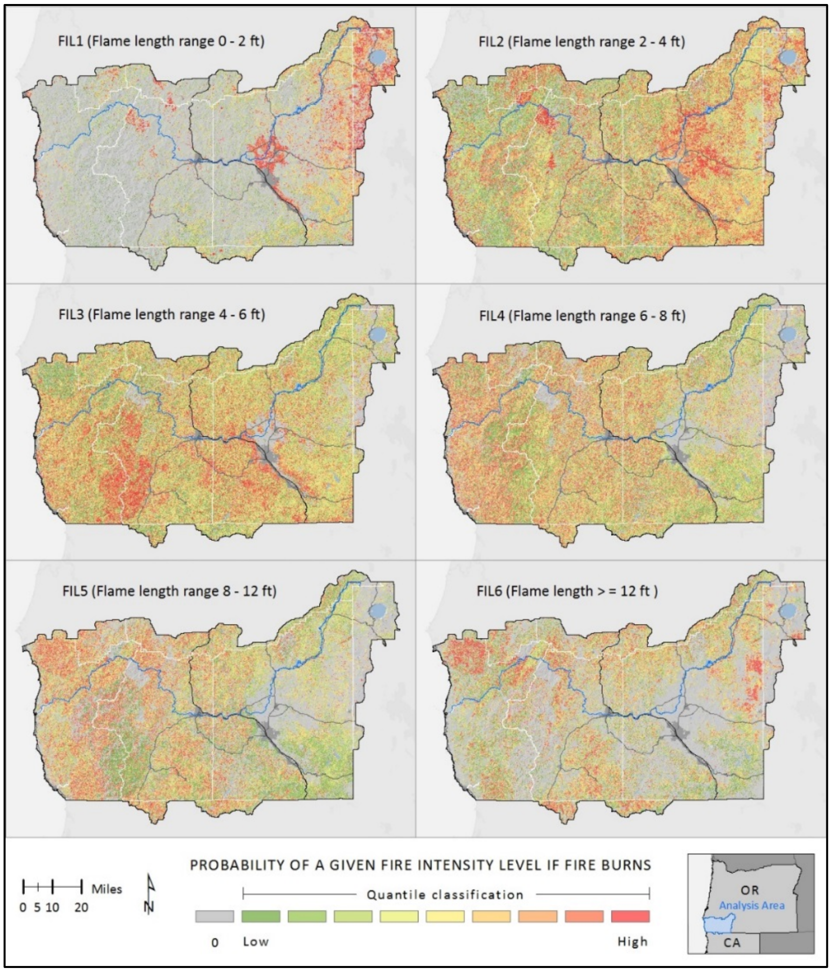


Figure 5: FSim generated probability of fire > 35-ac burning at six fire intensity levels (FIL) with one being the least and six the most intense when fire was predicted to occur across the 10 million-ac fire behavior modeling area.

High Value Resources and Assets

Local stakeholders identified high value resources and assets (HVRAs) at two workshops convened by the SOFRC and facilitated by Joe Scott of Pyrologix LLC. These workshops were attended by 51 participants representing a wide range of local, state, and federal agencies as well as non-governmental organizations (Appendix 2). Participants assembled an initial list of 59 values for subsequent mapping. After refining the list SOFRC mapped 12 HVRAs (Figure 6), split into 32 sub-HVRAs: 12 assets and 20 resources (Tables 3, 4, and 5). An asset is a human-built structure, such as a home, or cell tower, etc. Resources are natural features such as a forested wildlife habitat or a unique species for which the distribution can be mapped. All HVRAs had a defined spatial extent and were mapped consistently across the analysis area.

A second workshop series used a carefully structured and deliberative method to integrate science and value-based information to describe the likely responses of sub-HVRAs to wildfire of varying intensities (Tables 3, 4, and 5) and weight their relative importance. This workshop was facilitated by Joe Scott (Pyrologix LLC) and Matt Thompson (Rocky Mountain Research Station). Relative importance of HVRAs varied across a range of interest groups, but the entire group quickly agreed to an averaging of importance values as representative across groups, and the result across HVRAs was largely an even importance weighting (Figure 6a). After accounting for spatial extent of each HVRA, the technical team reached agreement on calibrating adjustments of relative importance of each HVRA while also reflecting the rank order of importance from the workshop (Figure 6b). Widespread HVRAs received a relatively low importance value while rare or restricted HVRAs received relatively higher importance scores.

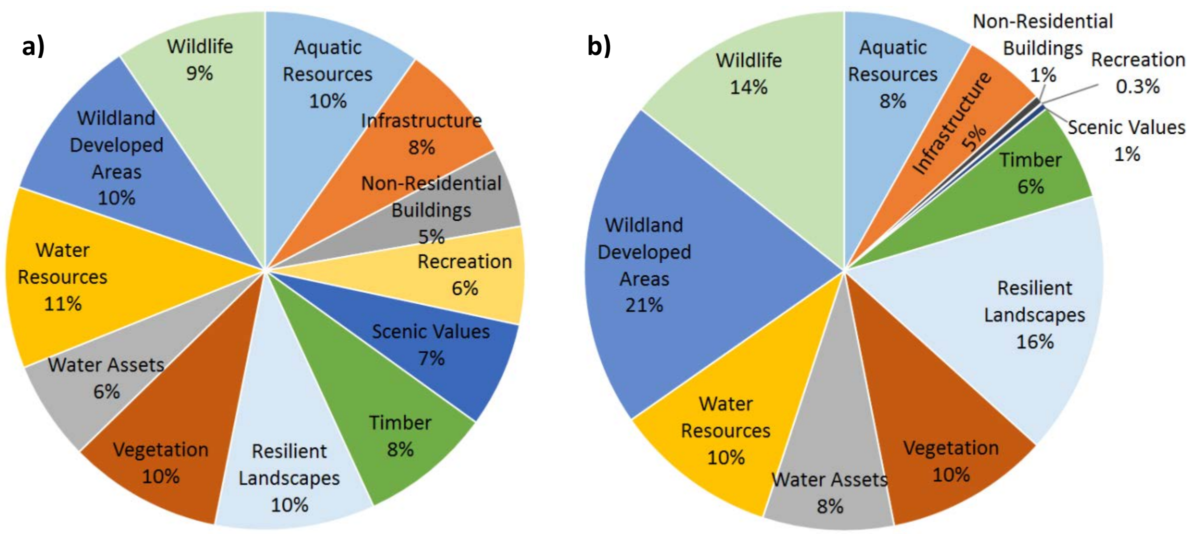


Figure 6: The relative importance of collaboratively identified high value resources and assets (a) as identified in the workshop and (b) after accounting for their relative extent and replacement value.

Photo: Pile burning in the Ashland watershed © The Nature Conservancy (Kerry Metlen)

Table 3: Five classes of assets (HVRA) were identified and mapped as 18 individual sub-HVRAs. Their likely wildfire response was classed on a scale ranging +/- 100, with -100 representing a complete removal of the asset and +100 being a 100% increase in the asset value.

		Fire Intensity Level*					
HVRA	**Sub-HVRA**	**1**	**2**	**3**	**4**	**5**	**6**
Infrastructure	Comm Sites/Cell Towers	0	0	-10	-20	-30	-30
	Electric Trans-Line/Sub	0	0	-20	-20	-20	-20
Non-residential	Fire Lookouts	0	-10	-30	-60	-100	-100
	National Park Structures	-10	-20	-40	-80	-100	-100
	Ski Area Buildings	-10	-20	-40	-80	-100	-100
	USFS Cabins/Structures	-10	-20	-40	-80	-100	-100
Recreation	Recreation Sites	-10	-20	-40	-80	-100	-100
	Ski Area (Mt. Ashland)	0	0	0	-10	-20	-40
	Pacific Crest Trail	0	0	-10	-10	-20	-20
Water Assets	Canals-Irrigation	0	0	0	-10	-10	-10
	Reservoirs - Drinking	0	0	0	-10	-20	-40
Where People Live	<1 residence /40 ac	-10	-20	-40	-80	-100	-100
	Residences 1/20-40 ac	-10	-20	-40	-80	-100	-100
	Residences 1/10 to 20 ac	-10	-20	-40	-80	-100	-100
	Residences 1/5 to 10 ac	-10	-20	-40	-80	-100	-100
	Residences 1/2 to 5 ac	-10	-40	-60	-100	-100	-100
	Residences 05. to 3/ac	-10	-40	-80	-100	-100	-100
	Residences 3+/ac	-20	-60	-80	-100	-100	-100

*Fire Intensity Level: 1 = 0-2 foot flame lengths, 2 = 2-4 foot flame lengths, 3 = 4-6 foot flame lengths, 4 = 6-8 foot flame lengths, 5 = 8-12 foot flame lengths, 6 = >12 foot flame lengths

Table 4: Four of the seven classes of resources (HVRA) identified and mapped as 27 covaried sub-HVRAs (of 48 total). Their likely wildfire response was classed on a scale ranging +/- 100, with -100 representing a complete removal of the resource and +100 being a 100% increase in the resource value.

			Fire Intensity Level*					
HVRA	**Sub-HVRA**	**Covariate**	**1**	**2**	**3**	**4**	**5**	**6**
Aquatic Resources	Chinook Distribution		10	10	10	0	-10	-20
	Coho Distribution		20	10	10	0	-30	-40
	Lamprey Distribution		10	10	10	0	-10	-20
	Resident Fish Species		10	-5	-30	-40	-60	-80
	Steelhead	Intermittent	20	10	0	0	-10	-20
	Steelhead	Perennial	20	10	0	-10	-20	-30
Resilient Landscapes**	Biophysical Settings	Seral States	Many					
Scenic Values	Scenic Byways		10	0	-20	-50	-70	-90
	Wild and Scenic rivers		10	0	-20	-50	-70	-90
Timber***	Federal Timber	Restricted (A)	10	10	-100	-100	-100	-100
	Federal Timber	Restricted (B)	10	50	-10	-100	-100	-100
	Federal Timber	Restricted (C)	20	50	-10	-100	-100	-100
	Federal Timber	Restricted (D)	30	50	30	-100	-100	-100
	Federal Timber	Restricted (E)	30	50	30	-50	-100	-100
	Federal Timber	Unrestricted (A)	10	-20	-100	-100	-100	-100
	Federal Timber	Unrestricted (B)	10	50	10	-90	-90	-90
	Federal Timber	Unrestricted (C)	20	50	10	-90	-90	-90
	Federal Timber	Unrestricted (D)	30	50	30	-60	-70	-70
	Federal Timber	Unrestricted (E)	30	50	30	-50	-60	-60
	Josephine Timber		10	20	10	-90	-90	-90
	Private Industrial		10	20	10	-90	-90	-90
	Private Non-industrial	(A)	10	-20	-100	-100	-100	-100
	Private Non-industrial	(B)	10	50	10	-35	-40	-40
	Private Non-industrial	(C)	20	50	10	-35	-40	-40
	Private Non-industrial	(D)	30	50	30	-30	-35	-35
	Private Non-industrial	(E)	30	50	30	-30	-35	-35
	State Timber		10	20	10	-90	-90	-90

*Fire Intensity Level: 1 = 0-2 foot flame lengths, 2 = 2-4 foot flame lengths, 3 = 4-6 foot flame lengths, 4 = 6-8 foot flame lengths, 5 = 8-12 foot flame lengths, 6 = >12 foot flame lengths
**Proportions of seral-structural states relative to the natural range of variation
***Federal and private non-industrial timber lands were mapped by successional class where A=early, B=mid-closed, C=mid-open, D=late-open and E=late-closed.

Table 5: Three of seven classes of resources (HVRA) identified and mapped as 21 covaried sub-HVRAs (of 48 total). Their likely wildfire response was classed on a scale ranging +/- 100, with -100 representing a complete removal of the resource and +100 being a 100% increase in the resource value.

			Fire Intensity Level*					
HVRA	**Sub-HVRA**	**Covariate**	**1**	**2**	**3**	**4**	**5**	**6**
Vegetation	Aspen		20	50	100	100	50	0
	Late-seral Forest	Dry, (D)	80	90	10	-10	-90	-100
	Late-seral Forest	Dry, (E)	70	30	-10	-50	-90	-100
	Late-seral Forest	Wet, (D)	80	90	10	-10	-90	-100
	Late-seral Forest	Wet, (E)	40	10	-30	-60	-100	-100
	Oak Woodlands		100	100	30	-40	-80	-100
	Tanoak		100	100	100	80	10	-20
	Unique/Endemic	Fire dependent	30	50	100	100	60	30
	Unique/Endemic	Fire resilient	60	70	60	60	-10	-40
	Unique/Endemic	Fire sensitive	0	-20	-40	-60	-80	-100
Water Resources	Municipal Watersheds	Ground water	10	20	30	0	-10	-20
	Municipal Watersheds	Spring source	10	20	0	-10	-30	-50
	Municipal Watersheds	Surface	10	20	-10	-40	-60	-90
	Riparian Zones		20	10	-5	-40	-80	-100
Wildlife	Deer and Elk Winter Range		10	50	50	30	10	-40
	Dispersal NSO **		20	0	-30	-60	-80	-100
	NRF NSO ***		10	-10	-40	-80	-100	-100
	Marbled Murrelet		20	10	-10	-80	-100	-100
	Mardon Skipper		-50	-100	-100	-100	-100	-100
	Oregon Spotted Frog		10	-10	-30	-40	-60	-80
	Siskiyou Mountain Salamander		20	10	0	-40	-70	-90

*Fire Intensity Level: 1 = 0-2 foot flame lengths, 2 = 2-4 foot flame lengths, 3 = 4-6 foot flame lengths, 4 = 6-8 foot flame lengths, 5 = 8-12 foot flame lengths, 6 = >12 foot flame lengths
**NSO=Northern Spotted Owl
***NRF NSO=Nesting, Roosting, and Foraging Northern Spotted Owl Habitat

Current Wildfire Risk

Relative importance, relative extent, and likely response to wildfire were combined with modeled fire behavior to generate wildfire risk across the project area for each HVRA separately and for combinations of HVRAs. This allows identification of locales with the greatest likely consequence of wildfire when it burns (conditional net value change, cNVC), as well as the likely risk due to wildfire across the landscape (expected net value change, eNVC; Scott et al. 2013). Conditional net value change (cNVC) highlights the likely effects of a fire *when* it burns, e.g. the range of potential likely negative and positive effects (Figure 7a). These conditional responses are simply multiplied by the burn probability to generate eNVC (Figure 7b); note the reduction in fire effect between cNVC and eNVC in the high Cascades, reflecting the relatively low wildfire probability in this area.

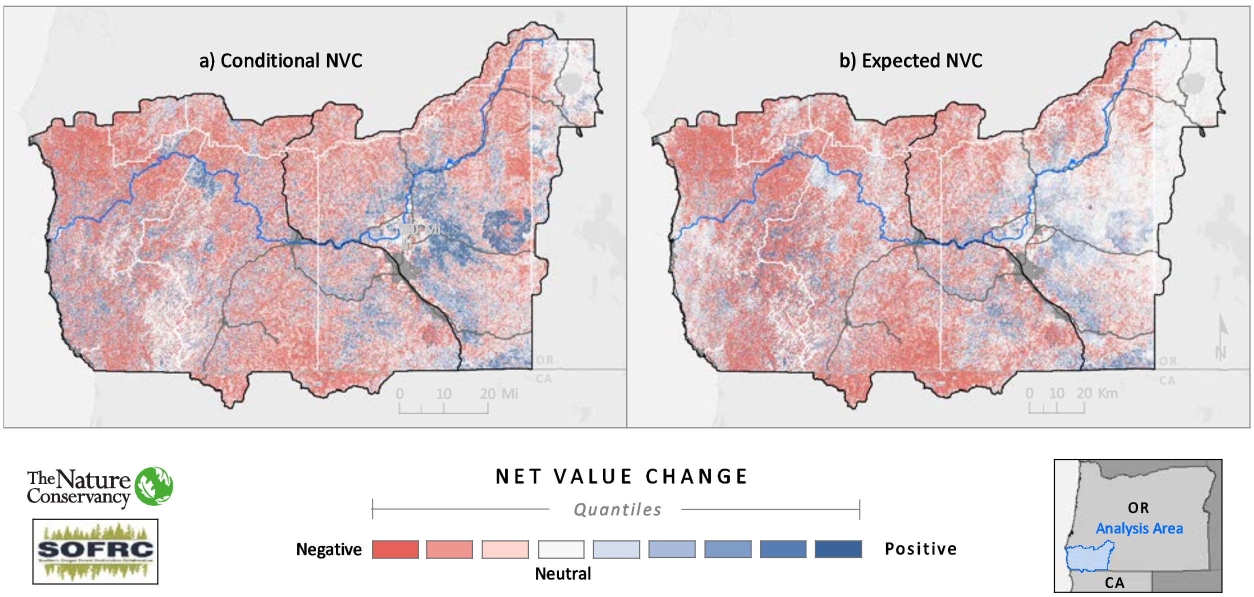


Figure 7: a) Conditional net value change (cNVC) and b) Expected net value change (eNVC) to all mapped high value resources and assets for the Rogue Basin analysis.

Probabilistic cNVC and eNVC can be used in a variety of ways to identify aggregations of potential wildfire impact, as well as the source of the fires that affected HVRAs. Similarly, the impact to HVRAs can be summed (Figure 7 or Figure 8) or used for individual HVRAs (Figure 8a, b, d). These risk data were used to prioritize risk-abatement treatments at the landscape scale, to evaluate the effectiveness of different strategies to reduce overall wildfire risk, and can be further used to inform safe and effective wildfire suppression response planning.

The patterns of likely wildfire responses vary widely across different resources and assets, and stakeholders' perceptions of risk can dramatically diverge depending on their interest and focus. On average, the effects of wildfires on deer winter range are expected to be more positive than negative (Figure 8a), contrasting sharply with largely negative predicted fire effects on timber resources, community assets, and NSO habitat (Figure 8b, c, and d). Note that the relative value of change to HVRAs also covaries; for example, risk to timber value varies among ownerships, land allocation, and successional class (Figure 8; Table 4).

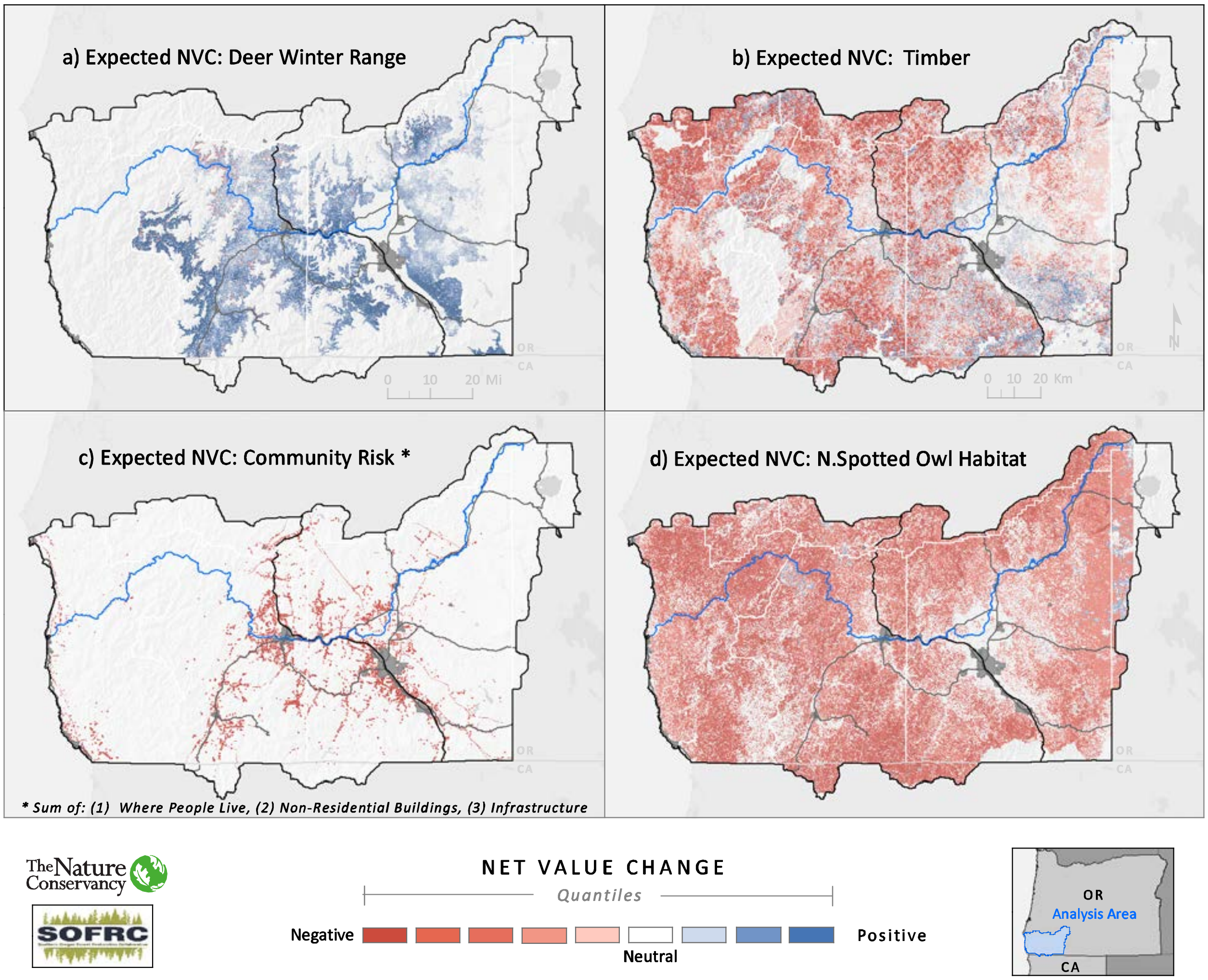


Figure 8: Expected net value change (eNVC) for a) deer winter range, b) timber value varied by ownership and land allocation (as in Table 4), c) the cumulative eNVC on assets mapped that impact community values, and d) Northern Spotted Owl dispersal, nesting, roosting, and foraging habitat.

