Acknowledgements

Moving Forward: Future Forest and Resource Management on City of Ashland Forestlands with Considerations for Climate Change

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5. Summary

Not considering climate change in management is akin to traveling in an unknowned territory without a map- one is not likely to arrive at the desired destination.

Source: Scanning the Conservation Horizon: A guide to Climate Change Vulnerability Assessment. Glick, P., B.A. Stein, and N.A. Edelson, editors. 2011. National Wildlife Federation, Washington, D.C.

“Be careful if you don’t know where you are going because you might not get there”

Yogi Berra

The issue of time

Objectives

1) Historical. Implementation practices in the last 25 years that got us to today, including an assessment of appropriateness from a climate adaptation perspective.

2) Current. Where we are today and what makes sense to continue in the same way (i.e. to persist)

3) Future. Where are we going in the next 25 years, given changes associated with climate. Where is continued persistence in our management actions appropriate? Where, in the context of forest and resource management on City lands, is a change appropriate now? And to what degree?

We cannot move forward optimally without understanding where we are today and how we've got here. Without this footing, we will not be able to recognize, let alone understand, changes when we see and experience them in the future.

History informs us, but shouldn’t be the only goalpost to shoot for. There are numerous “reference” conditions as one moves back in time, each determined by the climate, vegetation and disturbance processes unique to that time. No one reference condition is necessarily any better than another. And the combination of the climate, vegetation and disturbance processes we have today are much different than any other time in history. However, we can use information derived from the past to better help us understand how we got to where we are today and help us understand and prepare for for what may be coming.

While there are many important lessons to learn from the past, we believe that we cannot rely on past forest conditions to provide us with blueprints for current and future management (Millar *et al 2007). In particular, the nature and scale of* past variability in climate and forest conditions, coupled with our imprecise ability to fully reconstruct those conditions, introduce a number of conceptual and practical problems (Millar and Woolfenden 1999a). Detailed reconstructions of historical forest conditions, often dendroecologically based, are very useful but represent a relatively narrow window of time and tend to coincide with tree recruitment in the generally cooler period referred to as the little ice age (figure 1). As such, manipulation of current forests to resemble past conditions may not produce the desired result when considering future climates.

Restoration of forest structure to resemble those of the past provides no guarantee of sustainability into the future.

Stephens et.al. 2010. Operational approaches to managing forests of the future in Mediterranean regions within a context of changing climates.

The issue of scale

The importance of a local scale of reference

“If the focus is on a single management unit or land ownership, a relatively small internal planning process may be suitable. On the other hand, planning across a broader landscape controlled by diverse land management
and regulatory agencies and private interests will require a more concerted focus on stakeholder engagement and collaborative processes. “

Stein, B.A., P. Glick, N. Edelson, and A. Staudt (eds.). 2014.
Climate-Smart Conservation: Putting Adaptation Principles into Practice. National Wildlife Federation, Washington, D.C.