As a rule, assets are negatively impacted by wildfire, though susceptibility and replacement cost, as well as likely fire behavior, drive variable wildfire risk (Table 3). Many assets were mapped, but a subset (e.g. infrastructure and wildland developed areas) more directly impact fire adapted communities while others are much more diffusely located and less related to human communities (e.g. elk and deer winter range). A strength of the qualitative risk assessment is the ability to sum the response of multiple HVRAs to wildfire or focus on individual HVRAs in isolation (Figure 8). For example, in Figure 8c the eNVC for three classes of assets are summed: where people live (Oregon Department of Forestry et al. 2013), non-residential structures, and infrastructure. This represents the risk to community assets, scaled to likelihood of large wildfire.

Current wildfire risk and likely benefit across the Rogue Basin varies dramatically among resources and assets, as calculated by our wildfire risk assessment and embedded response functions and burn probabilities (Figure 9). As expected, houses are the asset most at risk of detrimental wildfire effects against which all other HVRA responses are scaled. Strikingly, Northern Spotted Owl nesting, roosting, and foraging habitat (NRF) also had a very negative expected wildfire response. In part this could be due to the very general mapping of NRF, including ridges and warm midslopes that are capable of growing NRF but are also prone to more severe fire effects (e.g., Taylor and Skinner 1998, 2003). Late seral forest, federal timber, municipal watersheds, and oak woodland are notable in that on the current landscape there is potential for significant negative and positive fire effects. One goal of restoration in these habitats is to increase the potential for favorable fire effects. Tanoak has the greatest potential for positive fire effects, likely due to a very favorable response function (Table 5) reflecting the capacity for fire to set back Douglas-fir thereby favoring tanoak.

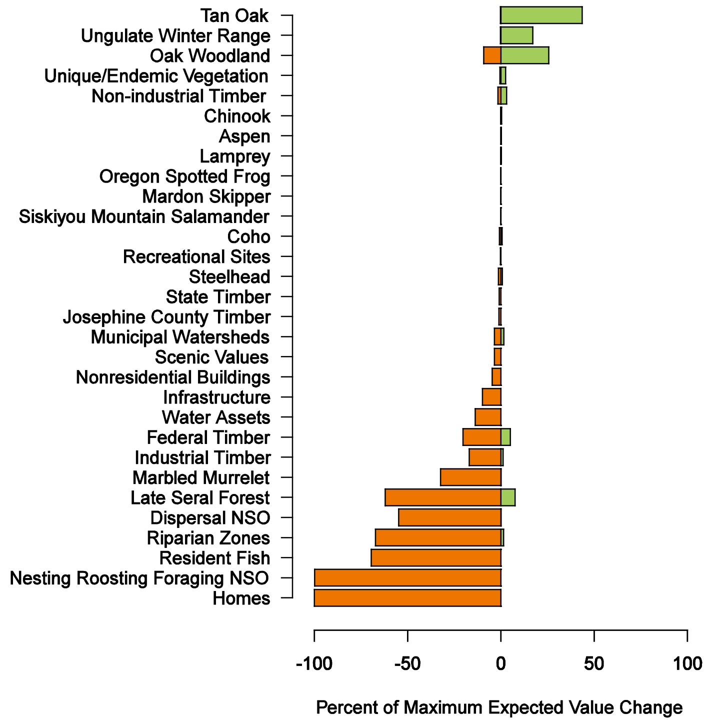


Figure 9: The relative wildfire risk of high value resources and assets mapped for the Rogue Basin quantitative wildfire risk assessment.

Photo: Controlled burning in the Ashland watershed © The Nature Conservancy (Evan Barrientos)

Landscape Management Objectives

Five landscape scale objectives were identified by the Southern Oregon Forest Restoration Collaborative to quantify priorities for mechanical treatments that mitigate wildfire risk and achieve ecological restoration (Figure 10 and Table 6, Appendix 1 data available here). These objectives directly address the National Cohesive Wildland Fire Management Strategy (Jewell and Vilsack 2014, Suh and Bonnie 2014). Consistent with the National Cohesive Wildland Fire Management Strategy resilient landscapes and fire adapted communities are primary overarching objectives. The Rogue Basin Strategy also acts on key components of the National Cohesive Strategy identified to facilitate implementation: strategic alignment, collaborative engagement, and programmatic alignment (Jewell and Vilsack 2014). This has been accomplished with broad-based collaborative meetings driving the assessment, frequent collaborative engagement at SOFRC meetings, and periodic updates and reports to the agencies. Programmatic alignment ultimately will require incorporation of SOFRC Strategy components into agency resource management plans but ongoing collaboratively-based restoration projects are already demonstrating convergence on shared goals and approaches.

Table 6: The Rogue Basin Cohesive Forest Restoration Strategy provides a framework for understanding how proposed planning areas can achieve five landscape objectives, all of which tier to key elements of the National Cohesive Wildland Fire Management Strategy National Action Plan (Suh and Bonnie 2014).

Objective	Description	National Cohesive Strategy Goals
1. Local fire community risk	Risk of fires originating within the Community at Risk	*Fire-adapted communities; Wildfire response*
2. Large wildfire community risk	Risk of fires to community assets from fires >35-ac	*Fire-adapted communities; Wildfire response*
3. Landscape resilience	Balancing the proportions of open and closed forest habitats	*Restore and maintain resilient landscapes*
4. Protecting and promoting Northern Spotted Owl habitat	Maintaining existing habitat and reducing adjacent wildfire risk while promoting complex forest in appropriate landscape settings	*Restore and maintain resilient landscapes*
5. Climate resilient landscapes	Prioritization of limited resources to landscapes most climate resilient	*Restore and maintain resilient landscapes*

Local Fire Community Risk

"Community At Risk" (CAR) focuses on a geographic area within and surrounding permanent dwellings (at least 1 home per 40-ac) with basic infrastructure and services, under a common fire protection jurisdiction, government, or tribal trust or allotment, for which there is a significant threat due to wildfire (Healthy Forests Restoration Act (HFRA) 2003). We defined our CAR beginning with the results of a statewide task force which established a uniform CAR framework for the state of Oregon (Oregon Department of Forestry 2006). This base CAR was augmented with the data on where people live generated by the West Wide Wildfire Risk Assessment using LandScan data from 2009 and people per housing unit from 2010 census data, integrated with a rigorous methodology (Oregon Department of Forestry et al. 2013).

The SOFRC's quantitative wildfire risk assessment did not analyze potential consequence of fires smaller than 35-ac. Suppression capabilities within the CAR generally keep fires small, although fires smaller than 35-ac have potential to impact community values due to highly aggregated assets. The West Wide Wildfire Risk Assessment (WWRA; Oregon Department of Forestry et al. 2013) utilized an ignition density grid of all fires, including the very small fires that can have high consequence for communities. Correspondingly, we supplemented our large fire risk assessment by creating a layer for Local Fire Community Risk using the Fire Risk Index from the WWRA within a 0.25-mile buffer of the SOFRC Communities at Risk (Figure 10a).

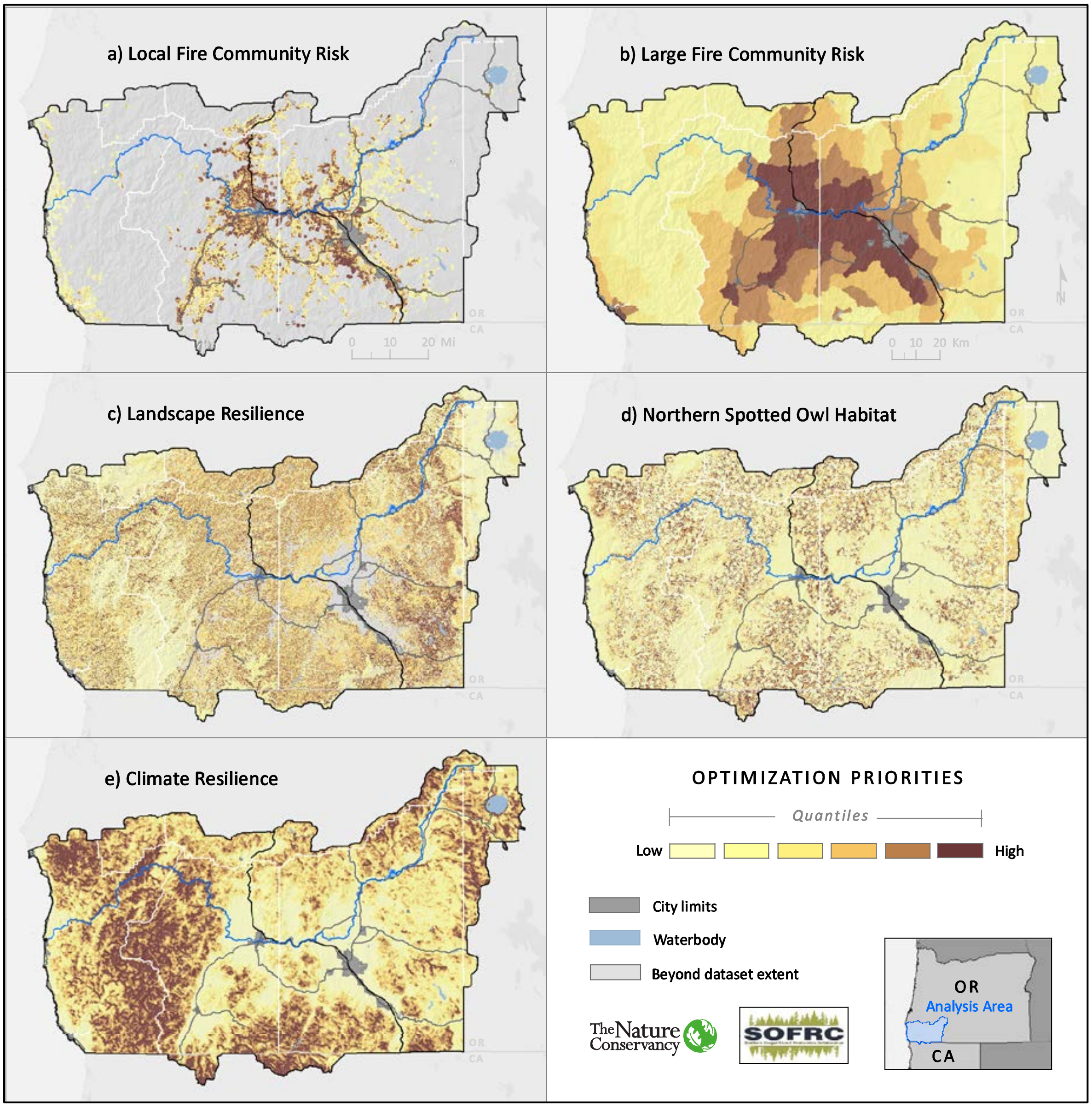


Figure 10: Fuel reduction treatments and forest restoration thinning were prioritized across the Rogue Basin project area based on five priorities a) fuel reduction to reduce local fire community risk b) fuel reduction to reduce large wildfire community risk c) thinning to promote landscape resilience d) thinning to promote and protect complex forest habitats e) thinning in settings likely to be resilient to climate change.

Large Wildfire Community Risk

The quantitative wildfire risk assessment developed for the Rogue Basin modeled likely large wildfire intensity for fires >35-ac and produced a quantified large wildfire risk metric for every pixel for all collaboratively derived resources and assets. Community assets evaluated for large wildfire community risk were: where people live (Oregon Department of Forestry et al. 2013), non-residential structures, infrastructure, and the only surface-water municipal watershed (Ashland, OR) in the analysis area. We summed the conditional net value change for each of these assets for every simulated wildfire, and then attributed the ignition source for those modeled fires with the likely consequence of that fire for our community assets. We then calculated the average cumulative conditional net value change to community assets for each 12-digit/6th level hydrologic unit code (HUC) to quantify the watersheds where ignitions are most likely to have consequences to communities (Figure 10b). The intent was to guide fuel reduction treatments, in part, toward locations most prone to producing wildland fires that damage the community.

Landscape Resilience

Treatment priority for landscape resilience incorporates vegetation departure from the natural range of variability and topographic position (Figure 10c). Treatments were prioritized to restore resilient landscapes by addressing ecological departure as in Haugo et al. (2015), utilizing data from appendices to the published paper. The data describe the potential vegetation type (PVT) and the successional class (s-class) for each 30-meter pixel, as well as the status of that s-class attributed as similar, deficit, or excess relative to the natural range of variability (NRV) at the appropriate landscape analytical extent for the vegetation type (Haugo et al. 2015).

In southwestern Oregon, the predominant biophysical settings (vegetation communities) tend to have much more closed canopied mid-seral forest than found in historically resilient landscapes and a profound deficit of late-open forest (Figure 11). In appropriate landscape settings, late-closed forest can be thinned to restore late-open forest that has been lost. However, the primary management action to rebalance landscape resilience is to thin mid-closed forest to restore mid-open and to accelerate develop of late-seral forest.

Landscape analytical spatial extent is a key context needed to understand the status of a particular s-class relative to the natural range of variability and it is tied to the frequency

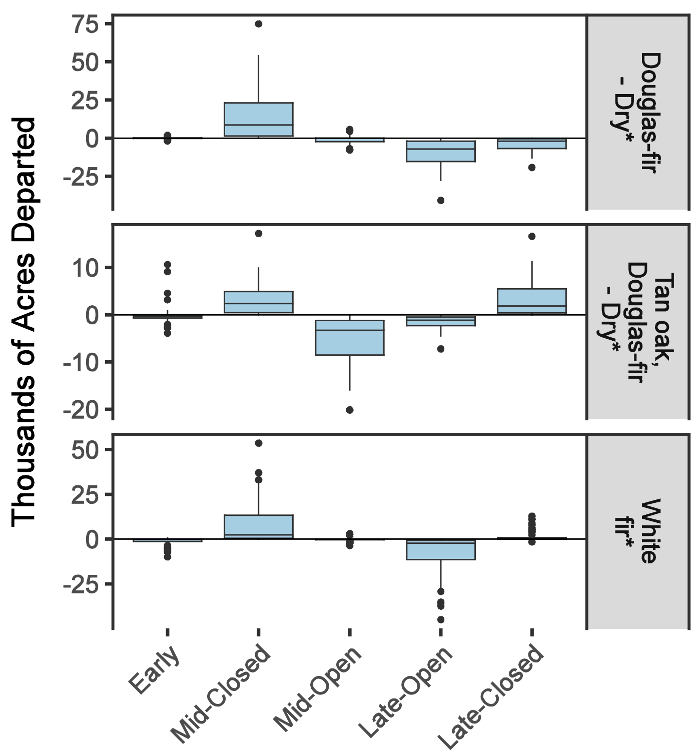


Figure 11: Landscape scale ecological departure for three of the most abundant biophysical settings in the Rogue Basin. Departure is calculated as the difference in abundance of seral states relative to the natural range of variability. Boxplots are acreage of departure.

*Douglas-fir dry = Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland, covering 1 million ac
Tanoak Douglas-fir – Dry = California Mixed Evergreen North, covering 431,519 ac
White-fir = Mixed Conifer Southwest, covering 710,782 ac

and severity of fires, generalized by fire regime groups associated with vegetation types (LANDFIRE 2010). Fire regime groups I and III are characterized by low-mixed severity fire regime at <35 or >35 years respectively. Fire regime group II is characterized as frequent, high severity and not found in forests of the analytical area. Fire regime groups IV and V are characterized as high severity of 35-200 and >200 years respectively. Conditions for fire in fire regime groups IV and V are driven by extreme weather events and thus fires tend to be larger and more uniform than fire in fire regime groups I and III which tend to be more fuel limited. Because of the long temporal and large spatial scales at which fire regime groups IV and V function, these forests were not included in prioritization of planning areas where mechanical thinning could address landscape resilience.

To identify appropriate places to apply restoration treatments we first identified two strata: biophysical settings associated with Fire Regime I and III (excluding subalpine woodland), in a closed s-class, evaluated at the appropriate landscape scale (Appendix A, Haugo et al. 2015). For fire regime group I this was the 10-digit/5th level hydrologic unit code (HUC), which averaged 84,993-ac across our project area. For fire regime group III the 8 digit/4th level HUC was used, averaging 633,169-ac across our project area.

Topographic position and solar insolation are important facets that influence vegetation composition and structure (Lydersen and North 2012). We attempt to recouple vegetation patterns with topographic facets (sensu Hessburg et al. 2015) by prioritizing thinning treatments on appropriate landscape positions. The vegetation data were intersected with solar insolation and topographic position creating two facets: bottoms and cool midslopes as appropriate locations to maintain more closed forests and ridges and warm midslopes as locations to more actively promote open forest. Thus, strata facets were the intersection of biophysical setting, s-class, topographic position, solar insolation, and landscape scale analytical unit.

Thinning relatively small, shade tolerant trees to reduce canopy cover, and to protect and promote larger trees was prioritized in excess late-closed forest if it was in appropriate landscape positions -- ridges or warm mid-slopes. The greater weight given to thinning excess late-seral forest in these settings was to represent the significant greater ecological investment in growing large old trees. Thinning was also prioritized in mid-seral closed stands on ridges and warm mid-slopes, landscape settings which are most appropriate for more open conditions (Table 7). Priority for treatment to open the forest from closed s-classes to open s-classes was calculated using Equation 1, giving an alternating ridge/bottom pattern of priority across the entire project area (Figure 10c). Across the 4.6 million-ac project area, 4 million-ac were vegetated, with 2.7 million-ac in strata where thinning could be appropriate (s-class B or E, fire regime I or III). Across these strata there were 2.1 million-ac of excess closed forest, suggesting a need for active treatments to promote more open forest conditions on about 51% of the forested landscape (Figure 10c).

$$\text{Equation 1: } \boldsymbol{Ecological\ Departure\ Priority = M_D * (\frac{E}{C})}$$

Where:

M_D = Priority Multiplier from Table 7
E = Excess acres of that strata facet
C = Current acres of that strata facet

Table 7: Priority for thinning forests to promote landscape resilience was limited to closed seral classes (s-classes) and favored in appropriate topographic positions (facets).

S-class (Code)	Facet	Priority Multiplier
(E) Late-closed	Ridges and warm mid-slopes	**2**
(B) Mid-closed	Ridges and warm mid-slopes	**0.5**
(B) Mid-closed	Bottoms and cool mid-slopes	**0.3**
(E) Late-closed	Bottoms and cool mid-slopes	**0.2**
(C) Mid-open	All	**0**
(E) Late-open	All	**0**
(A) Early	All	**0**

Northern Spotted Owl Habitat

Development and maintenance of complex forest associated with Northern Spotted Owl (NSO) habitat in accordance with NSO recovery actions RA 10 and RA 32 (U.S. Fish & Wildlife Service 2011, 2013) of the revised recovery plan (U.S. Fish & Wildlife Service 2011), and NSO critical habitat designation (U.S. Fish & Wildlife Service 2012) is an essential feature of the Strategy (Figure 10d). First, the Strategy identifies important nesting, roosting, and foraging habitat (NRF) to retain, based on relative habitat suitability (RHS; U.S. Fish & Wildlife Service 2013) and activity areas based on historical ½ mile core activity areas. Then, the Strategy prioritizes active management to reduce risk of delivering severe wildfire to existing NRF habitat, develop future habitat in appropriate landscape positions, and focus on ecological restoration as the overriding management theme throughout the landscape.

Treatment areas were prioritized based on existing NSO habitat and two classes of RHS (U.S. Fish & Wildlife Service 2013). Existing NSO habitat was modeled using the GNN data (Landscape Ecology Modeling Mapping and Analysis (LEMMA) 2014) and locally derived vegetation thresholds (U.S. Fish & Wildlife Service 2013) to identify NRF and dispersal habitat. The RHS layer utilized the same GNN data but also incorporated abiotic and biotic variables (e.g. slope position, aspect, and core use area size) that are associated with successful NSO habitat use patterns (U.S. Fish & Wildlife Service 2011). For this analysis, areas classified as high RHS ranged from 35-127 and low RHS was classified <35. These classifications were identified by Rogue Basin FWS, BLM, and USFS wildlife specialists and informed by the NSO recovery plan (U.S. Fish & Wildlife Service 2013). Combinations of existing NSO habitat and RHS were used to identify treatment priorities and objectives (Table 8).

Meaningful aggregations of habitat were emphasized by running a majority filter on modeled existing habitat. The majority filter was based on the classification of the neighboring eight cells, and we then ran a boundary clean function. To ensure treatment placement would optimally reduce wildfire risk to existing NRF in high RHS, an adjacency function was used where pixels closer to existing NRF in high RHS were prioritized for treatment. Wildfire risk was also considered by including the expected net value change to NRF and dispersal habitat for that pixel. These factors were combined as in Equation 2 to rank forests for thinning to promote and protect complex forest habitats (Figure 10d).

This analysis utilized remotely sensed data to inform landscape objectives, planning area prioritization, and estimates of likely work needed relative to NSO objectives. As on-the-ground projects are developed, **site-specific analysis will be needed for every project** to appropriately balance short-term impacts and long-term benefits for NSO conservation and other objectives**.**

Equation 2: $Northern\ Spotted\ Owl\ Priority = M_{NSO} * 1/D_{NRFH} * R_{Habitat}$

Where:

M_{NSO} = Priority Multiplier from Table 8
D_{NRFH} = Distance to High RHS NRF scaled to max
$R_{Habitat}$ = Wildfire risk to NSO NRF or dispersal habitat for that pixel scaled to the maximum value

Table 8: Northern Spotted Owl (NSO) existing habitat and relative habitat suitability (RHS) classes used to prioritize active management. Priority of 0 indicates no proposed treatment. Priorities are further weighted by adjacency to existing nesting, roosting and foraging (NRF) habitat in high RHS settings. Site specific review is critical for every project.

Abbreviation	Definition	Objectives	Priority Multiplier
NRF high anywhere and NRF low within ½ mile known core	Existing NRF in high RHS or within any historic core	No treatment	**0**
Dispersal high (Near Range NRF)	Dispersal habitat in high RHS setting	Promote development to NRF by thinning single canopied dense stands	**1.5**
Capable high (Long Range NRF)	Capable habitat in high RHS setting	Promote development to dispersal by thinning in young stands	**1.4**
NRF low	Existing NRF in low RHS **Outside of ½ mile core**	Reduce wildfire risk to adjacent NRF and encourage ecological resistance by maintaining large trees and more open forest in ecologically appropriate settings	**1.3**
Dispersal low	Dispersal habitat in low RHS settings	Thinning to promote ecological resilience while maintaining NSO dispersal capability at the landscape scale	**1**
Capable low	Capable habitat in low RHS settings	Thinning to promote ecological resilience while maintaining NSO dispersal capability at the landscape scale	**1**

Climate Resilient Landscapes

The Strategy employs climate adaptation approaches recently highlighted for the Rogue Basin by Halofsky et al. (2016). We prioritize forest restoration and fuel reduction treatments in landscapes likely to be resilient to climate change as mapped by Buttrick et al. (2015) and then rescaled to our project area (Figure 10e). These settings tend to have high geophysical diversity and relatively high landscape permeability to migration. With robust protections for complex forests in bottoms and cool midslopes, climate resilient landscape settings are important locations to focus on thinning and fire intended to maximize biodiversity retention and increase the capacity to adapt to climate change on ridges and warm midslopes.

Across the Pacific Northwest there is a fire deficit, meaning that historically forests would have experienced more frequent fires than they do currently, and current weather patterns would support far more fire than currently exists on the landscape (Marlon et al. 2012, Reilly et al. 2017). Contrasting with a reduced footprint of fire, the size of high severity patches is growing (Reilly et al. 2017). Large patches of high severity fire can fail to regenerate with conifers due to proximity to seed source (Donato et al. 2009), Abella and Fornwalt (2015), harsh environmental conditions, and competition from other vegetation (Bonnet et al. 2005, Dodson and Root 2013). High severity patches can subsequently burn at high severity, creating a self-reinforcing dynamic that moves communities from forest to shrub or grassland (Thompson et al. 2007, Airey Lauvaux et al. 2016, Coop et al. 2016, Coppoletta et al. 2016).

Mechanical restoration treatments combined with low-mixed severity fire to promote forests with large fire resistant trees are proposed to facilitate dry-forest adaptation to a changing climate while minimizing undesirable state changes (McKinley et al. 2011, Stephens et al. 2013, Hessburg et al. 2016). This approach relies on identifying threshold-inducing events, be they fire, drought, insects, or disease and develop effective risk mitigation strategies (Millar and Stephenson 2015, Golladay et al. 2016). In this context, fuel reduction treatments are important to mitigate wildfire effects (Safford et al. 2012, Martinson and Omi 2013) and to provide opportunities to beneficially manage fire to facilitate climate adaptation at larger scales (Hessburg et al. 2016, Schoennagel et al. 2017).

Restoration Needs by Treatment Theme

To estimate the amount of work needed to achieve landscape management objectives, we developed a structural restoration needs component into the Strategy that evaluates existing vegetation, and the trees that would be removed to achieve landscape objectives. By accounting for treatment intensity, accessibility, and resale of merchantable material this assessment provides a transparent budgeting of the economics underpinning the Strategy. Central to this assessment is the designation of three landscape treatment themes, each with distinct management guidance that vary by biophysical setting and treatment objective. These treatment themes articulate a target stand density and structure, given that treatment is recommended to achieve landscape goals.

Landscape Treatment Themes:

1) **Fuels Management** – This area occupies a quarter-mile buffer around Communities at Risk as defined in the risk assessment and is largely not in public ownership, limiting access. Here, fire resistant forests of larger trees and simple structure are promoted and the primary goal is to reduce asset losses from fire and create safer suppression conditions by reducing surface and ladder fuels and raising canopy height.

2) **Complex Forest Habitat** – This area identifies the dense, multi-story forest favored by the Northern Spotted Owl and other species and values consistent with older, complex forest.

    a. **Existing high quality** Northern Spotted Owl (NSO) habitat within older, complex forests and supporting other critical species is protected and where no treatments will occur.
    b. **Near-range emerging** NSO habitat where light thinning will promote multiple canopy layers in relatively simple stands with large trees, accelerating development to high quality complex habitat within 50 years. Treatments to improve habitat function may generate timber byproducts.

c**. Long-range potential NSO habitat** where more thorough thinning is needed in young stands to accelerate development of large trees with large branches and deep crowns, providing high-quality complex habitat within 50-100 years. Treatments to improve habitat function may generate timber byproducts.

3) **Ecosystem Resilience and Forest Productivity** – This treatment theme embraces broad forest management objectives. Restoration of open forest habitats and promotion of fire and drought resistant tree species is expected to promote long-term sustainable forests resilient to a variety of stressors, and in combination with controlled burning management, the potential to provide economic return from harvest. Restoration goals of this treatment theme include:

i. Maintain and restore diversity of habitat, species, and stand structure
ii. Reduce loss to fire, insects, and drought (increase resistance and resilience)
iii. Conserve old trees and stands in and outside complex forest habitat areas
iv. Establish conditions for controlled underburning to maintain landscape resilience
v. Foster conditions for timber production using restoration forestry principles
vi. Generate ongoing products and employment through long-term maintenance/timber harvest

Treatment themes outline compositional and structural goals from a desired ecological restoration and fire response perspective, with timber production derived only as a byproduct of meeting restoration goals. The guidance is robust, yet allows managers flexibility to use site specific actions as projects and plans require. Where active management is proposed, managers will use a blend of ecologically restorative thinning to maintain forests with reduced density and prescribed fire to reduce fuels and return natural processes (sunsu Franklin and Johnson 2012, Hessburg et al. 2016). Openings will be created to maintain existing shade intolerant trees (e.g. pines and oaks), foster their regeneration, and restore understory plant diversity. Initial treatments should provide flexibility for future management, anticipating that sustained forest resilience will be fostered through an appropriate blend of under-burning, mechanical treatments, and merchantable harvest, tiered to historic fire return intervals, stand productivity, and management designation.

Estimation of Restoration Need

The most abundant PVTs in the mapped available and accessible landscape are Douglas-fir – Dry, White fir – Intermediate, and Tanoak – Douglas-fir – Moist (Appendix 4). Density targets for each treatment theme in terms of Relative Density Index (RDI) and Stand Density Index (SDI) are provided in Appendix 5 and vary by treatment theme, vegetation type, and solar insolation. Proposed density targets and associated removals are used to guide prescription development and are the basis of estimated trees/acre to be removed and subsequent restoration byproduct volume as well as investment needed.

Acres of work, the number of trees to be removed, and restoration byproduct volume was calculated by comparing desired stand density and structure to existing vegetation using collaboratively derived restoration targets and existing vegetation data from GNN (Landscape Ecology Modeling Mapping and Analysis (LEMMA) 2014). This analysis predicted likely work needed and restoration byproduct timber volume produced in treated areas at the resolution of 30 m x 30 m (0.22-ac). Meaningful aggregations of volume were emphasized by running a majority filter with an 8 cell neighborhood on predicted restoration volume. We then ran a boundary clean function to remove very isolated pixels. Average current conditions and treatment intensities vary across the treatment themes with the greatest basal area in the existing complex habitat but the highest density of trees per acre in the long-range treatment theme (Figure 12). Similarly, for actively managed treatment themes the target densities vary across the tree diameter distribution (Figure 13). As articulated below, restoration work needed was further summed to a 27-ac grid (fishnet) for identification of potential treatment areas.

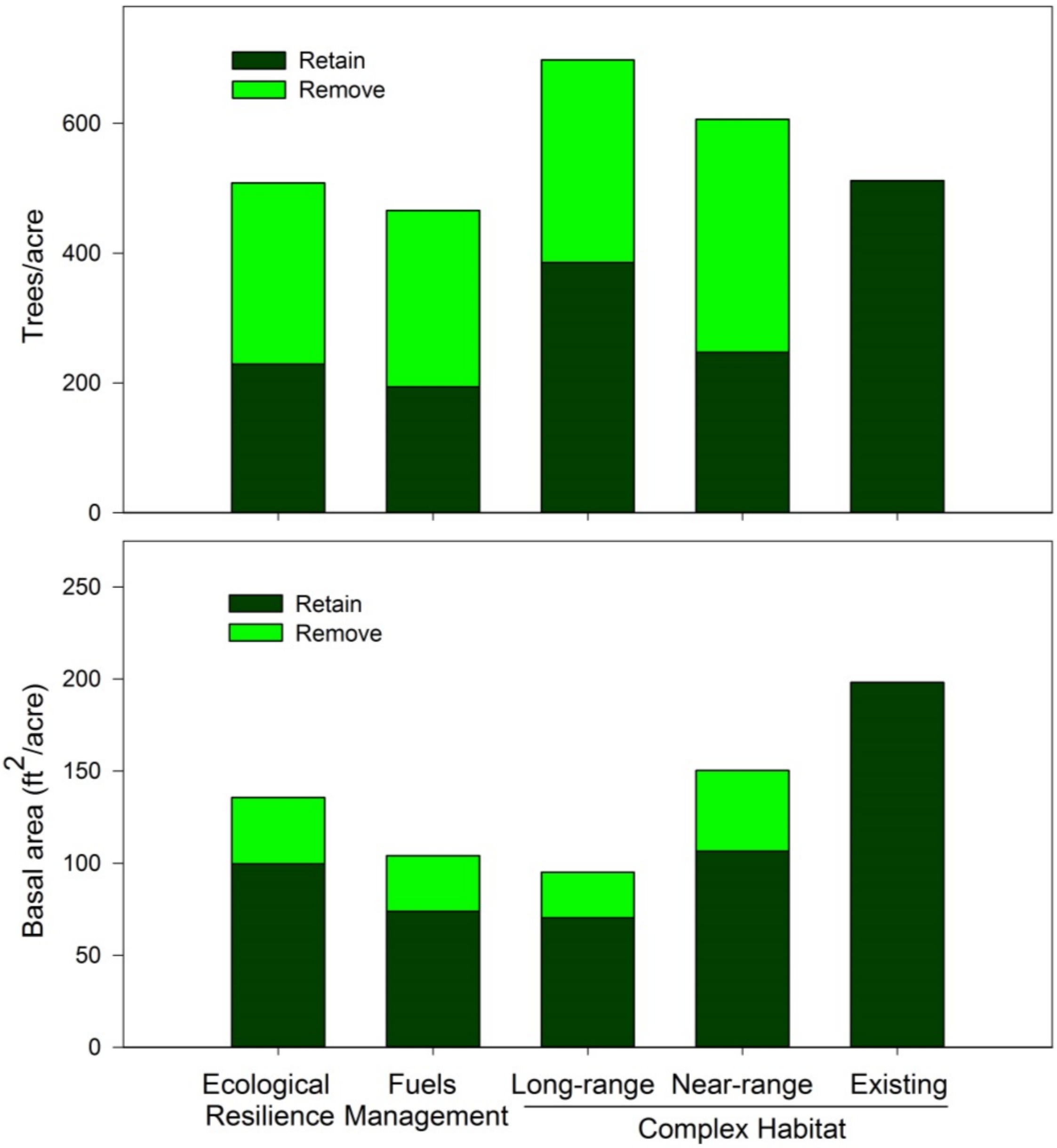


Figure 12: Average existing trees per acre and basal area for each of the treatment themes with proposed trees retained (dark green) and removed (light green) through application of SOFRC restoration strategies to the available and accessible portions of the analysis area. Existing complex habitat that would not be treated is included for comparison.

To evaluate assumptions about how treatments would affect canopy cover, a key metric of forest structure, we used the Forest Vegetation Simulator (FVS; Dixon 2002) on a subset of plots representative of the PVTs that together make up 57% of the potentially treatable landscape. For each actively managed treatment theme we selected the 5 most abundant PVT/insolation classes. This evaluation suggests that the post treatment canopy cover will be marginally higher (~4%) in cool insolation settings than in warm insolation settings, and will average about 42%, 48%, 44%, and 54% canopy cover for the ecological resilience, fuel management, long-range complex, and near-range complex treatment themes respectively. Post treatment canopy cover will be lowest in the least productive PVTs, most notably the Oregon white oak PVT with an average post treatment canopy cover around 25%.

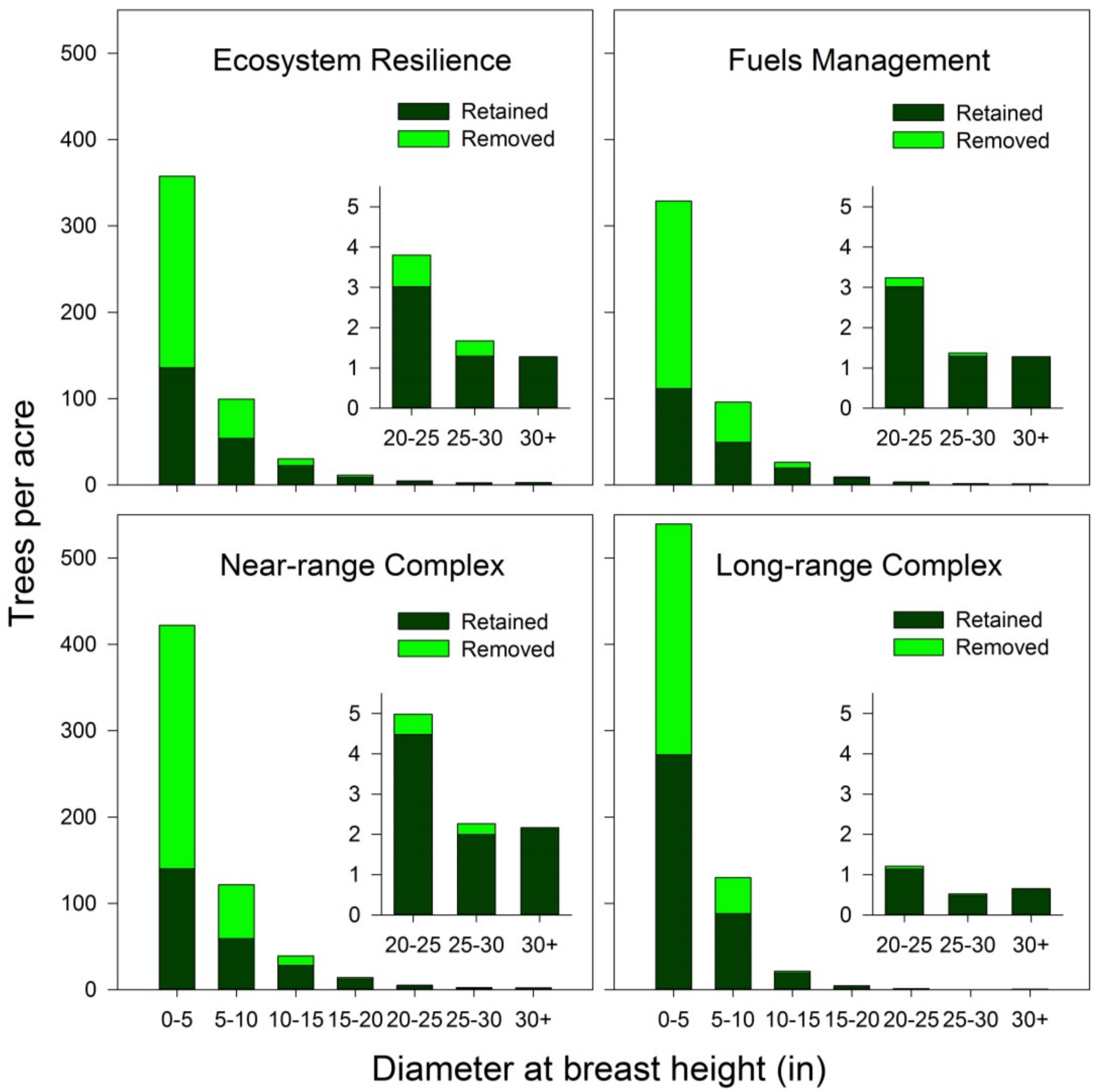


Figure 13: Average existing trees per acre by diameter class (inches) by treatment theme for the available and accessible portions of the analysis area. Application of the SOFRC restoration treatment themes will retain (dark green) or remove (light green) an average number of trees per acre. Inset focuses on trees >20 in. diameter at breast height. The comparison with existing complex habitat is not provided here.

Treatment Placement Filters

Treatment placement was constrained by filters to quantify byproduct timber volume and likely receipts and conform to land allocation and ecological considerations for no-treatment areas.

Restoration Byproduct Timber

Potential restoration byproduct merchantable volume was calculated as above in the structural restoration needs assessment. To clarify merchantable timber availability and advance the efficiency of restoration projects which include timber harvest, SOFRC generated a logging systems and access tool that considers the existing transportation system, topography, and operations awareness to inform potential project scope and design (Table 9). The tool identifies considerations such as fish streams, owl cores, major highways, ridges, and uphill units to categorize accessibility by harvest system (i.e., tractor, cable, mixed). It also identifies the part of the landscape with access only by helicopter which require strong markets and logistical fine-tuning. We mapped areas with access, limited by the existing system of roads, excluding areas which would require new road construction for access (Table 9). Costs were modeled based on work needed and predicted restoration byproduct of merchantable volume aggregated to a 27-ac fishnet and predominant yarding system for that 27-ac cell (Table 10).

Table 9: Accessibility by ownership and vegetation type under the existing road network (acres). Bureau of Land Management (BLM) and US Forest Service (FS) lands are predominately Medford District BLM or Rogue River Siskiyou National Forest, but include 117,000-ac of neighboring agency lands.

Accessibility/Vegetation	BLM	USFS	All Others	Total
Accessible	475,003	670,966	1,153,850	2,299,820
Forest	453,253	638,485	936,945	2,028,683
Non-burnable	17,576	27,940	176,127	221,644
Non-Forest, Burnable	4,174	4,541	40,778	49,493
Helicopter accessible	383,480	603,198	483,936	1,470,614
Forest	373,942	593,477	414,914	1,382,333
Non-burnable	4,945	6,253	52,364	63,562
Non-Forest, Burnable	4,593	3,468	16,658	24,720
Limited access	58,880	545,323	197,872	802,075
Forest	56,609	536,311	154,777	747,698
Developed	386	3,541	32,149	36,076
Non-Forest, Burnable	1,885	5,470	10,945	18,300
Total	**917,363**	**1,819,488**	**1,835,658**	**4,572,508**

Table 10: Cost to remove merchantable product, determined by yarding system and density of restoration byproduct volume (in thousands of board feet /acre; MBF/ac).