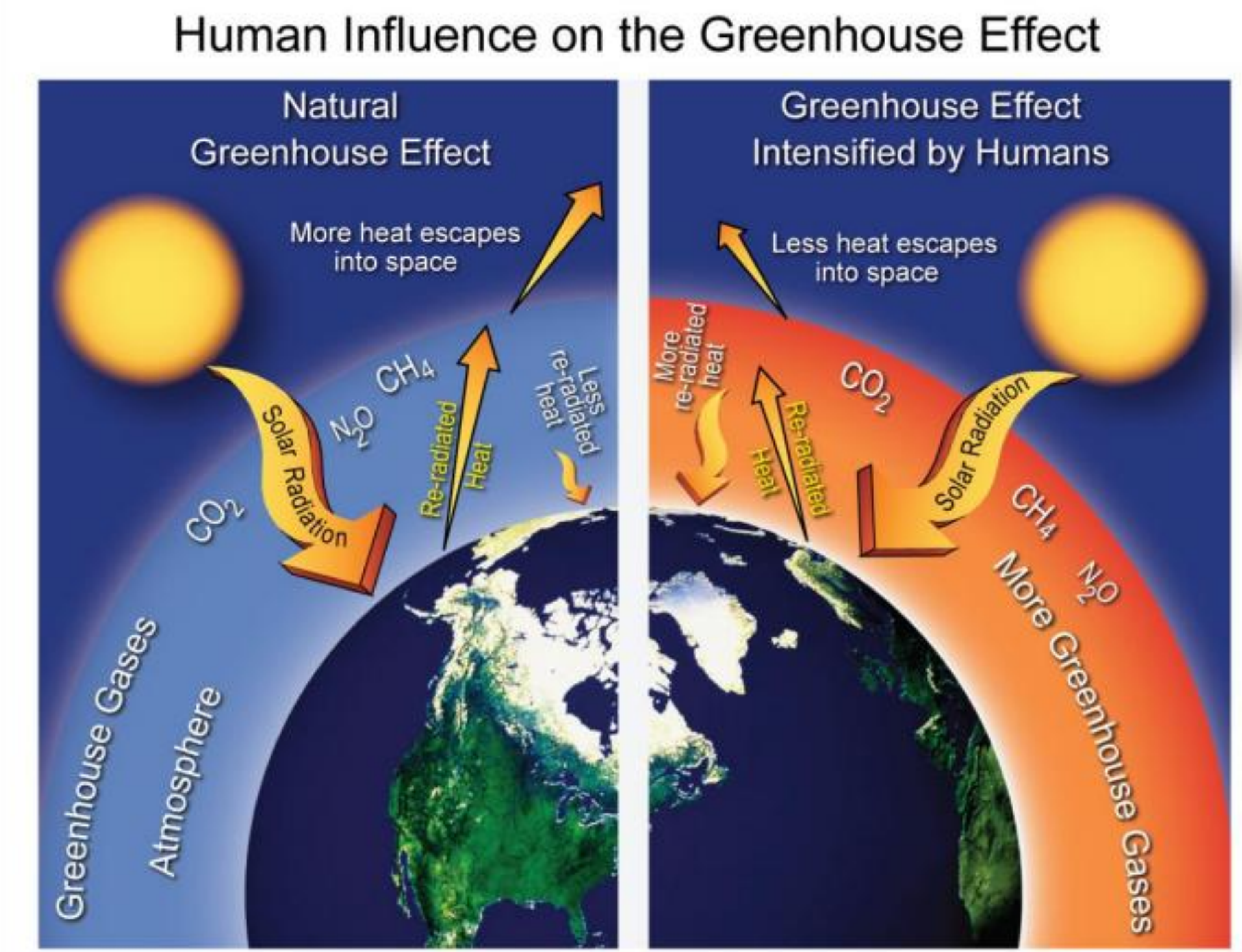
“Climate acts as a top-down, broader scale control of fire, but human management serves a bottom-up, local control.”

Vachula et.al. 2019. Climate exceeded human management as the dominant control of fire at the regional scale in California’s Sierra Nevada.

“In the legitimate haste of the scientific community to understand the large-scale atmospheric phenomena associated with climate change, we should not forget that part of the equation that deals with the ecological changes occurring in local ecosystems.”

Perry et. al 1990. Species Migrations and Ecosystem Stability During Climate Change: The Belowground Connection.

Figure 22. *The natural greenhouse effect intensified by human influence (Walsh et al., 2014a).*



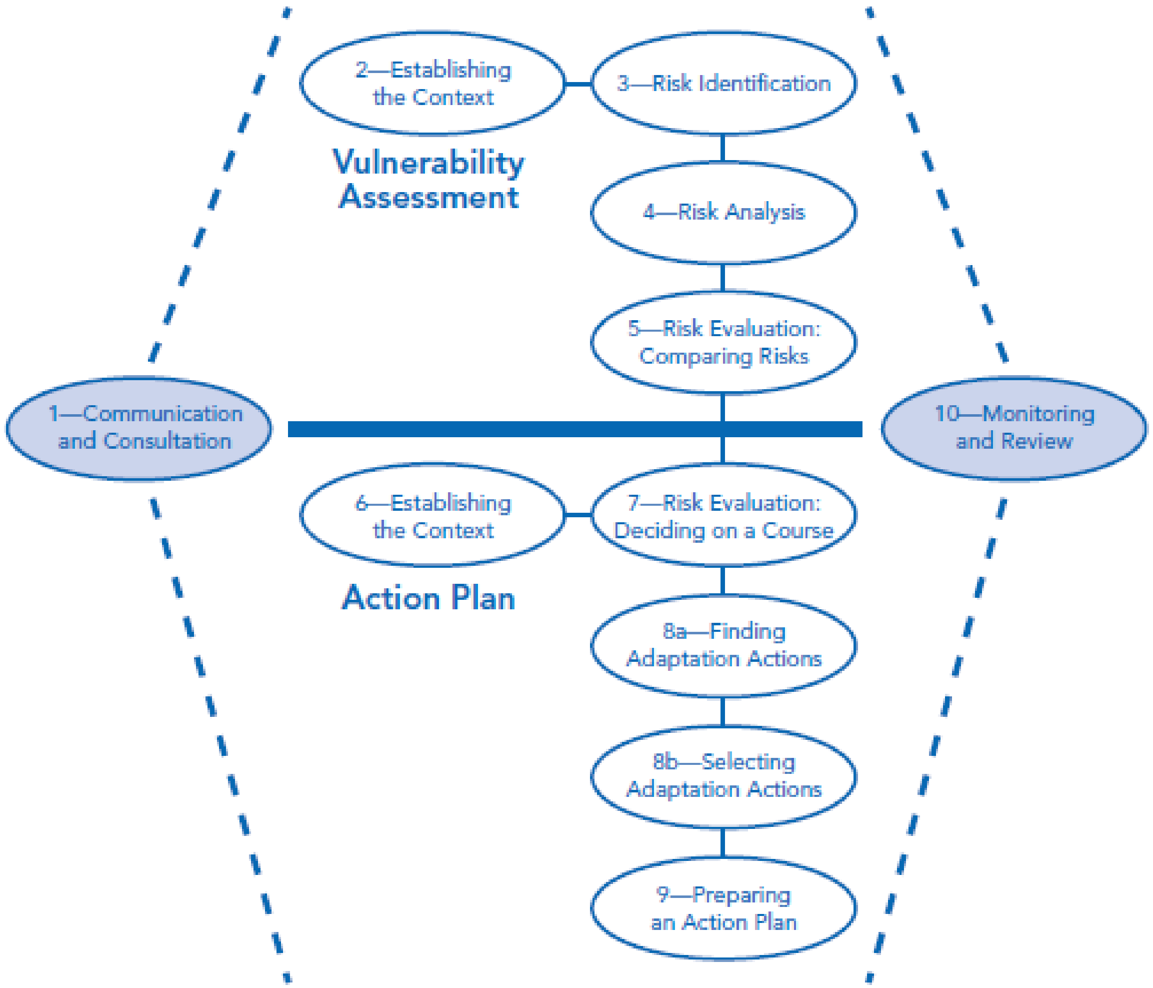


Figure I-1. A roadmap showing Step 1 through Step 5 of the vulnerability assessment and Step 6 through Step 10 of action planning. Communication and consultation should be part of every step. Monitoring and review keeps the whole adaptation plan up to date.

Source: EPA. 2014. Being Prepared for Climate Change- A Workbook for Developing Risk-Based Adaptation Plans