Logging system	Definition	Restoration byproduct (MBF/ac)		
		< 2	2-6	>6
Skidder	Accessible via existing roads with slopes <35%	$350	$275	$250
Short cable	200-800 downhill of existing roads	$633	$413	$322
Long cable	800-1600 downhill of existing roads	$800	$675	$400
Helicopter	Within ½ mile of existing roads	$1,575	$922	$664
Limited	Inaccessible via existing road system	**Inaccessible**		

No-treatment Filters
Congressionally withdrawn lands (i.e. wilderness) were excluded from the analysis of restoration need. Conservation-oriented management designations (including Late Successional Reserves, Inventoried Roadless Areas, Research Natural Areas, and National Monuments) were included as candidates for mechanical treatment, but ecological benefits of restoration thinning are the sole justification for mechanical treatments in land designations outside of those allocated for timber production. As such, greater scrutiny will be provided for projects in these management allocations even though the urgency of protecting existing fire dependent late seral forest and Northern Spotted Owl habitat may prioritize work in these areas over projects where ecological values have fewer administrative protections. Though not explicitly excluded, all roadless areas limit access to treatable stands for the lack of roads and no new road construction is modeled in the Strategy. As a result, when restoration thinning is modeled for Inventoried Roadless Areas, they are within ½ mile of existing system roads.

The federal land alternatives focused on the RRS and MBLM. The All-lands alternative treated all ownerships equally. While the All-lands strategy includes minimal acreage of the Klamath, Umpqua, and Fremont-Winema National Forests as well as the Roseburg District BLM, treatment priorities will of course need to be assessed for those administrative units in their entirety. They are only included here from a neighbor-effects perspective.

No treatment was identified for Northwest Forest Plan riparian reserves, Northern Spotted Owl existing NRF in high RHS locations, and all historical ½ mile NSO cores. Site-specific surveys may alter these no-treatment areas. Riparian reserves were mapped using the National Hydrography Dataset (USGS NHD 2015) with perennial streams buffered by 300 feet and intermittent streams buffered by 150 feet. Northern Spotted Owl nest cores will be evaluated with project level surveys and a hierarchical approach as articulated in RA 10 (U.S. Fish & Wildlife Service 2013).

Within the existing framework 47% of the landscape is available for active management and within ½ mile of existing system roads (Table 11). This percentage is much lower for federal management scenarios, which incorporate significant wilderness and unroaded areas, while an all lands approach inherently incorporates a higher proportion of heavily roaded forest and woodland adjacent to where people live. Viewed another way, 83% of the total assessment area is potentially accessible for treatment, but only 57% of the accessible area is available for treatment, due largely to riparian reserve and NSO habitat filters, parts of which overlap.

Table 11: Filters used (acres) to determine where treatments could potentially be placed. The portions of the landscape unavailable for treatment often substantially overlap.

	BLM	USFS	All Others	Total	Percent of Grand Total
Accessible	**851,621**	**1,275,468**	**1,637,154**	**3,764,243**	**83**
Developed/unburnable	22,966	34,325	226,810	**284,100**	**6**
Congressionally Reserved	14,839	60,655	440	**75,935**	**2**
Riparian Reserve*	165,524	297,144	301,708	**764,376**	**17**
Northern Spotted Owl**	211,666	334,665	122,551	**668,882**	**15**
Inaccessible* **	**58,279**	**542,408**	**196,164**	**796,851**	**17**
Available	137,360	17,682	135,861	**290,903**	**6**
Developed/unburnable	406	3,559	32,057	**36,022**	**1**
Congressionally Reserved	24,413	319,171	1,127	**344,711**	**8**
Riparian Reserve*	9,982	118,504	17,291	**145,777**	**3**
Northern Spotted Owl**	13,062	86,301	11,969	**111,332**	**2**
Available and Accessible	470,715	640,550	1,034,749	**2,146,014**	**47**
Unavailable and/or Inaccessible	439,186	1,177,326	798,568	**2,415,080**	**53**
Grand Total	**909,901**	**1,817,876**	**1,833,318**	**4,561,094**	

*National Hydrography Dataset perennial streams buffered by 300 feet and intermittent streams buffered by 150 feet

** Existing Northern Spotted Owl nesting, roosting, and foraging habitat in high relative habitat suitability settings or within historical nest cores

***Otherwise available for treatment, but >1/2 mile from existing system roads

Optimizing Management Scenarios

The Rogue Basin Strategy identifies priorities and aggregates data to inform management decisions at a landscape scale. Data for wildfire risk, landscape scale objectives, treatment themes, and accessibility can be used separately at multiple scales, but we also identify and prioritize 96 project areas (Appendix 1; available here). These project areas are based on hydrologic units (watersheds), and they average 45,000-ac in size, containing an average of 9,000-ac of treatable and accessible forest on federal ownership under the existing system roads. Planning area boundaries were created in a systematic way to allow an evenhanded evaluation of the landscape.

We used the optimization software Marxan (Ball and Possingham 2000) to compare potential treatment areas for their ability to perform on the five landscape objectives: 1) mitigating local fire community risk, 2) mitigating large wildfire community risk, 3) promoting resilient landscapes by addressing ecological departure, 4) protecting and promoting Northern Spotted Owl habitat, and 5) promoting landscapes resilient to climate change (from Figure 10). The Marxan algorithm randomly selects a set of potential treatment units and then randomly adds or removes units, iteratively identifying improvements to this initial solution, as measured by a mathematical expression of the landscape objectives (objective function). The solution for each iteration is compared with the prior solution, and the best of 250 million iterations is retained. Simulated annealing (Kirkpatrick et al. 1982) was used to search for optimal solutions, thus greatly increasing the chances of converging on a highly efficient solution. This process was done three times to generate solutions for the three management scenarios (Figure 14). For a detailed description of the methods used to parameterize and use Marxan see Appendix 6 (available here).

As primary inputs, Marxan requires a landscape of polygons to provide the costs and benefits of inclusion in potential projects. To optimize the tradeoff between analysis resolution and processing time we chose to use a 27-ac fishnet grid. This fishnet grid was populated using base data that often was mapped on a 0.22 -ac pixel. For categorical variables, we assigned the classes with the greatest representation (majority) of underlying finer resolution cells to the fishnet cell. For continuous variables, we summed across the underlying cell values, or in the case of the Northern Spotted Owl prioritization we used the average value. To prioritize planning areas, the Marxan optimization scores from potential treatment units modeled for treatment for that scenario are aggregated to the planning area and are available in the RBS_Planning_Areas feature class of the RBS_Components geodatabase in (Appendix 1, available here). *Note: "RBS" is the acronym used for the Strategy in the geodatabases*

20-year Management Scenarios

Three management scenarios serve as book-ends for 20-year alternatives (Figure 14) to evaluate landscape management outcomes. Management scenarios were developed through an iterative process using Marxan (Appendix 6). Performance of the scenarios on moderating wildfire risk, restoring resilient landscapes, protecting and promoting complex forest habitat, and economic concerns allows tradeoffs to be evaluated at a landscape scale. The management scenarios also provide a context for interpreting the importance of work in one planning area relative to other planning areas across the Rogue Basin, assuming the work implemented conforms to the Strategy principles of protection, proactive treatment, and follow-up maintenance. All scenarios assume wilderness, Northwest Forest Plan riparian reserves, and core Northern Spotted Owl habitat will not be mechanically treated (Figure 14).

The **Business as Usual** scenario is based on the last 5 years of work on the Rogue River-Siskiyou Mountains National Forest and the Medford District BLM. Over 20 years it assumes treatments covering 9,000 ac/year. The Marxan optimization prioritizes treatments based on timber economics and an even weighting of the five landscape objectives (Figure 10), while limiting treatment to only 11% of a given planning area.

The **Maximum Federal** scenario entails increased pace and scale, with treatment of all treatable and accessible Forest Service and BLM lands within the analytical area (0.9 million acres), assuming *no new system roads* with a maximum ½ mile helicopter haul. Prioritization of treatments is based solely on performance in the five restoration objectives (Figure 10). This scenario clearly would require a major scaling-up of federal workforce capacity to plan and administer contracts to accomplish the work, as well as a revitalization of local workforce capacity to accomplish the work. It assumes that all forested lands outside of wilderness, riparian reserves, or core Spotted Owl habitat have the potential to be treated mechanically if ecologically beneficial.

The **All Lands** scenario builds on the Maximum Federal scenario – strictly Federal forest restoration projects -- to improve risk reduction to communities, growing the footprint of fuels treatment across all lands to treat up to 40% of the Community at Risk (1.1 million acres). Prioritization within the treated footprint is for the five restoration objectives (Figure 10). The All Lands scenario speaks to the importance of fuel reduction on lands of all ownerships to effectively reduce wildfire risk to communities, consistent with the National Cohesive Wildland Fire Management Strategy (Jewell and Vilsack 2014). Optimized treatments of as little as 10% of the landscape have been shown effective at reducing potential wildfire severity, with optimal treatment effectiveness coming at 20-40% of the landscape, after which decreasing fire severity is disproportionate with increasing area treated (Finney 2001, Ager et al. 2007, Finney et al. 2007, Schmidt et al. 2008, Cochrane et al. 2012). However, increasing reserve area, particularly when >50% of the landscape, necessitates more widespread treatment to achieve similar risk reduction (Finney et al. 2007, Schmidt et al. 2008). Treatment of 2% of a landscape every year for 20-years (40% of the landscape), followed with maintenance of that landscape was found to be the most efficient fuel reduction strategy in case studies of Montana, Idaho, and California (Finney et al. 2007) but treatments in the Wildland Urban Interface are most important for mitigating community impacts (Ager et al. 2010, Scott et al. 2016).

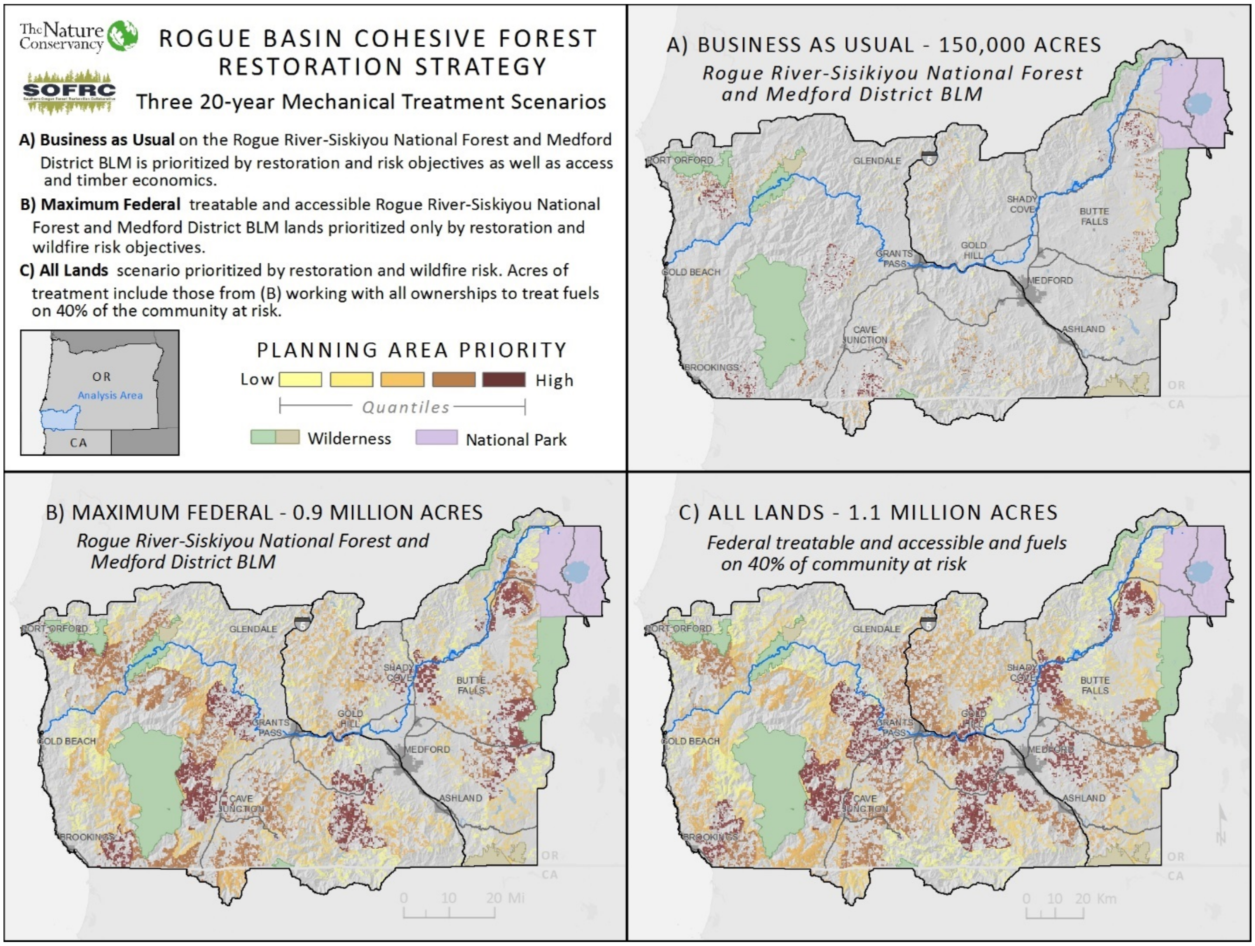


Figure 14: Three potential management scenarios for the Rogue Basin showing mechanical treatment priorities of potential treatment units as summed across planning areas.

To evaluate landscape scale effects of these proposed management scenarios, we updated seral structural state, Spotted Owl habitat class, and fuels characteristics, consistent with likely treatment outcomes under footprints of the three scenarios, as identified by the Marxan optimization. Modeled ecosystem resilience or long-range complex treatment themes moved seral structural states from closed to open but maintained stand age. Fuel Management and Near Range treatment themes do not transition among seral structural states. Treatment on ridges and midslopes in Spotted Owl nesting, roosting, and foraging habitat downgraded it to dispersal habitat. The rulesets for determining posttreatment fuel characteristics are available in Appendix 7 (available here). Wildfire behavior modeling with FSim and the wildfire risk assessment were then repeated for each scenario to allow evaluation of wildfire risk under each scenario.

Wildfire Risk Performance
Reduction in wildfire risk to high value resources and assets is substantial under the Maximum Federal and All Lands scenarios, particularly when treatments are modeled in close proximity to the HVRA in question (Figure 15). Total expected net value change was reduced by 37% by the Maximum Federal and by 70% by the All Lands scenario relative to Business as Usual. The Maximum Federal scenario achieved a modest reduction in wildfire risk to homes (the most at-risk asset), but the All Lands scenarios reduced risk to homes by 50%, despite only adding an additional 200,000 acres of treatment.

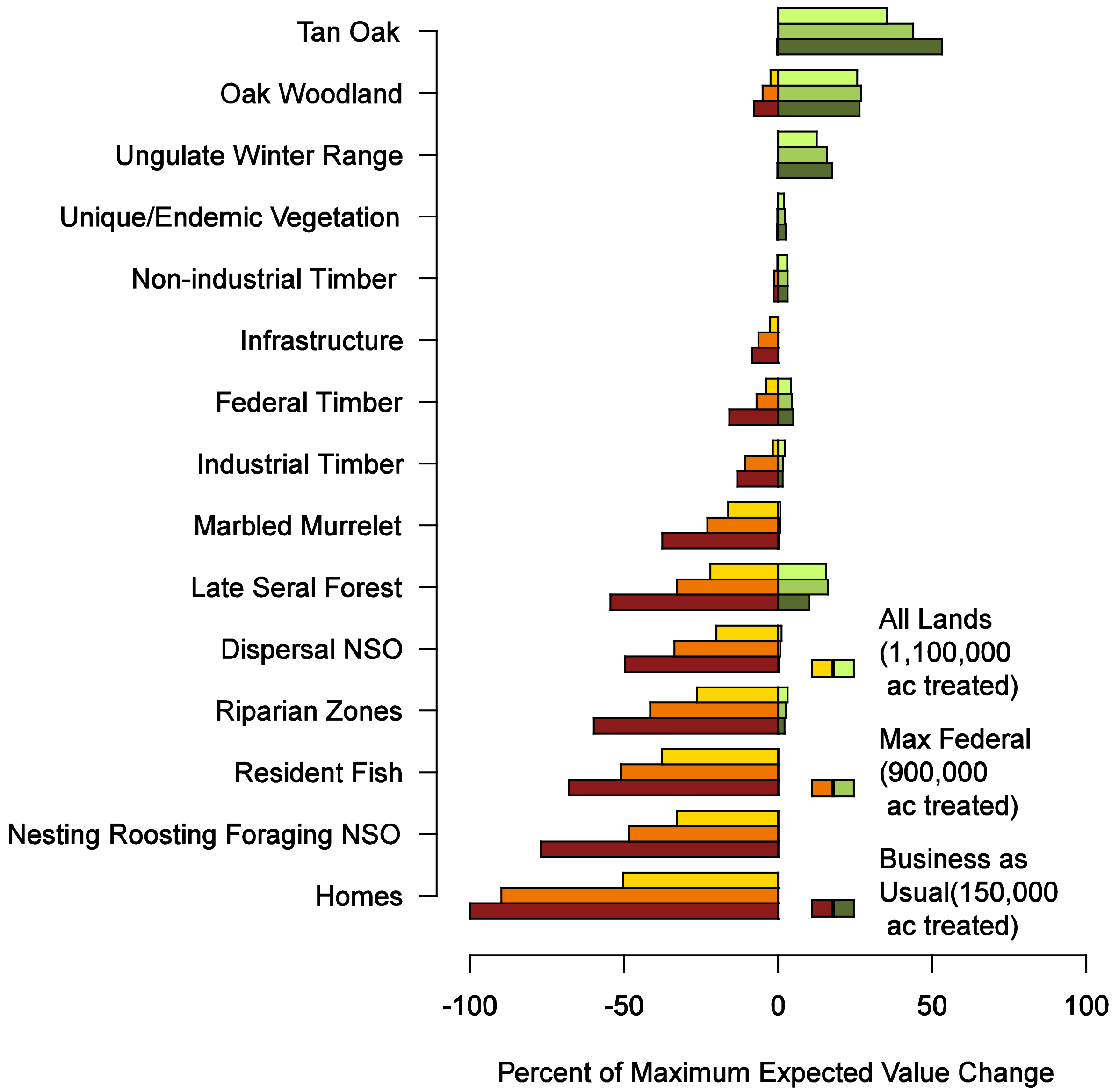


Figure 15: Landscape management scenarios alter cumulative negative and positive modeled wildfire responses. High value resources and assets with relatively little expected wildfire response are omitted from this figure: Chinook, aspen, Lamprey, Oregon Spotted Frog, Mardon Skipper, Siskiyou Mountain Salamander, Coho, recreational sites, Steelhead, state timber, Josephine county timber, municipal watersheds, and scenic values.

Wildfire risk to Northern Spotted Owl and late seral habitat was reduced by more than a third by treating federal lands, with only modest further reductions in risk with increasing the treatment footprint to all lands. In a similar pattern, wildfire risk to riparian reserves was reduced by a third under the Maximum Federal scenario and by 50% under the All Lands scenario, despite no treatments within the riparian reserves. Among the largest proportional beneficiaries of the All Lands scenario was industrial timber with a dramatic decrease in wildfire risk of > 90%.

Beneficial fire effects were increased in late seral forest, reflecting an increase in acreage of fire resistant late seral open forests (Figure 15). Conversely, beneficial wildfire effects were diminished for tanoak systems, likely because the beneficial effect of fire in tanoak systems was modeled where high severity fire removed conifers. In general, the beneficial effects of fire may be underestimated in this analysis in part because the temporal frame is inherently short-term (initial effects) and creation of high severity patches, consistent with the evolutionary history of the forest species, are beneficial for landscape resilience. The benefits of proactive treatments and subsequent beneficial fire accrue over time as development trajectories are avoided where forest habitats are converted to non-forest habitats by uncharacteristically severe fire (as in Coppoletta et al. 2016): a critical climate adaptation strategy (Stephens et al. 2013, Millar and Stephenson 2015).

Photo: Biscuit wildfire from Rough and Ready creek © The Nature Conservancy (Karen Hussey)

Landscape Resilience Performance

Mechanical treatments in excess closed forest can increase the proportion of open forests, addressing departure from the natural range of variability both directly and by creating conditions for growth that will accelerate development of late seral forest (Haugo et al. 2015). Summarized across the entire Rogue Basin, the development of excess closed forest is evident when the major forest types of the Rogue Basin are evaluated (Figure 11) and mechanical restoration even on the full treatable and accessible footprint of federal lands had a surprisingly modest effect on departure from the natural range of variability (Figure 16). In each instance, excess closed mid-seral forest is best reduced by the All Lands and Maximum Federal scenarios, but further thinning with mechanical treatment or fire and significant growth into late seral forest is needed to return resilient forests to the landscape.

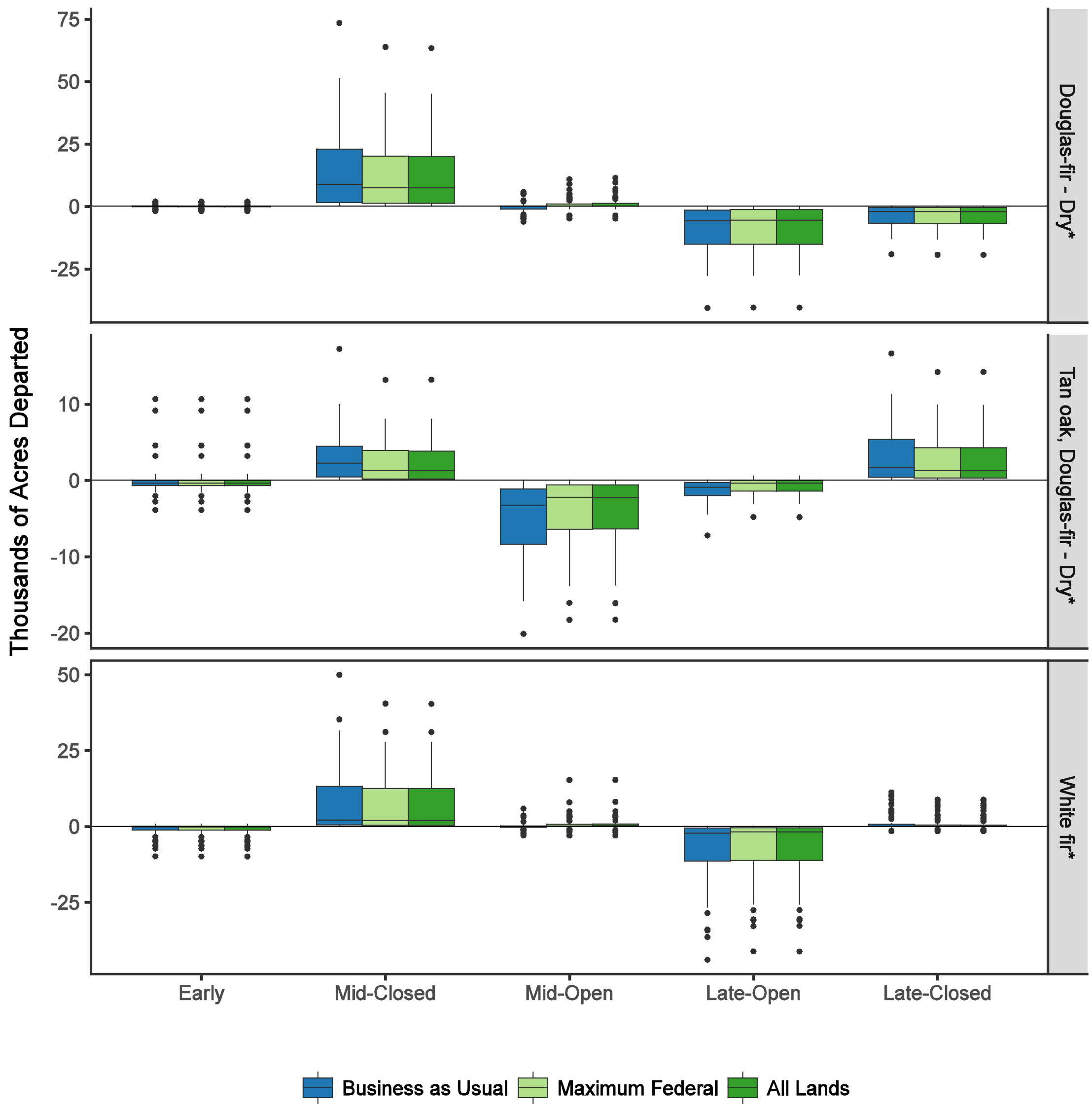


Figure 16: Landscape scale departure for biophysical settings common across the Rogue Basin and performance of three landscape scale management scenarios at returning those vegetation classes to the natural range of variability. *Douglas-fir - dry = Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland, Tanoak Douglas-fir – Dry = California Mixed Evergreen North, White fir = Mixed Conifer SW.

A closer analysis shows that it is possible to affect the proportion of seral states at a more local scale. In Figure 17 the ecological departure of dry Douglas-fir forests (the Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland biophysical setting) is evaluated for two 90,000 acre watersheds. In the Lower Applegate Watershed, work in mid-closed forest returns the mid-open seral structural state to the natural range of variability. Unfortunately, a profound lack of late seral forest means that significant growth is needed to bring this landscape into the natural range of variability. This can be accelerated with further work in the mid-seral closed stands to accelerate the development of large trees and complex forest structures. Conceptually, this could result in a situation as illustrated by the Rogue River watershed where work in mid-closed forests results in surplus mid-open forests, which functionally is accelerating development of late-seral open and closed seral structural states, both of which are lacking across the landscape (Figure 11 and Figure 17).

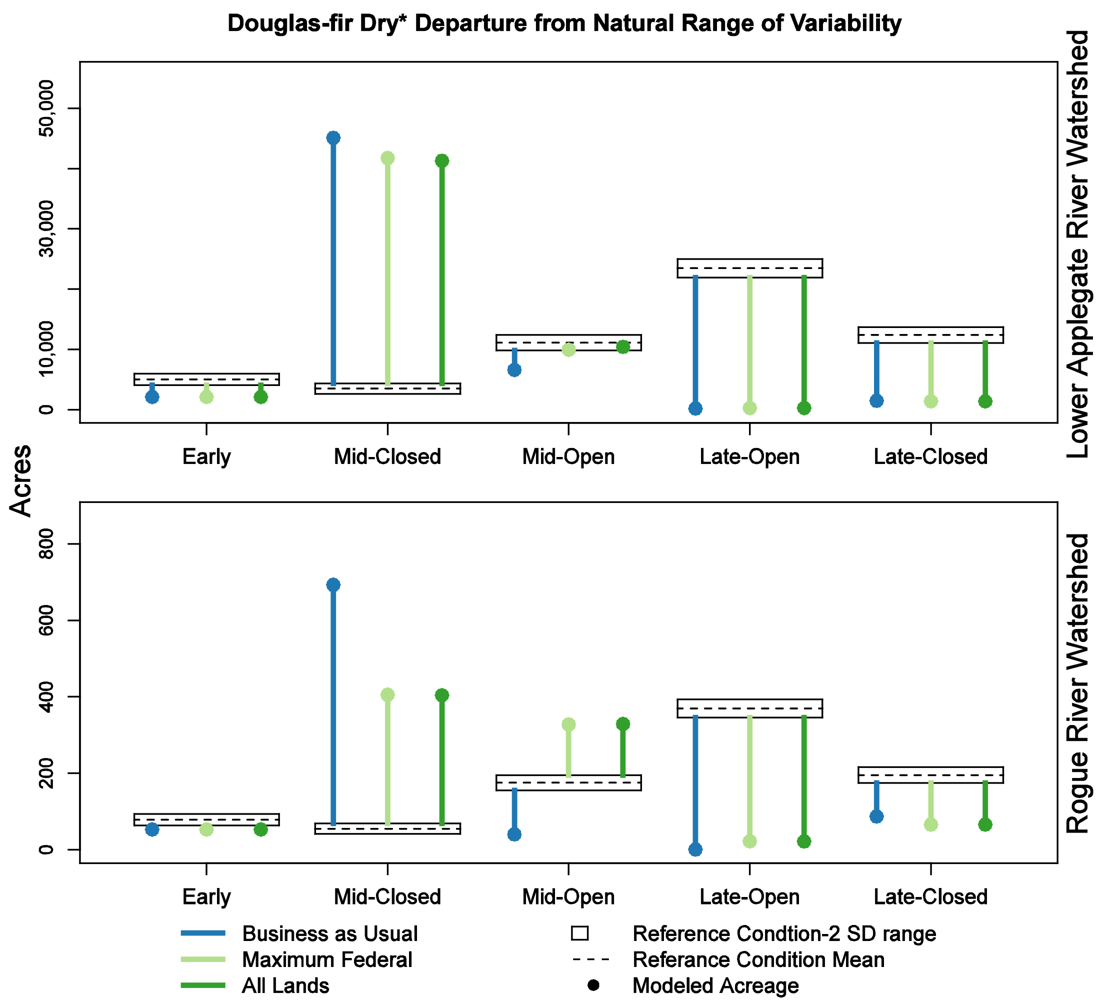


Figure 17: Departure from natural range of variability for dry Douglas-fir (Mediterranean California Dry-Mesic Mixed Conifer Forest and Woodland) in two exemplar watersheds to illustrate how three management scenarios perform at returning the natural range of variability.

Complex Forest Habitat Performance

In fire-prone forests, severe fire can be a threat to spotted owl habitat with significant detrimental effects on long-term population dynamics (Davis et al. 2015, Jones et al. 2016, Rockweit et al. 2017). Importantly, spotted owls evolved with fire and utilize habitats burned at all severities (Stephens et al. 2014, Tempel et al. 2014, Lee and Bond 2015) even relatively small patches of high severity fire (Comfort et al. 2016, Eyes et al. 2017). Spotted owls also utilize harvested areas (Stephens et al. 2014, Tempel et al. 2014), particularly those thinned at a moderate intensity (Irwin et al. 2015). Proactive fuels treatments that reduce the potential for large patches of high-severity fire may be an important part of spotted owl recovery (U.S. Fish & Wildlife Service 2011, Roloff et al. 2012, Tempel et al. 2014, Davis et al. 2015, Jones et al. 2016), though the amount of the landscape treated can dramatically alter these effects (Ager et al. 2007, Roloff et al. 2012, Spies et al. 2017).

Relative to the Business as Usual scenario, the more proactive Maximum Federal and All Lands management scenarios reduce nesting, roosting, and foraging habitat (NRF) by 15 and 16% respectively but reduce wildfire risk to core Northern Spotted Owl areas even more -- 28% under the Maximum Federal scenario and 47% under the All Lands scenario (Figure 18). Importantly, the downgrade to dispersal habitat is located on *low relative habitat suitability* settings, largely warm ridges and midslope settings consistent with the Northern Spotted Owl recovery plan (U.S. Fish & Wildlife Service 2011, 2013).

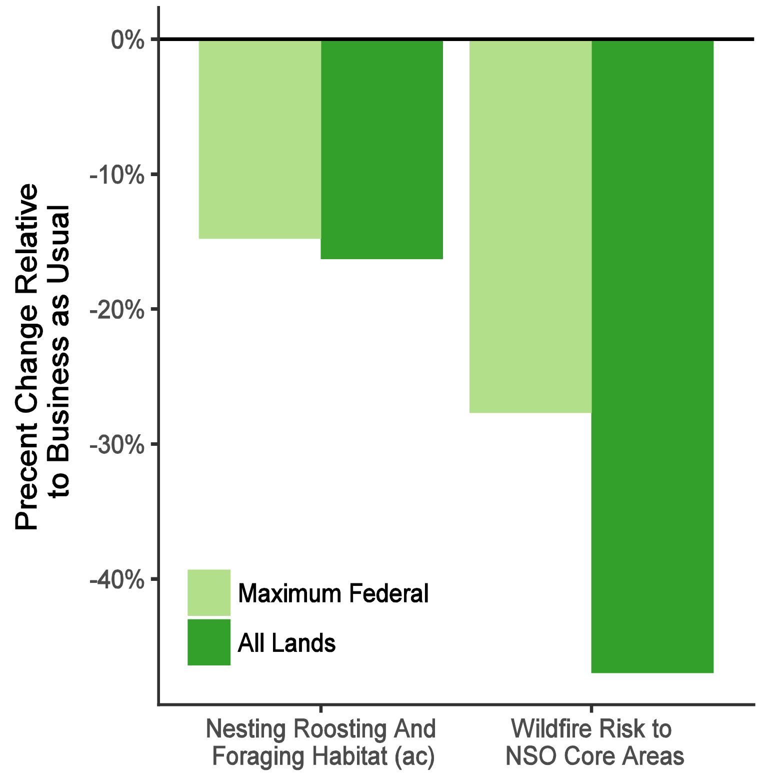


Figure 18: Comparison of the Maximum Federal and All Lands management scenarios to the Business as Usual scenario for Northern Spotted Owl nesting, roosting, and foraging habitat extent (ac) and wildfire risk to core nesting, roosting, and foraging habitat.

Given the uncertainty around spotted owl dynamics, it is fortuitous that monitoring is in place to evaluate Northern Spotted Owl responses to landscape restoration in the Ashland Forest Resiliency project (website), a demonstration of the approaches promoted by the Strategy. The goal of the Ashland project is to reduce the risk of wildfire to many values, including the community, municipal water supply, and designated Northern Spotted Owl critical habitat while restoring open forest and landscape resilience. The analysis identified 7,600-ac for treatment over a 23,000-ac analytical area. Nesting, roosting, and foraging habitat was classified on 17,000-ac using 2011 remotely sensed data with 1,200-ac (7%) proposed for downgrade to dispersal. However, the mapping of NRF at the time was overly permissive and remapping of the same area with 2012 GNN data reveals only 10,000 acres of NRF, so 1,200 ac of downgrade is 12% of the NRF in the analytical area for the Ashland project. This scale of treatment is somewhat less than that proposed under the Strategy, and lessons learned in Ashland will strongly influence implementation of the Strategy.

Economic Costs of Implementation

The Rogue Basin Strategy applies restoration treatments that include a combination of thinning that generates merchantable byproduct and mechanical treatments that are strictly non-merchantable in nature, followed by prescribed burning to reduce fuels where appropriate. We quantify the near-term (20-year) monetary investment required to implement mechanical treatments consistent with the Strategy and the value of the resulting merchantable byproduct, reported in long-log scale to be consistent with industry standards. Investment in the Strategy will help to promote regional economic and workforce viability, including support of the current manufacturing infrastructure, and this is an important component of the Strategy. Our accounting here does not detail other costs such as planning, environmental assessment and associated surveys for implementation, anticipated maintenance, or the benefits of avoided costs resulting from implementation.

Costs associated with mechanical implementation considered were: logging and hauling, non-merchantable thinning, and activity fuels treatment. For each 27-ac fishnet cell selected for treatment net revenues were calculated and summed for each of the three management scenarios based on Equation 3.

$$\text{Equation 3:}\ Net\ Revenue = Revenue - Implementation\ \ Cost$$

Where:

Revenue = (long log volume removed x delivered log price)

Cost = logging and hauling + activity fuels + non-merchantable thinning

To understand the economic repercussions of the Strategy while avoiding the issue of how private landowners will spend their timber receipts we focus here on the economic outcomes of the Maximum Federal scenario. Under this scenario 0.9 million-ac are treatable and accessible, but only 689,000 require mechanical treatments of which 214,000-ac are strictly non-merchantable and 475,000-ac have a merchantable component. In general, the findings for the All Lands scenario are similar, but with more acres treated, greater total volume removed, and higher overall costs associated with the benefits in wildfire risk reduction described above.

Restoration conceived in the Maximum Federal scenario requires a significant investment: the total net cost is $607 million, or about $30 million to treat 34,000-ac per year over the 20-year plan horizon. The Strategy removes 11 million non-merchantable trees and the total timber harvested is 1.3 billion board feet, or 66 million board feet (MMBF) annually. Of this, 23 MMBF annually are commercially viable; to generate the other 43 MMBF would require a subsidy of $24 million per year.

On average the combined MBLM and RRS currently treat about 9,000-ac annually and from 2005-2014 they annually offered 58 MMBF in long log scale, officially 78 MMBF in short log scale (Medford District Bureau of Land Management 2015, Rogue River - Siskiyou Mountains National Forest 2015). Once volume estimates calibrated to long log scale, the Maximum Federal scenario treats four times the acreage and generates 13% more volume than currently offered on federal lands. This may reflect the tendency of federal planning to balance stewardship with work that generates timber receipts, while the Strategy elevates fuels treatment and thinning in overly dense stands that may or may not have commercial value but where stewardship can have significant benefits for landscape resilience and community safety.

Most acres require an investment when logging and fuels operations costs are considered: of the 34,500 annual treatment acres, 86% would require an investment, while treatment of the remaining acres yield positive net revenue. About 34% of the acres cost more than $1,000/ac to treat, even after accounting for timber revenues, and treatment of these acres accounts for 59% of the total cost.

Conversely, the 66% of the acres that cost less than $1,000/ac to treat account for only 41% of the total cost. Areas that cost more than $1,000/acre to treat are primarily those that remove low volumes per acre and/or use more expensive yarding systems, i.e., helicopter or cable.

Treatments with helicopter yarding and/or that remove less than 2 MBF/acre contribute disproportionately to the total treatment cost (Figure 20). Of the treatable and accessible acres yielding merchantable byproduct, some 32% are only accessible via helicopter and 49% yield less than 2 MBF/ac. Only 4% can be treated with ground-based logging generating 6 MBF or more per acre. There is also a substantial area (31% of the treatable and accessible acres) that exclusively needs non-merchantable thinning. Creating a ceiling for per acre investment, such as $2,000/ac or even $1,000/ac, could greatly reduce overall implementation costs, but would reduce the number of acres treated and objective performance. For example, excluding areas where implementation would remove <6 MBF/ac merchantable timber with helicopters reduces the mechanically treated footprint by 7,500 acres (22%) and the cost by nearly $10 million (33%) annually with modest reductions in objective function.

The potential for revenues from commercially viable treatments to offset more expensive acres (i.e., stewardship contracting) is relatively limited; commercial revenues of $4 million per year from harvest of 22 MMBF could subsidize treatment of perhaps 3,000 to 5,000 acres/year, depending on the types and costs of acres treated. Removing more volume per acre, building temporary roads, and reducing activity fuels costs could reduce implementation costs but trigger ecological and social tradeoffs this assessment has not evaluated.

It should be noted that the Strategy is very conservative in nature. Thinning to lower target densities could be justified in many settings to promote early seral tree species and development of future age cohorts of trees, both reasonable components of a long-term strategy for forest resilience. Additionally, this analysis is based on a static picture of stand volumes and does not account for likely growth over the 20-year implementation period. This growth could increase volume at local and regional scales, reducing costs and increasing revenues over the baseline described in this report. Finally, scaling up to the levels of the Strategy could come with significant improvements in efficiency as local workforce capacity improves.

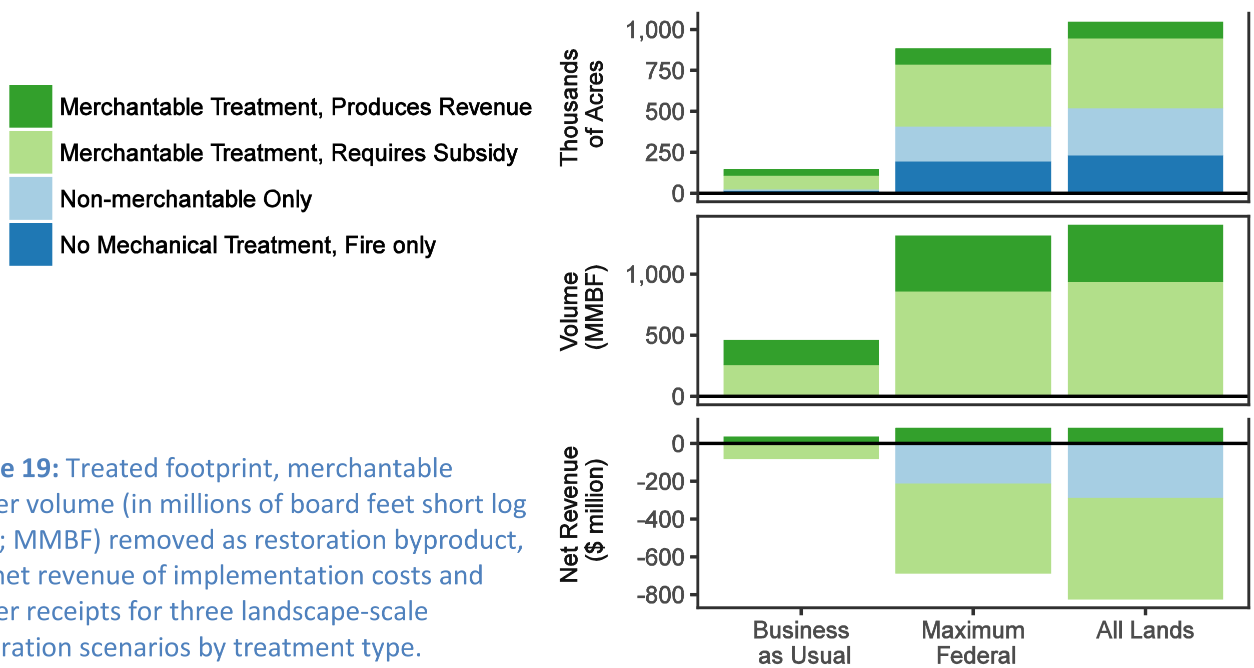


Figure 19: Treated footprint, merchantable timber volume (in millions of board feet short log scale; MMBF) removed as restoration byproduct, and net revenue of implementation costs and timber receipts for three landscape-scale restoration scenarios by treatment type.

Prestemon et al. (2012) evaluated the economics of mechanical fuels treatments across the West and, consistent with our assessment they found that when conservative mechanical treatments like those described under the Rogue Basin Strategy were applied in southwestern Oregon, they required capital investment. However, when avoided wildfire costs were included the economic outcomes of investing in the landscape were positive.

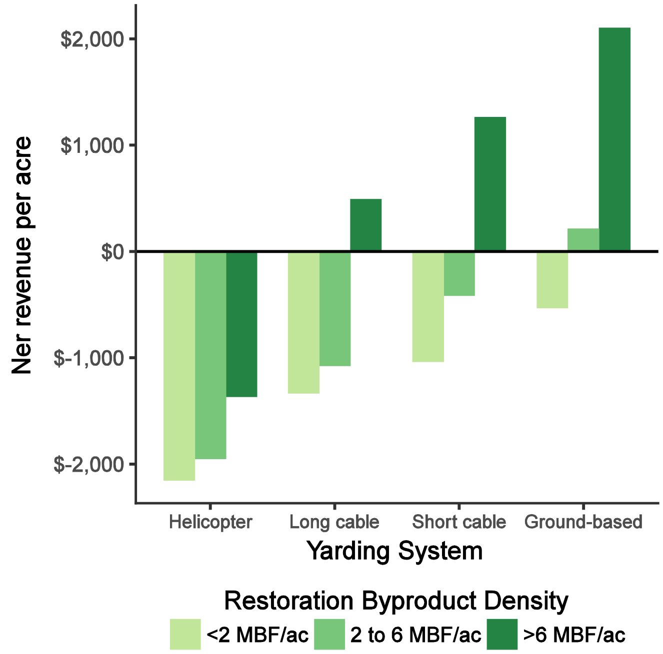


Figure 20: Net revenue per acre by yarding system and density of volume removal under the Maximum Federal scenario where merchantable volume is removed.

Proactive fuels management can reduce wildland fire size and fire cost (Ecological Restoration Institute 2013, Huang et al. 2013, Thompson et al. 2013b) and while avoided costs attributable to fuel reduction can range widely from 2-30 times the direct cost of suppression (Western Forestry Leadership Coalition 2010). When the landscape includes water reservoirs that would have to be dredged after severe fire events, avoided costs can skyrocket; in an avoided costs assessment of the Mokelumne watershed, Buckley et al. (2014) found that fuels treatment had positive return on investment ranging from a benefit of $2-$3 for every $1 invested.

A study in northern Arizona evaluated avoided costs of suppression, carbon release, water, houses, timber value, fatalities, regeneration and rehabilitation; benefits of fuel reduction ranged from a benefit of $2,000/ac to a net cost of -$1,417/ac (Huang et al. 2013) with the primary cost drivers being periodicity of prescribed burning (10 or 20 years) and likelihood of severe fire (50 or 100 years). In the Rogue Basin maintenance burning under a 10-20 year interval may be appropriate, 10 years where resprouts are aggressive, and closer to 20 years when they are not. This, combined with relatively high fire risk suggest a potential positive net cost for our landscape when avoided costs are included. Periodic maintenance treatments with either mechanical work or managed fire will be necessary but substantially less costly if implemented on a timely basis. For example, managed fire may cost between $250-$800/ac, while this initial treatment will cost >$1,000/ac over many acres.

The bottom line is that resilient landscapes require significant investment. Implementation of either the Maximum Federal or All Lands scenarios requires external funding, but the investment comes with local economic benefits as well. We used the full implementation of the Maximum Federal strategy (66 MMBF requiring $30 million investment annually) in mechanical treatments as inputs to calculate jobs and economic activity using the Southwestern Oregon Restoration Economic Impacts Calculator (Ecosystem Workforce Program 2015). The calculator predicts that full implementation of the Maximum Federal Scenario and related economic activity would annually support 1,700 direct and indirect jobs, generate over $65 million in local wages, and generate over $260 million in local economic output.

The Strategy was built in part around the expectation that the boost to the local economy, along with the avoided costs that accrue over time, more than justify the initial operations investment in this landscape. A more comprehensive description of the analysis and results is in Appendix 8 (available here).

Implementation of the Rogue Basin Strategy

This Strategy advances the ongoing dialogue about strategic, integrative, and cohesive land management in the Rogue Basin. It provides base data layers, including wildfire hazard and risk to high value resources and assets, consideration of climate adaptation, and an analytical approach to make transparent the Collaborative's principles and vision (Appendix 1; data available here). As such it can be used to identify planning areas for future investment, or can guide implementation of established planning areas. This process can be facilitated by using factsheets developed for all 96 planning areas (Appendix 9 available here). Given superior performance at reducing wildfire risk to communities, the All Lands is the SOFRC preferred scenario. It is acknowledged that federal projects will be most effectively planned for and funded, providing a demonstration and catalyst for private lands investment. A successful model of this catalytic effect of federal lands management exists in the Ashland All Lands Restoration project (AFAR; Strategy Planning Area 1), where the Ashland Forest Resiliency Stewardship Project (website) led to investment by the Natural Resources Conservation Service and Oregon Watershed Enhancement Board in the AFAR project which expands conservation and wildfire risk reduction strategies initiated on federal land to the larger landscape.

Frequent wildfire historically maintained landscape resilience in the Rogue Basin, but fire exclusion has created a backlog of "treatment", which has been termed a "fire deficit" (sensu North et al. 2012). The fire deficit, in concert with other management practices has resulted in a landscape that lacks variability and resilience, a landscape characterized by 2.1 million-ac of excess closed forest (Haugo et al. 2015). Ironically, the Strategy estimates 2.1 million-ac on all lands where treatments could occur given existing constraints, but the acreage of stands that need thinned and that are treatable and accessible do not necessarily overlap. For example, 1.0 million-ac of the total are on private ownership and will be managed by a diverse array of owner objectives. Another 0.6 million-ac occur within the Community at Risk, an important footprint where management will reduce fuels and promote fire adapted communities. However, work in the Community at Risk is unlikely to transition stands from closed to open, as necessary to achieve landscape resilience. Anticipated annual wildfire effects (26,000-ac annually over the last 20-years) will reduce the needed footprint of mechanical treatments, but also could increase the urgent need to protect and promote late successional habitats.

As discussed in North et al. (2012) the magnitude of work needed outstrips the current capacity of the federal agencies to complete the work needed to achieve resilient landscapes. Under the existing framework federal treatments impact 1/3 of the acreage that wildfires impact. This situation elevates the need to incorporate managed wildfire to accomplish societal objectives of reducing wildfire risk and promoting resilient landscapes. The potential for achieving this will be improved with proactive, strategically placed treatments to promote more favorable fire effects combined with increased options for managing wildfire to burn under an appropriate range of fire weather conditions, in the right parts of the landscape (North et al. 2012, Hessburg et al. 2016, Schoennagel et al. 2017).

Prioritizing Among Potential Planning Areas

Identifying the most important planning areas for investment hinges on local opportunities, priorities of local stakeholders, and local conditions on the ground. A focus on achieving all five landscape scale objectives elevates planning areas that do just that, and therefore may not perform as well on a given landscape objective (Figure 21). Under the All Lands scenario, many of the planning areas that best achieve all five landscape scale objectives are concentrated around communities (Medford, Grants Pass, Shady Cove, Cave Junction, and Brookings), directly reflecting the landscape scale objectives to reduce local and large fire risk. Cumulative objectives drive this prioritization however and the highest performing planning area, which overlaps with the existing Elk Camel project, is among the highest performing planning areas for climate resilience and Northern Spotted Owl habitat, but in the second quantile for local community fire risk, large wildfire community risk, and resilient forests (Figure 21). The value of a given planning area thereby lies both in its ability to achieve all five objectives at once, as well as its ability to perform on individual objectives that serve a group of stakeholders.

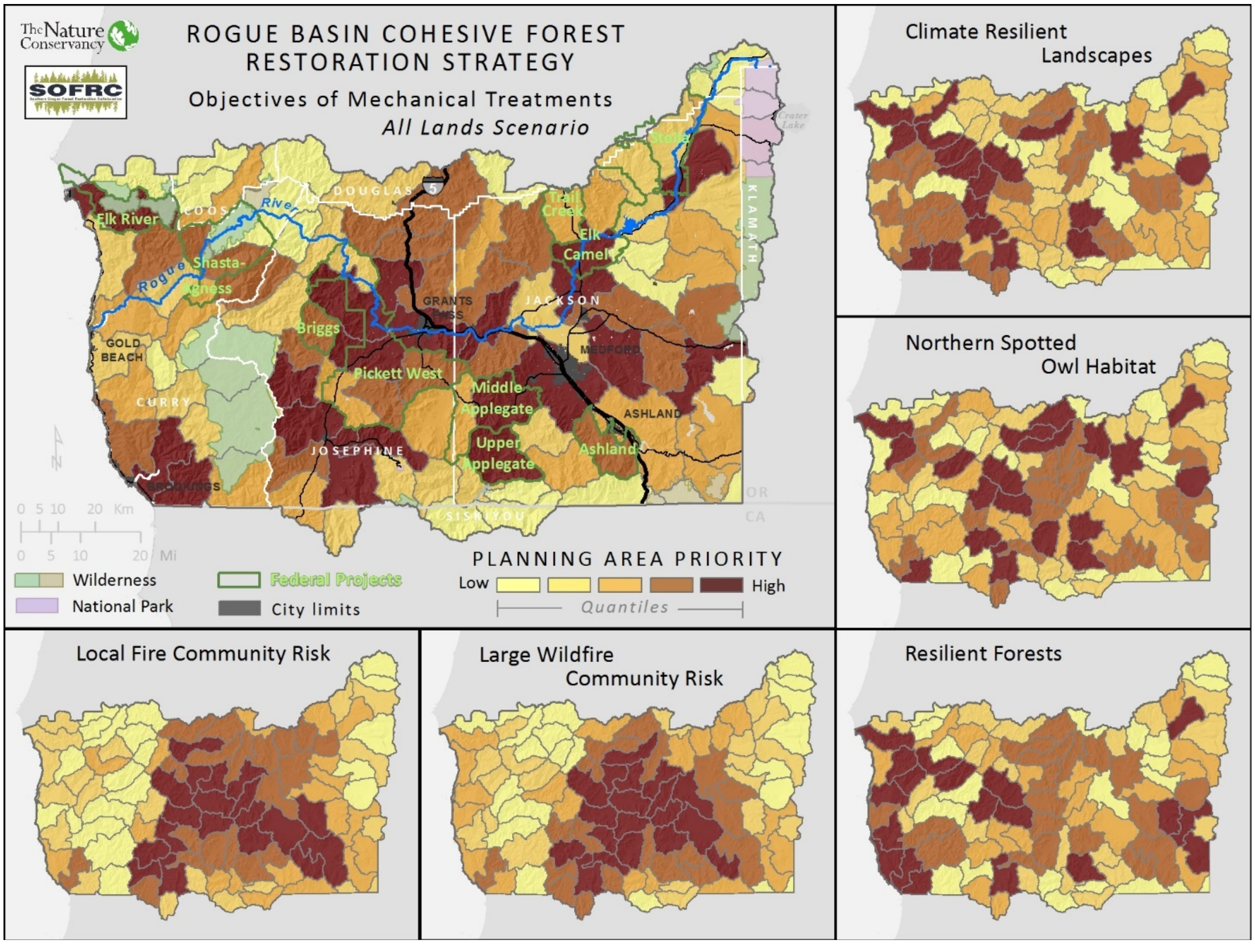


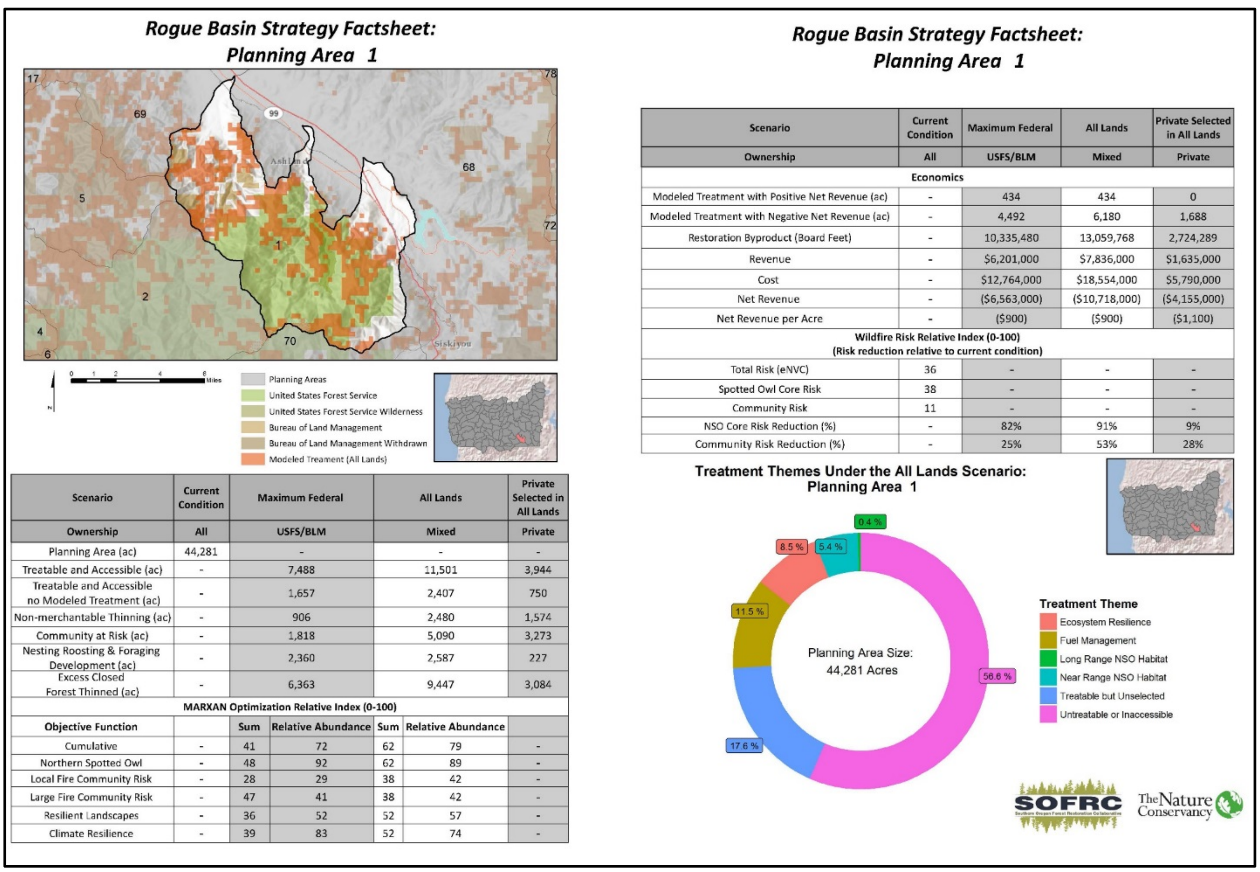
Figure 21: Prioritized planning areas for the Rogue Basin All Lands scenario, overlaid with existing planning areas and their relative performance on five landscape scale objectives, assuming the full treatable and accessible footprint is treated. While the All Lands scenario optimizes for performance on all five landscape objectives simultaneously, focus on individual objectives elevates differing planning areas.

Purpose and Need Within a Planning Area

Once a planning area has been selected, identifying the purpose and need, as well as the amount of treatment needed and where those treatments should be placed will be critical for achieving the desired objectives. We have developed factsheets for the Strategy that can be used to evaluate proposed planning areas for several metrics, including total acres, acres to protect, treatable and accessible acres, and performance on landscape scale objectives Appendix 9 (available here).

As an example, planning area 1, adjacent to the city of Ashland, is a 44,281-ac planning area with 7,488-ac treatable and accessible on federal lands and 3,944-ac modeled for treatment under the All Lands scenario (Figure 22). This planning area does not perform particularly well cumulatively: the index of performance for the cumulative objective function is only 41 for the Maximum Federal scenario and 62 for the All Lands scenario. As illustrated in the ring chart, 57% of the planning area is modeled as inappropriate for treatment, or inaccessible under the Strategy with only 12% of the planning area modeled for fuel management, 9% modeled for treatments to address ecosystem resilience, and 6% of the planning area selected to protect and promote near- and long-range Northern Spotted Owl Habitat. 18% of the planning area is identified as treatable and accessible, but with <2 MBF merchantable volume and <150 trees/ac to be removed, mechanical treatments are not modeled at this time, though there is likely to be underburning or non-merchantable work to be done, particularly in the community at risk. Despite a relatively small footprint of modeled mechanical treatment, this planning area performs quite well for protecting and promoting Spotted Owl habitat, particularly once the index of performance is scaled for treatment area with relative abundance of the Northern Spotted Owl performance index at 92 and 89 for the Maximum Federal and All Lands Scenarios respectively.

Implementation of the Strategy in the planning area is expected to thin 6,363-ac of excess closed forest on federal land and 3,084-ac of excess closed forest on other ownerships. Treating planning area 1 generates merchantable timber volume: 10 MMBF from federal land and 2.7 MMBF from private land (Figure 22). Under the Maximum Federal scenario, assuming timber receipts are applied to stewardship, the project has a net revenue of $900/ac and implementation of treatments will cost $6.5 million, excluding planning, monitoring, and community outreach. This investment is modeled to reduce wildfire risk to Northern Spotted Owl by 82% under the Maximum Federal scenario and 91% under the All Lands scenario. The Maximum Federal scenario reduces wildfire risk to communities by 25%, but treating an additional 3,194-ac community wildfire risk is reduced by 53%.



Scenario	Current Condition	Maximum Federal		All Lands		Private Selected in All Lands
Ownership	All	USFS/BLM		Mixed		Private
Planning Area (ac)	44,281	-		-		-
Treatable and Accessible (ac)	-	7,488		11,501		3,944
Treatable and Accessible no Modeled Treatment (ac)	-	1,657		2,407		750
Non-merchantable Thinning (ac)	-	906		2,480		1,574
Community at Risk (ac)	-	1,818		5,090		3,273
Nesting Roosting & Foraging Development (ac)	-	2,360		2,587		227
Excess Closed Forest Thinned (ac)	-	6,363		9,447		3,084
MARXAN Optimization Relative Index (0-100)						
Objective Function		Sum	Relative Abundance	Sum	Relative Abundance	
Cumulative	-	41	72	62	79	-
Northern Spotted Owl	-	48	92	62	89	-
Local Fire Community Risk	-	28	29	38	42	-
Large Fire Community Risk	-	47	41	38	42	-
Resilient Landscapes	-	36	52	52	57	-
Climate Resilience	-	39	83	52	74	-

Scenario	Current Condition	Maximum Federal	All Lands	Private Selected in All Lands
Ownership	All	USFS/BLM	Mixed	Private
Economics				
Modeled Treatment with Positive Net Revenue (ac)	-	434	434	0
Modeled Treatment with Negative Net Revenue (ac)	-	4,492	6,180	1,688
Restoration Byproduct (Board Feet)	-	10,335,480	13,059,768	2,724,289
Revenue	-	$6,201,000	$7,836,000	$1,635,000
Cost	-	$12,764,000	$18,554,000	$5,790,000
Net Revenue	-	($6,563,000)	($10,718,000)	($4,155,000)
Net Revenue per Acre	-	($900)	($900)	($1,100)
Wildfire Risk Relative Index (0-100) (Risk reduction relative to current condition)				
Total Risk (eNVC)	36	-	-	-
Spotted Owl Core Risk	38	-	-	-
Community Risk	11	-	-	-
NSO Core Risk Reduction (%)	-	82%	91%	9%
Community Risk Reduction (%)	-	25%	53%	28%

Figure 22: Example factsheet for planning area #1, which happens to be centered on the Ashland municipal watershed and site of the Ashland Forest All Lands Restoration project. Factsheets for all 96 planning areas are in Appendix 9 ([available here]()).

Multiparty Monitoring

The Strategy lacks a monitoring plan with indicators of success. A tiered, multiparty monitoring approach is recommended where project level monitoring can inform adaptive management and provide a baseline for effectiveness monitoring, then optimally be rolled up to regional monitoring that evaluates progress toward resilient landscapes and communities (Figure 2). Local concerns will drive specific monitoring needs as well, as in the case of the Ashland Forest Resiliency project where the presence of pacific fisher, Northern Spotted Owl, abundant large old trees, partners that monitor avian communities, and a municipal watershed have provided significant opportunities for multiparty monitoring to invest in effectiveness monitoring. Critically, project level monitoring should guard against unintended negative consequences such as non-native species invasion, ineffective thinning that fails to reduce fuels or restore open forest, and overly aggressive thinning that removes the largest trees or eliminates all dense vegetation, thereby compromising landscape resilience.

Monitoring of the AFAR project is an example of what scalable project-level monitoring could look like. Primary AFAR monitoring goals are to: a) Spatially track treatment planning and implementation, including dollars invested and commercial volume removed, b) Evaluate success at restoring open habitats where treatments occur, including retention of appropriate proportions of denser habitat and protection of forest legacy structures, and c) Estimate change in potential wildfire spread and intensity due to treatment. Within AFAR key stand-scale indicators collected on every unit include pre- and post-treatment fuel model (Scott and Burgan 2005), ladder fuel hazard (Menning and Stephens 2007), canopy base height, stand structure, representative photos, and legacy tree status.

Fuel model and canopy base height allow updated fire behavior modeling to evaluate changes in wildfire hazard which, combined with the mapping of high value resources and assets from the Strategy allow calculation of risk. Stand structure allows calculation of seral structural state (as in Haugo et al. 2015) and Northern Spotted Owl habitat class based on locally-derived thresholds (e.g., U.S. Fish & Wildlife Service 2013). Tracking jobs created is an important economic indicator, but dollars invested, acres treated, and commercial volume sold to local mills are critical inputs for the Southwestern Oregon Restoration Economic Impacts Calculator (Ecosystem Workforce Program 2015), thereby providing a robust gauge of how investing in landscapes directly supports local communities. Additional indicators, such as using bird communities to evaluate landscape scale restoration success, should be developed as partners and opportunities arise.

Social Engagement

Consistent with the National Cohesive Wildland Fire Management Strategy, we anticipate that implementation of this scope of work will require strategic and programmatic alignment across agencies, governance, and organizations, as well as significant public support. To this end engagement with partners, stakeholders, and community to better integrate social values, concerns, and needs in the Strategy is ongoing. Agency engagement during development of the strategy included periodic collaborative public meetings convened by the SOFRC, creation of the interdisciplinary and multi-agency technical team, workshops on fuels and high value resources and assets, a USFS Region 6 workshop on landscape planning, and finally a series of interdisciplinary planning workshops with the districts of the Rogue River-Siskiyou National Forest. More general engagement has come in the form of invited presentations, interactions with scientists working on similar projects, a workshop co-convened by the Fire Learning Network and Fire Adapted Communities Learning Network specifically on stakeholder engagement, and a climate adaptation workshop convened by SOFRC with the Southern Oregon Climate Action Now. These efforts build science-manager-public partnerships for engagement, multiparty monitoring, and leveraged pooling of funds (sensu Golladay et al. 2016, Halofsky et al. 2016).

In June 2016, the Fire Learning Network, SOFRC, Fire Adapted Communities Learning Network, and The Nature Conservancy jointly convened a workshop with ~75 participants, predominantly highly engaged local and regional stakeholders to share the Strategy and gain insight on public perceptions of it. Participants suggested elevating the protective nature of the Strategy, specifically the existing critical design elements of no “take” of existing spotted owl home ranges and exclusion of new road construction. Stakeholders elevated the importance of climate change strategies and metrics of success, as well as the understanding of how fire would be dealt with under the Strategy. To advance implementation, stakeholders suggested flexibility under the Strategy to choose project areas among emerging opportunities, rather than following a strict prioritization of planning areas to treat. Workshop participants advocated for local decision making, down to the community level, empowered by long-term partners who could share and help communities use the framework and data built into the Strategy to forward common landscape objectives. To support and develop local leaders, workshop participants advised development of outreach materials specifically for the local leader audience, which they could then share.

In a second workshop, jointly convened by SOFRC, Southern Oregon Climate Action Now (SOCAN website) and The Nature Conservancy in November 2016, participants evaluated the Strategy’s integration of climate change and climate adaptation. The workshop brought together rural and urban community members with land management organizations and those engaged in 'on-the-ground' projects such as Ashland Forests All-lands Restoration Project. The workshop participants found that the Strategy performed well at addressing: 1) risks of uncharacteristically severe wildfire by prioritizing thinning and fuels reduction, 2) integrating thinning and fuel reduction approaches within agencies and with private landowners, 3) promoting improved management and planning for fire risk reduction, 4) supporting the update of the county fire plans, and 5) managing for old growth/late seral habitat. Participants also identified a few key areas to be improved: 1) accounting for long-term carbon dynamics, 2) addressing long-term maintenance and management, 3) address long-term economics, including increasing emphasis on ecosystem benefits. Detailed outcomes of the workshop are in Appendix 10 (available here).

The outcomes of these workshops, as well as multiple SOFRC collaborative meetings and technical working groups have been incorporated into this revision of the Strategy. We anticipate working with agency partners to develop and update an implementation plan to apply the Strategy to increase forest resilience in the Rogue Basin. To-date this has involved participation in the Jackson and Josephine County Wildfire Protection Plan (online storyboard), and a quantitative wildfire risk assessment by the Region 6 of the USFS for Oregon and Washington that will update wildfire response strategies in USFS forest management plans. In both instances, base data and approaches from the Strategy are being applied to partnership analyses increasing the potential for proactive treatments or more informed wildfire response decisions.

The SOFRC is engaging with agencies as existing projects are planned and implemented (Figure 21) and as future projects are developed to implement, monitor, and improve the restoration principles of the Rogue Basin Cohesive Forest Restoration Strategy. Through these efforts individual projects will be developed that adhere to the basic Strategy, but are also tailored to local concerns and considerations. Collaborative projects developed with transparent objectives focused on ecosystem restoration, along with other community needs and priorities, are expected to better achieve integrated objectives, receive greater public support and better aligned diverse funding sources, and thereby increase the quality, pace, and scale of forest restoration in the Rogue Basin.

References

Abella, S. R., and P. J. Fornwalt. 2015. Ten years of vegetation assembly after a North American mega fire. Global Change Biology **21**:789-802.

Agee, J. K. 1991. Fire history along an elevational gradient in the Siskiyou Mountains, Oregon. Northwest Science **65**:188-199.

Ager, A., M. Finney, B. Kerns, and H. Maffei. 2007. Modeling wildfire risk to Northern Spotted Owl (*Strix occidentalis caurina*) habitat in Central Oregon, USA. Forest Ecology and Management **246**:45-56.

Ager, A. A., N. M. Vaillant, and M. A. Finney. 2010. A comparison of landscape fuel treatment strategies to mitigate wildland fire risk in the urban interface and preserve old forest structure. Forest Ecology and Management **259**:1556-1570.

Airey Lauvaux, C., C. N. Skinner, and A. H. Taylor. 2016. High severity fire and mixed conifer forest-chaparral dynamics in the southern Cascade Range, USA. Forest Ecology and Management **363**:74-85.

Ball, I. R., and H. P. Possingham. 2000. MARXAN (V1.8.2): Marine Reserve Design Using Spatially Explicit Annealing, a Manual. Great Barrier Reef Marine Park Authority, University of Queensland, Brisbane, Australia.

Bonnet, V. H., A. W. Schoettle, and W. D. Shepperd. 2005. Postfire environmental conditions influence the spatial pattern of regeneration for *Pinus ponderosa*. Canadian Journal of Forest Research **35**:37-47.

Buckley, M., N. Beck, P. Bowden, M. E. Miller, B. Hill, C. Luce, W. J. Elliot, N. Enstice, K. Podolak, E. Winford, S. L. Smith, M. Bokach, M. Reichert, D. Edelson, and J. Gaither. 2014. Mokelumne watershed avoided cost analysis: Why Sierra fuel treatments make economic sense. Prepared for the Sierra Nevada Conservancy, The Nature Conservancy, and USDA Forest Service, Sierra Nevada Conservancy. Auburn, California. Online: http://www.sierranevadaconservancy.ca.gov/mokelumne.

Buttrick, S., K. Popper, M. Schindel, B. McRae, B. Unnasch, A. Jones, and J. Platt. 2015. Conserving Nature's stage: identifying resilient terrestrial landscapes in the Pacific Northwest. The Nature Conservancy, Portland, OR, available online: http://nature.ly/resilienceNW.

Cochrane, M., C. Moran, M. Wimberly, A. Baer, M. Finney, K. Beckendorf, J. Eidenshink, and Z. Zhu. 2012. Estimation of wildfire size and risk changes due to fuels treatments. International Journal of Wildland Fire.

Colombaroli, D., and D. G. Gavin. 2010. Highly episodic fire and erosion regime over the past 2,000 y in the Siskiyou Mountains, Oregon. Proceedings of the National Academy of Sciences **107**:18909–18914.

Comfort, E. J., D. A. Clark, R. G. Anthony, J. Bailey, and M. G. Betts. 2016. Quantifying edges as gradients at multiple scales improves habitat selection models for northern spotted owl. Landscape ecology **31**:1227-1240.

Connolly, T. J. 1988. A Culture-Historical Model for the Klamath Mountain Region of Southwest Oregon and Northern California. Journal of California and Great Basin Anthropology **10**:246-260.

Coop, J. D., S. A. Parks, S. R. McClernan, and L. M. Holsinger. 2016. Influences of prior wildfires on vegetation response to subsequent fire in a reburned Southwestern landscape. Ecological Applications **26**:346-354.

Coppoletta, M., K. E. Merriam, and B. M. Collins. 2016. Post-fire vegetation and fuel development influences fire severity patterns in reburns. Ecological Applications **26**:686-699.

Davis, R. J., J. L. Ohmann, R. E. Kennedy, W. B. Cohen, M. J. Gregory, Z. Yang, H. M. Roberts, A. N. Gray, and T. A. Spies. 2015. Northwest Forest Plan–the first 20 years (1994-2013): status and trends of late-successional and old-growth forests. USFS Pacific Northwest Research Station **PNW-GTR-911**.

Dixon, G. E. 2002. Essential FVS: a user's guide to the Forest Vegetation Simulator. Internal Report. USDA Forest Service, Forest Management Service Center.

Dodson, E. K., and H. T. Root. 2013. Conifer regeneration following stand-replacing wildfire varies along an elevation gradient in a ponderosa pine forest, Oregon, USA. Forest Ecology and Management **302**:163-170.

Donato, D. C., J. B. Fontaine, J. L. Campbell, W. D. Robinson, J. B. Kauffman, and B. E. Law. 2009. Conifer regeneration in stand-replacement portions of a large mixed-severity wildfire in the Klamath-Siskiyou Mountains. Canadian Journal of Forest Research **39**:823-838.

Ecological Restoration Institute. 2013. The efficacy of hazardous fuel treatments: A rapid assessment of the economic and ecologic consequences of alternative hazardous fuel treatmens: A summary document for policy makers. Northern Arizona University.

Ecosystem Workforce Program. 2015. Southwestern Oregon Restoration Economic Impacts Calculator. University of Oregon, Eugene, Oregon. Available online: http://ewp.uoregon.edu/.

Eyes, S. A., S. L. Roberts, and M. D. Johnson. 2017. California Spotted Owl (*Strix occidentalis occidentalis*) habitat use patterns in a burned landscape. The Condor:375-388.

Finney, M. A. 2001. Design of regular landscape fuel treatment patterns for modifying fire growth and behavior. Forest Science **47**:219-228.

Finney, M. A., R. C. Seli, C. W. McHugh, A. A. Ager, B. Bahro, and J. K. Agee. 2007. Simulation of long-term landscape-level fuel treatment effects on large wildfires. International Journal of Wildland Fire **16**:712-727.

Franklin, J. F., and K. N. Johnson. 2012. A restoration framework for federal forests in the Pacific Northwest. Journal of Forestry **110**:429-439.

Golladay, S., K. Martin, J. Vose, D. Wear, A. Covich, R. Hobbs, K. Klepzig, G. Likens, R. Naiman, and A. Shearer. 2016. Achievable future conditions as a framework for guiding forest conservation and management. Forest Ecology and Management **360**:80-96.

Halofsky, J. E., D. C. Donato, D. E. Hibbs, J. L. Cambell, M. Donaghy, J. B. Fontaine, J. R. Thompson, R. G. Anthony, B. T. Bormann, L. J. Kayes, B. E. Law, D. L. Peterson, T. A. Spies, and 7. 2011. Mixed-severity fire regimes: lessons and hypotheses from the Klamath-Siskiyou Ecoregion. Ecosphere **2**:1-14.

Halofsky, J. E., D. L. Peterson, K. L. Metlen, M. G. Myer, and V. A. Sample. 2016. Developing and implementing climate change adaptation options in forest ecosystems: A case study in southwestern Oregon, USA. Forests **7**:1-18.

Haugo, R., C. Zanger, T. DeMeo, C. Ringo, A. Shlisky, K. Blankenship, M. Simpson, K. Mellen-McLean, J. Kertis, and M. Stern. 2015. A new approach to evaluate forest structure restoration needs across Oregon and Washington, USA. Forest Ecology and Management **335**:37-50.

Healthy Forests Restoration Act (HFRA). 2003. One Hundred Eighth Congress of the United States of America, H.R. 1904. Available online: http://www.gpo.gov/fdsys/pkg/BILLS-108hr1904enr/pdf/BILLS-108hr1904enr.pdf.

Hessburg, P. F., D. J. Churchill, A. J. Larson, R. D. Haugo, C. Miller, T. A. Spies, M. P. North, N. A. Povak, R. T. Belote, and P. H. Singleton. 2015. Restoring fire-prone Inland Pacific landscapes: seven core principles. Landscape ecology **30**:1805-1835.

Hessburg, P. F., T. A. Spies, D. A. Perry, C. N. Skinner, A. H. Taylor, P. M. Brown, S. L. Stephens, A. J. Larson, D. J. Churchill, and N. A. Povak. 2016. Tamm Review: Management of mixed-severity fire regime forests in Oregon, Washington, and Northern California. Forest Ecology and Management **366**:221-250.

Hoekstra, J. M., T. M. Boucher, T. H. Ricketts, and C. Roberts. 2005. Confronting a biome crisis: global disparities of habitat loss and protection. Ecology Letters **8**:23-29.

Huang, C.-H., A. Finkral, C. Sorensen, and T. Kolb. 2013. Toward full economic valuation of forest fuels-reduction treatments. Journal of environmental management **130**:221-231.

Irwin, L. L., D. F. Rock, S. C. Rock, C. Loehle, and P. Van Deusen. 2015. Forest ecosystem restoration: Initial response of spotted owls to partial harvesting. Forest Ecology and Management **354**:232-242.

Jewell, S., and T. J. Vilsack. 2014. The National Strategy: The final phase in the development of the National Cohesive Wildland Fire Management Strategy. available online: http://www.forestsandrangelands.gov/strategy/thestrategy.shtml.

Jones, G. M., R. J. Gutiérrez, D. J. Tempel, S. A. Whitmore, W. J. Berigan, and M. Z. Peery. 2016. Megafires: an emerging threat to old-forest species. Frontiers in Ecology and the Environment **14**:300-306.

Kirkpatrick, S., C. D. Gelatt, Jr., and M. P. Vecchi. 1982. Optimization by simulated annealing. Science **220**:671-680.

LANDFIRE. 2010. LANDFIRE 1.1.0 Existing Vegetation Type layer. U.S. Department of the Interior, Geological Survey, available online: http://landfire.cr.usgs.gov/viewer/

Landscape Ecology Modeling Mapping and Analysis (LEMMA). 2014. Gradient Nearest Neighbor (GNN) 2012 vegetation data. Published online: http://lemma.forestry.oregonstate.edu/data/. (Retrieved August 17, 2015).

Lee, D. E., and M. L. Bond. 2015. Occupancy of California Spotted Owl sites following a large fire in the Sierra Nevada, California. The Condor **117**:228-236.

Long, J. W., M. K. Anderson, L. Quinn-Davidson, R. W. Goode, F. K. Lake, and C. N. Skinner. 2016. Restoring California black oak to support tribal values and wildlife. USFS Pacific Southwest Research Station **PSW-GTR-252**.

Lydersen, J., and M. North. 2012. Topographic variation in structure of mixed-conifer forests under an active-fire regime. Ecosystems **15**:1134-1146.

Marlon, J. R., P. J. Bartlein, D. G. Gavin, C. J. Long, R. S. Anderson, C. E. Briles, K. J. Brown, D. Colombaroli, D. J. Hallett, M. J. Power, E. A. Scharf, and M. K. Walsh. 2012. Long-term perspective on wildfires in the western USA. Proceedings of the National Academy of Sciences **109**:E535-E543.

Martinson, E. J., and P. N. Omi. 2013. Fuel treatments and fire severity: a meta-analysis. USDA Forest Service, Rocky Mountain Research Station **RMRS-RP-103WWW**.

McKinley, D., M. Ryan, R. Birdsey, C. Giardina, M. Harmon, L. Heath, R. Houghton, R. Jackson, J. Morrison, B. Murray, D. E. Pataki, and K. E. Skog. 2011. A synthesis of current knowledge on forests and carbon storage in the United States. Ecological Applications **21**:1902-1924.

McNeil, R. C., and D. B. Zobel. 1980. Vegetation and fire history of a ponderosa pine-white fir forest in Crater Lake National Park. Northwest Science **54**:30-46.

Medford District Bureau of Land Management. 2015. Medford District annual program summary and monitoring report: fiscal year 2015. Medford District Office **Available online: https://www.blm.gov/or/districts/medford/plans/files/aps-2015.pdf**.

Menning, K. M., and S. L. Stephens. 2007. Fire climbing in the forest: a semiqualitative, semiquantitative approach to assessing ladder fuel hazards. Western Journal of Applied Forestry **22**:88-93.

Messier, M. S., J. Shatford, and D. E. Hibbs. 2012. Fire exclusion effects on riparian forest dynamics in southwestern Oregon. Forest Ecology and Management **264**:60-71.

Millar, C. I., and N. L. Stephenson. 2015. Temperate forest health in an era of emerging megadisturbance. Science **349**:823-826.

North, M., B. M. Collins, and S. Stephens. 2012. Using fire to increase the scale, benefits, and future maintenance of fuels treatments. Journal of Forestry **110**:392-401.

Oregon Department of Fish and Wildlife. 2016. Oregon Conservation Strategy. Oregon Department of Fish and Wildlife, Salem, Oregon. available at http://www.oregonconservationstrategy.org/.

Oregon Department of Forestry. 2006. Oregon's *Communities at Risk* Assessment. Oregon Department of Forestry, Salem, OR.

Oregon Department of Forestry, Western Forestry Leadership Coalition, and Council of Western State Foresters. 2013. West Wide Wildfire Risk Assessment. Oregon Department of Forestry, Salem, OR.

Perry, D. A., P. F. Hessburg, C. N. Skinner, T. A. Spies, S. L. Stephens, A. H. Taylor, J. F. Franklin, B. McComb, and G. Riegel. 2011. The ecology of mixed severity fire regimes in Washington, Oregon, and Northern California. Forest Ecology and Management **262**:703-717.

Prestemon, J. P., K. L. Abt, and R. J. Barbour. 2012. Quantifying the net economic benefits of mechanical wildfire hazard treatments on timberlands of the western United States. Forest Policy and Economics **21**:44-53.

Pullen, R. 1996. Overview of the environment of native inhabitants of southwestern Oregon, late prehistoric era. Pullen Consulting, Prepared for USDA Forest Service Rogue River Siskiyou National Forest and USDI Bureau of Land Management Medford District. Available at: http://soda.sou.edu/awdata/021204a1.pdf.

Reilly, M. J., C. J. Dunn, G. W. Meigs, T. A. Spies, R. E. Kennedy, J. D. Bailey, and K. Briggs. 2017. Contemporary patterns of fire extent and severity in forests of the Pacific Northwest, USA (1985–2010). Ecosphere **8**:e01695.

Rockweit, J., A. Franklin, and P. Carlson. 2017. Differential impacts of wildfire on the population dynamics of an old-forest species. Ecology **In press**.

Rogue River - Siskiyou Mountains National Forest. 2015. Rogue River-Siskiyou National Forest land and resource management plans monitoring and evaluation report: fiscal year 2014. USDA Forest Service Pacific Northwest Region **Available online: https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3854846.pdf**.

Roloff, G. J., S. P. Mealey, and J. D. Bailey. 2012. Comparative hazard assessment for protected species in a fire-prone landscape. Forest Ecology and Management **277**:1-10.

Safford, H., J. Stevens, K. Merriam, M. Meyer, and A. Latimer. 2012. Fuel treatment effectiveness in California yellow pine and mixed conifer forests. Forest Ecology and Management **274**:17-28.

Schmidt, D. A., A. H. Taylor, and C. N. Skinner. 2008. The influence of fuels treatment and landscape arrangement on simulated fire behavior, Southern Cascade range, California. Forest Ecology and Management **255**:3170-3184.

Schoennagel, T., J. K. Balch, H. Brenkert-Smith, P. E. Dennison, B. J. Harvey, M. A. Krawchuk, N. Mietkiewicz, P. Morgan, M. A. Moritz, R. Rasker, M. G. Turner, and C. Whitlock. 2017. Adapt to more wildfire in western North American forests as climate changes. Proceedings of the National Academy of Sciences.

Scott, J. H. 2014. Summarizing contemporary large-fire occurrence for land and resource management planning. USDA Forest Service, Washington Office.

Scott, J. H., and R. E. Burgan. 2005. Standard fire behavior fuel models: a comprehensive set for use with Rothermel's surface fire spread model. USDA Forest Service, Rocky Mountain Research Station **RMRS-GTR-153**:66.

Scott, J. H., M. P. Thompson, and D. E. Calkin. 2013. A wildfire risk assessment framework for land and resource management. USDA Forest Service, Rocky Mountain Research Station **RMRS-GTR-315**.

Scott, J. H., M. P. Thompson, and J. W. Gilbertson-Day. 2015. Exploring how alternative mapping approaches influence fireshed assessment and human community exposure to wildfire. GeoJournal:1-15.

Scott, J. H., M. P. Thompson, and J. W. Gilbertson-Day. 2016. Examining alternative fuel management strategies and the relative contribution of National Forest System land to wildfire risk to adjacent homes–A pilot assessment on the Sierra National Forest, California, USA. Forest Ecology and Management **362**:29-37.

Sensenig, T., J. D. Bailey, and J. C. Tappeiner. 2013. Stand development, fire and growth of old-growth and young forests in southwestern Oregon, USA. Forest Ecology and Management **291**:96-109.

Spies, T., E. White, A. Ager, J. Kline, J. Bolte, E. Platt, K. Olsen, R. Pabst, A. Barros, and J. Bailey. 2017. Using an agent-based model to examine forest management outcomes in a fire-prone landscape in Oregon, USA. Ecology and Society **22**.

Stephens, S., J. Agee, P. Fulé, M. North, W. Romme, T. Swetnam, and M. Turner. 2013. Managing forests and fire in changing climates. Science **342**:41-42.

Stephens, S. L., S. W. Bigelow, R. D. Burnett, B. M. Collins, C. V. Gallagher, J. Keane, D. A. Kelt, M. P. North, L. J. Roberts, and P. A. Stine. 2014. California Spotted Owl, songbird, and small mammal responses to landscape fuel treatments. BioScience:biu137.

Suh, R. S., and R. Bonnie. 2014. National Action Plan: An implementation framework for the *National Cohesive Wildland Fire Management Strategy*. U.S. Department of the Interior, U.S. Department of Agriculture, Forest Service, National Park Service, Fish and Wildlife Service, Bureau of Land Management, Bureau of Indian Affairs, U.S. Geological Survey, U.S. Department of Homeland Security/U.S. Fire Administration, Western Governors' Association, National Governors' Association, National Association of Counties, Intertribal Timber Council, National League of Cities, National Association of State Foresters, International Association of Fire Chiefs, available online: http://www.forestsandrangelands.gov/strategy/thestrategy.shtml.

Taylor, A. H., and C. N. Skinner. 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA. Forest Ecology and Management **111**:285-301.

Taylor, A. H., and C. N. Skinner. 2003. Spatial patterns and controls on historical fire regimes and forest structure in the Klamath Mountains. Ecological Applications **13**:704-719.

Tempel, D. J., R. J. Gutiérrez, S. A. Whitmore, M. J. Reetz, R. E. Stoelting, W. J. Berigan, M. E. Seamans, and M. Z. Peery. 2014. Effects of forest management on California Spotted Owls: implications for reducing wildfire risk in fire-prone forests. Ecological Applications **24**:2089-2106.

Thompson, J. R., T. A. Spies, and L. M. Ganio. 2007. Reburn severity in managed and unmanaged vegetation in a large wildfire. Proceedings of the National Academy of Sciences **104**:10743-10748.

Thompson, M. P., B. G. Marcot, F. R. Thompson, S. McNulty, L. A. Fisher, M. C. Runge, D. Cleaves, and M. Tomosy. 2013a. The science of decision making: applications for sustainable forest and grassland management in the National Forest System. USDA Forest Service General Technical Report **WO-88**.

Thompson, M. P., N. M. Vaillant, J. R. Haas, K. M. Gebert, and K. D. Stockmann. 2013b. Quantifying the potential impacts of fuel treatments on wildfire suppression costs. Journal of Forestry **111**:49-58.

U.S. Fish & Wildlife Service. 2011. Revised recovery plan for the Northern Spotted Owl (*Strix occidentalis caurina*). Page xvi + 258 US Department of Interior, Portland, Oregon, USA.

U.S. Fish & Wildlife Service. 2012. Endangered and threatened wildlife and plants; designation of revised critical habitat for the Northern Spotted Owl. Medford Bureau of Land Management, Rogue River-Siskiyou National Forest, and USFWS Roseburg Field Office, US Department of Interior, Federal Register.

U.S. Fish & Wildlife Service. 2013. Recovery plan implementation guidance: interim Recovery Action 10. Medford Bureau of Land Management, Rogue River-Siskiyou National Forest, and USFWS Roseburg Field Office, US Department of Interior, Portland, Oregon, USA.

United States Census Bureau. 2010. Census Data. available online: https://www.census.gov/data/.

USGS NHD. 2015. National Hydrography Dataset: Watershed Boundary Dataset U.S. Department of Interior, U.S. Geological Survey, available online: http://nhd.usgs.gov/.

Vander Schaaf, D. M., M. Schindel, D. Borgias, C. Mayer, D. Tolman, G. Kittel, J. Kagan, T. Keeler-Wolf, J. H. L. Serpa, and K. Popper. 2004. Klamath Mountains Ecoregional Conservation Assessment. The Nature Conservancy, Portland, Oregon.

Western Forestry Leadership Coalition. 2010. The True Cost of Wildfire in the Western U.S., Western Forestry Leadership Coalition, Lakewood, CO. available at: www.wflcweb.org.

Photo: Soda springs oak woodland © Kerry Metlen

Appendices

Appendix 1: Data and supporting information underpinning the Rogue Basin Strategy are available here. These data were developed by the Southern Oregon Forest Restoration Collaborative and The Nature Conservancy to inform project development and provide landscape context for restoration work planned.

Appendix 2a: Non-federal participants in the Wildfire Risk Assessment workshops convened by the Southern Oregon Forest Restoration Collaborative in 2015.

Name	Title	Affiliation
Jack Shipley	Executive Director	Applegate Watershed Council
Ken Wienke	Timber Purchaser	Boise Cascade, Inc.
Kendra Smith	Model Watershed Program Director	Bonneville Environmental Foundation
Robert Kentta	Tribal Council	Confederated Tribe of the Siletz Indians
Neil Benson	Fire Plan Coordinator	Fire Plan
Dave Schott	Owner	Forest Glen Lumber
Eugene Wier	Project Manager	The Freshwater Trust
Guy Sparks	Fire Professional	Grayback Forestry, Inc.
Sean Hendricks	Fire Professional	Grayback Forestry, Inc.
Jim Wolf	Wildfire Operations Chief	Intterra Group, Inc.
Karim Naguib	Information Technology	Jackson County
Jenny Hall	Emergency Management Coordinator	Jackson/Josephine County
Simon Hare	County Commissioner	Josephine County
Jaime Stephens	Science Director	Klamath Bird Observatory
Joe Vaile	Executive Director	Klamath-Siskiyou Wildlands Center
Vince Oredson	Wildlife Habitat Specialist	Oregon Department of Fish and Wildlife
Dan Thorpe	District Forester	Oregon Department of Forestry
Greg Alexander	Medford Unit Forester	Oregon Department of Forestry
Herb Johnson	Prevention Specialist	Oregon Department of Forestry
John O'Connor	Cohesive Wildfire Strategy Coordinator	Oregon Department of Forestry
Matt Krunglevich	Prevention Planner	Oregon Department of Forestry
Charley Phoenix	Fire Science Consultant	Phenix Consulting and Education, Inc.
Joe Scott	Wildfire Modeling Specialist	Pyrologix, LLC
Blair Moody	SOFRC Board	Retired BLM/FS
Ed Reilly	Spatial Analyst	Retired BLM/FS
Steve Ziel	Fire Behavior Modeler	Retired Forest Service
Marty Main	Forester	Small Woodland Services, Inc.
Stanley Petrowski	President and Executive Director	South Umpqua Rural Community Partnership
George McKinley	Executive Director	Southern Oregon Forest Restoration Collaborative
Tobin Smail	Fire and Fuels GIS Specialist	Stinger Ghaffarian Technologies, Inc.
Ashley Lara	Fire Adapted Communities Coordinator	The City of Ashland
Chris Chambers	Forest Division Chief	The City of Ashland
Steve Parks	Fire Adapted Communities Coordinator	The City of Ashland
Darren Borgias	Southwest Oregon Program Director	The Nature Conservancy
Derek Olson	Spatial Analyst	The Nature Conservancy
Kerry Metlen	Forest Ecologist	The Nature Conservancy

Appendix 2b: Federal participants in the Wildfire Risk Assessment workshops convened by the Southern Oregon Forest Restoration Collaborative in 2015.

Name	Title	Agency
Al Mason	Fuels Management Specialist	Medford District BLM
Allen Mitchell	Fire and Fuels Management	Medford District BLM
Bryan Wender	District Botany Lead	Medford District BLM
Dayne Barron	Medford District Manager	Medford District BLM
Jena Volpe	Fire Ecologist	Medford District BLM
Jon Larson	Ashland Fuels	Medford District BLM
Kristi Mastrofini	Ashland Supervisor	Medford District BLM
Mark Metevier	District GIS Program Lead	Medford District BLM
Robin Snider	District Wildlife Lead	Medford District BLM
Terry Fairbanks	District Silviculturist	Medford District BLM
Tony Kerwin	District Planner	Medford District BLM
Yanu Gallimore	Fire Management Specialist	Medford District BLM
Peter Winnick	Soil Conservationist	Natural Resources Conservation Service
Amy Amrhein	Staff to Senator Merkley	United States Senate
Cindy Donegan	Fish and Wildlife Biologist	US Fish and Wildlife Service
Charley Martin	Senior Scientist SGT-EROS	US Geological Survey
Bill Schaupp	Entomologist	USFS Forest Health Protection
Josh Bronson	Forest Pathologist	USFS Forest Health Protection
Nikola Smith	Ecosystem Services Specialist	USFS Pacific Northwest Region
Tara Umphries	Sub-regional Fire Planner	USFS/BLM Pacific Northwest Region
Matt Thompson	Research Forester	USFS Rocky Mountain Research Station
Aimee Ross	Botany Technician	USFS Rogue River-Siskiyou National Forest
Allan Hahn	Natural Resources Staff	USFS Rogue River-Siskiyou National Forest
Brian Long	Recreation	USFS Rogue River-Siskiyou National Forest
Clint Emerson	Gold Beach Botanist	USFS Rogue River-Siskiyou National Forest
Craig Trulock	Deputy Forest Supervisor	USFS Rogue River-Siskiyou National Forest
Don Boucher	Environmental Coordinator	USFS Rogue River-Siskiyou National Forest
Donna Mickley	Siskiyou Mountains District Ranger	USFS Rogue River-Siskiyou National Forest
Eric Hensel	Fire and Aviation Staff Officer	USFS Rogue River-Siskiyou National Forest
Jeff von Kienast	Fisheries and Wildlife Biologist	USFS Rogue River-Siskiyou National Forest
Jon Lamb	Fire and Fuels Management	USFS Rogue River-Siskiyou National Forest
Joni Brazier	Hydrology/Soils	USFS Rogue River-Siskiyou National Forest
Mark Hocken	Range Biologist	USFS Rogue River-Siskiyou National Forest
Monty Edwards	Fire Management Officer	USFS Rogue River-Siskiyou National Forest
Patricia Hochhalter	Ecologist	USFS Rogue River-Siskiyou National Forest
Rob Budge	Deputy Fire Staff - Fuels	USFS Rogue River-Siskiyou National Forest
Rob McWhorter	Forest Supervisor	USFS Rogue River-Siskiyou National Forest
Robert Shoemaker	Minerals Specialist	USFS Rogue River-Siskiyou National Forest
Shannon Downey	Environmental Coordinator	USFS Rogue River-Siskiyou National Forest
Donald Helmbrecht	Wildland Fire Analyst	USFS TEAMS Enterprise Unit

Appendix 3: Detailed methodology for developing and refining fuel data from LANDFIRE and the local fuels calibration workshop, as well as running the FSIM large fire simulations. Analysis run and appendix written by Donald Helmbrecht of USFS Teams, available here.

Appendix 4: Acreage of Southern Oregon Forest Restoration Collaborative treatment themes available for treatment and accessible via the existing system roads, by potential vegetation type (PVT) and ownership class.

Potential Vegetation Type	Ecosystem Resilience	Fuel Management	Long-range	Near-range	Total	Percent (%)
Douglas-fir - Dry	298,739	254,206	11,265	81,524	645,733	32.8
Douglas-fir – Moist	37,138	3,503	1,984	9,774	52,399	2.7
Jeffrey pine	29,025	8,838	293	2,456	40,612	2.1
Oregon white oak	43,371	71,668	818	2,090	117,947	6.0
Ponderosa pine - Dry	16,097	24,246	252	1,032	41,627	2.1
Shasta red fir - Dry	2,173	100	0	0	2,273	0.1
Shasta red fir - Moist	7,589	16	84	1,976	9,665	0.5
Sitka spruce	4,235	9,353	0	0	13,588	0.7
Tanoak - Douglas-fir - Dry	103,881	17,809	4,411	19,324	145,424	7.4
Tanoak - Douglas-fir - Moist	181,751	46,847	6,660	13,598	248,855	12.6
Ultramafic	35,548	4,961	191	823	41,524	2.1
Western hemlock - Hyperdry	22,446	1,773	752	3,617	28,588	1.4
Western hemlock - Intermediate	49,725	2,590	1,361	3,550	57,226	2.9
Western hemlock - Moist	38,788	2,473	642	2,586	44,489	2.3
White fir – Cool	65,383	3,088	447	7,693	76,611	3.9
White fir - Intermediate	259,234	40,504	8,294	58,430	366,462	18.6
White fir - Moist	3,127	354	340	1,582	5,403	0.3
Other PVTs	92,760	85,079	869	4,880	183,588	8.7
Ownership						
Bureau of Land Management	286,877	102,735	9,226	63,690	462,528	21.8
U.S. Forest Service	505,527	35,640	11,693	74,406	627,266	29.6
Other ownership	497,893	437,903	17,717	76,736	1,030,249	48.6
Total available and accessible	**1,290,297**	**576,278**	**38,636**	**214,832**	**2,120,043**	

Appendix 5: Restoration density targets in for each treatment theme in terms of Relative Density Index (RDI) and Stand Density Index (SDI) scaled by the maximum SDI (Max SDI) of the seral tree species (seral) tailored to potential vegetation type and solar insolation. Excludes PVTs comprising <1% of the treatable landscape.

				Ecosystem Resilience		Fuel Management		Long-range		Near-range	
Potential Vegetation Type	**Insolation**	**Seral***	**Max SDI**	**RDI**	**SDI**	**RDI**	**SDI**	**RDI**	**SDI**	**RDI**	**SDI**
Douglas-fir - Dry	Cool	PIPO	499	0.35	175	0.40	200	0.30	150	0.45	225
Douglas-fir - Dry	Warm	PIPO	499	0.30	150	0.35	175	0.30	150	0.45	225
Douglas-fir – Moist	Cool	PIPO	499	0.40	200	0.45	225	0.30	150	0.45	225
Douglas-fir – Moist	Warm	PIPO	499	0.35	175	0.40	200	0.30	150	0.45	225
Jeffrey pine	Cool	PIJE	264	0.35	92	0.40	106	0.30	79	0.45	119
Jeffrey pine	Warm	PIJE	264	0.25	66	0.35	92	0.30	79	0.45	119
Oregon white oak	Cool	QUGA	200	0.35	70	0.40	80	0.30	60	0.45	90
Oregon white oak	Warm	QUGA	200	0.30	60	0.35	70	0.30	60	0.45	90
Ponderosa pine - Dry	Cool	PIPO	499	0.30	150	0.40	200	0.30	150	0.45	225
Ponderosa pine - Dry	Warm	PIPO	499	0.25	125	0.35	175	0.30	150	0.45	225
Shasta red fir - Dry	Cool	ABMAS	755	0.45	340	0.45	340	0.30	227	0.45	340
Shasta red fir - Dry	Warm	ABMAS	755	0.40	302	0.40	302	0.30	227	0.45	340
Shasta red fir - Moist	Cool	ABMAS	755	0.45	340	0.45	340	0.30	227	0.45	340
Shasta red fir - Moist	Warm	ABMAS	755	0.40	302	0.40	302	0.30	227	0.45	340
Sitka spruce	Cool	PISI	700	0.45	315	0.45	315	0.30	210	0.45	315
Sitka spruce	Warm	PISI	700	0.40	280	0.40	280	0.30	210	0.45	315
Tanoak - Douglas-fir - Dry	Cool	PSME	600	0.35	210	0.40	240	0.30	180	0.45	270
Tanoak - Douglas-fir - Dry	Warm	PSME	600	0.30	180	0.35	210	0.30	180	0.45	270
Tanoak - Douglas-fir - Moist	Cool	PSME	600	0.35	210	0.45	270	0.30	180	0.45	270
Tanoak - Douglas-fir - Moist	Warm	PSME	600	0.30	180	0.40	240	0.30	180	0.45	270
Ultramafic	Cool	PIJE	294	0.30	88	0.40	118	0.30	88	0.45	132
Ultramafic	Warm	PIJE	294	0.25	74	0.35	103	0.30	88	0.45	132
Western hemlock - Hyperdry	Cool	PSME	600	0.35	210	0.45	270	0.30	180	0.45	270
Western hemlock - Hyperdry	Warm	PSME	600	0.30	180	0.40	240	0.30	180	0.45	270
Western hemlock - Intermediate	Cool	PSME	600	0.45	270	0.45	270	0.30	180	0.45	270
Western hemlock - Intermediate	Warm	PSME	600	0.40	240	0.40	240	0.30	180	0.45	270
Western hemlock - Moist	Cool	PSME	600	0.35	210	0.45	270	0.30	180	0.45	270
Western hemlock - Moist	Warm	PSME	600	0.30	180	0.40	240	0.30	180	0.45	270
White fir – Cool	Cool	ABMAS	750	0.40	300	0.45	338	0.30	225	0.45	338
White fir – Cool	Warm	ABMAS	750	0.35	263	0.40	300	0.30	225	0.45	338
White fir - Intermediate	Cool	PSME	530	0.35	186	0.40	212	0.30	159	0.45	239
White fir - Intermediate	Warm	PSME	530	0.30	159	0.35	186	0.30	159	0.45	239

*Seral tree species: ABMAS=Shasta red fir, PIJE=Jeffrey pine, PIPO=ponderosa pine, PISI=Sitka spruce, PSME=Douglas-fir, QUGA=Oregon white oak

Appendix 6: Detailed methodology for parametrizing the Marxan optimization software and developing the three landscape scale management scenarios are available here.

Appendix 7: Detailed methodology for modifying fuel characteristics for modeling fire behavior under the three management scenarios are available here.

Appendix 8: Detailed economic analysis and underlying assumptions for the Rogue Basin Strategy (available here).

Appendix 9: Factsheets that summarize characteristic of all 96 planning areas analyzed under the Rogue Basin Strategy and their performance on landscape objectives, risk reduction, acreage by potential treatment category, and economics (available here).

Appendix 10: Description and outcomes of a workshop with engaged stakeholders to introduce the Rogue Basin Strategy and receive feedback on how well the Rogue Basin Strategy addresses climate change concerns (available here).