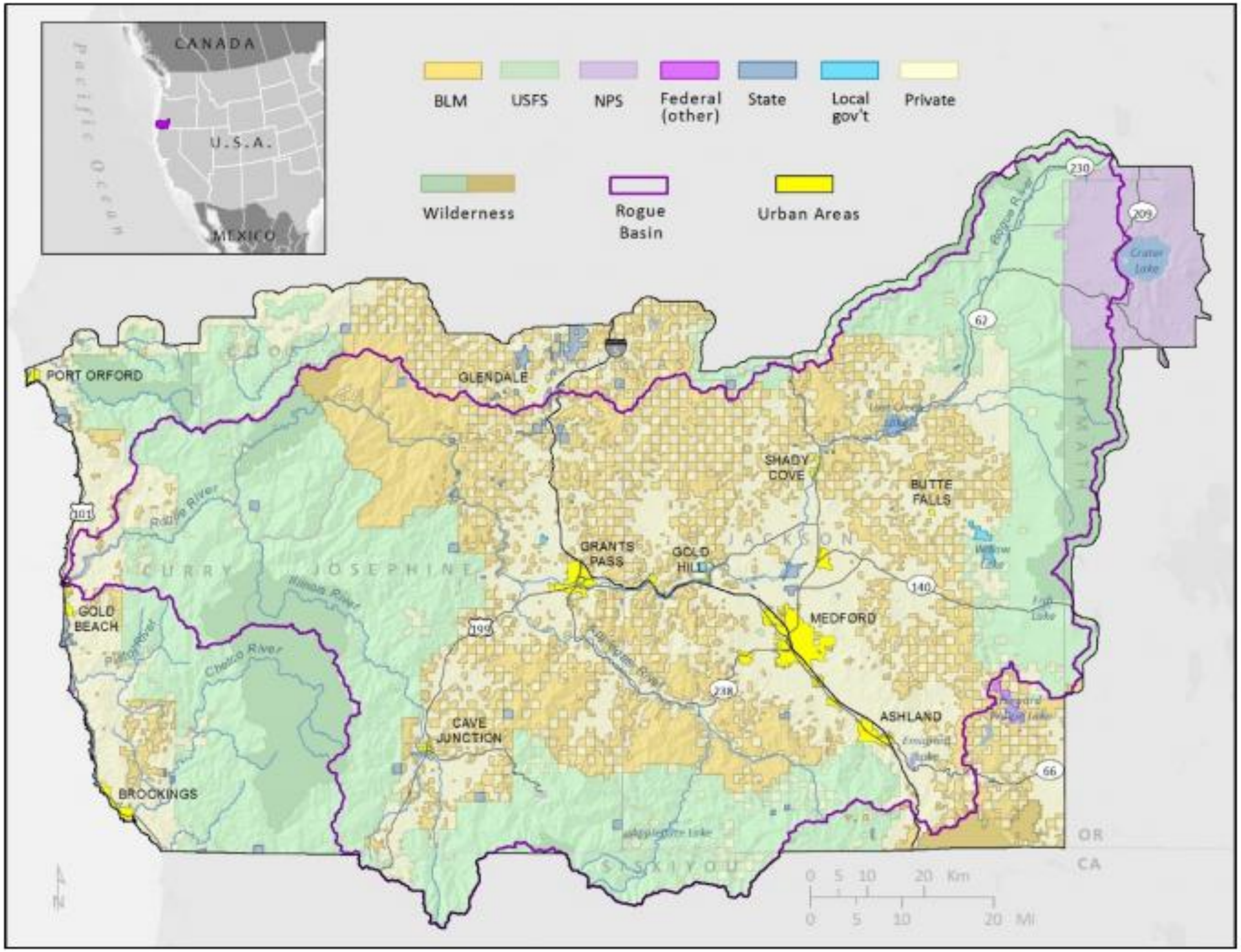
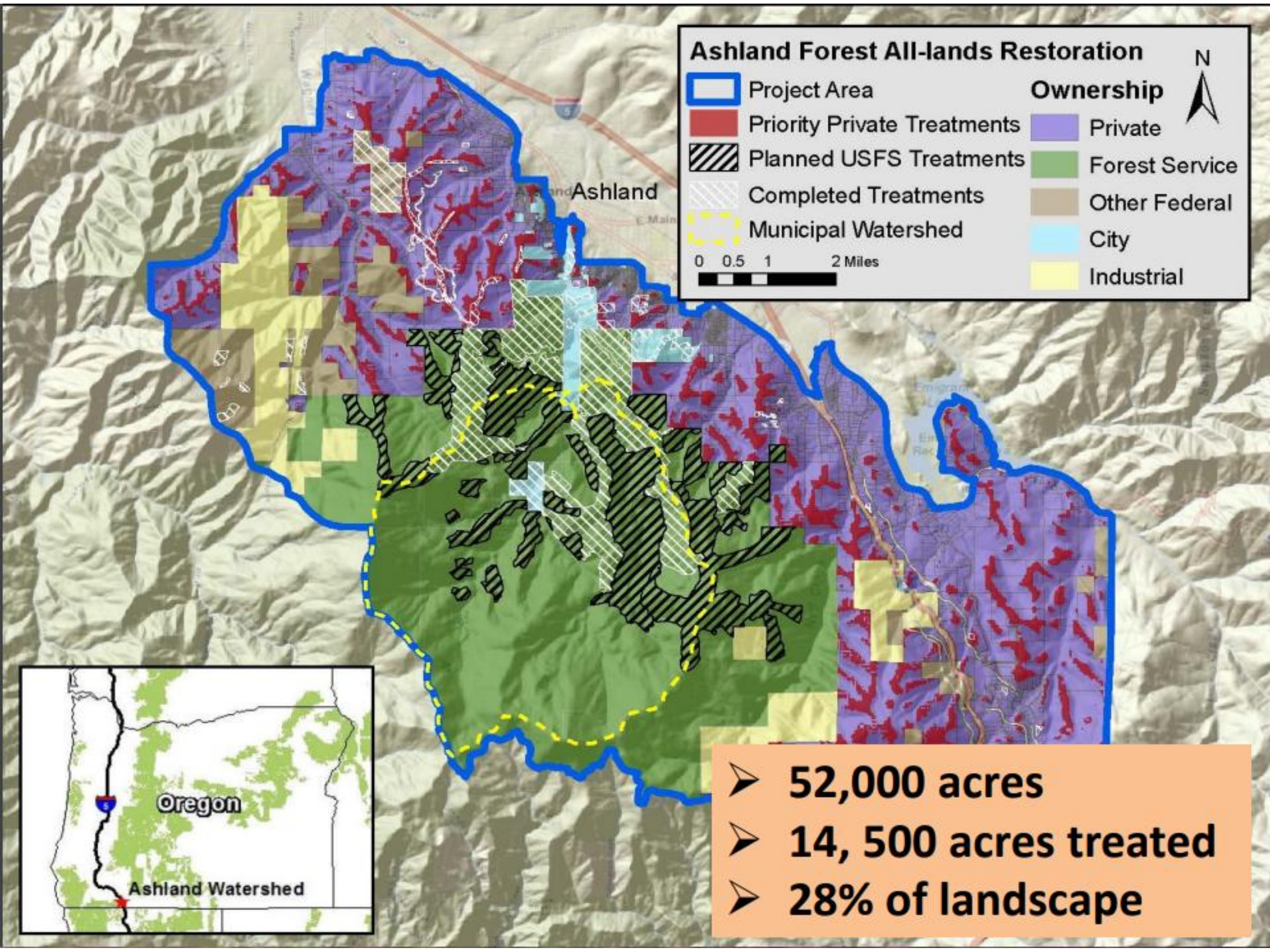
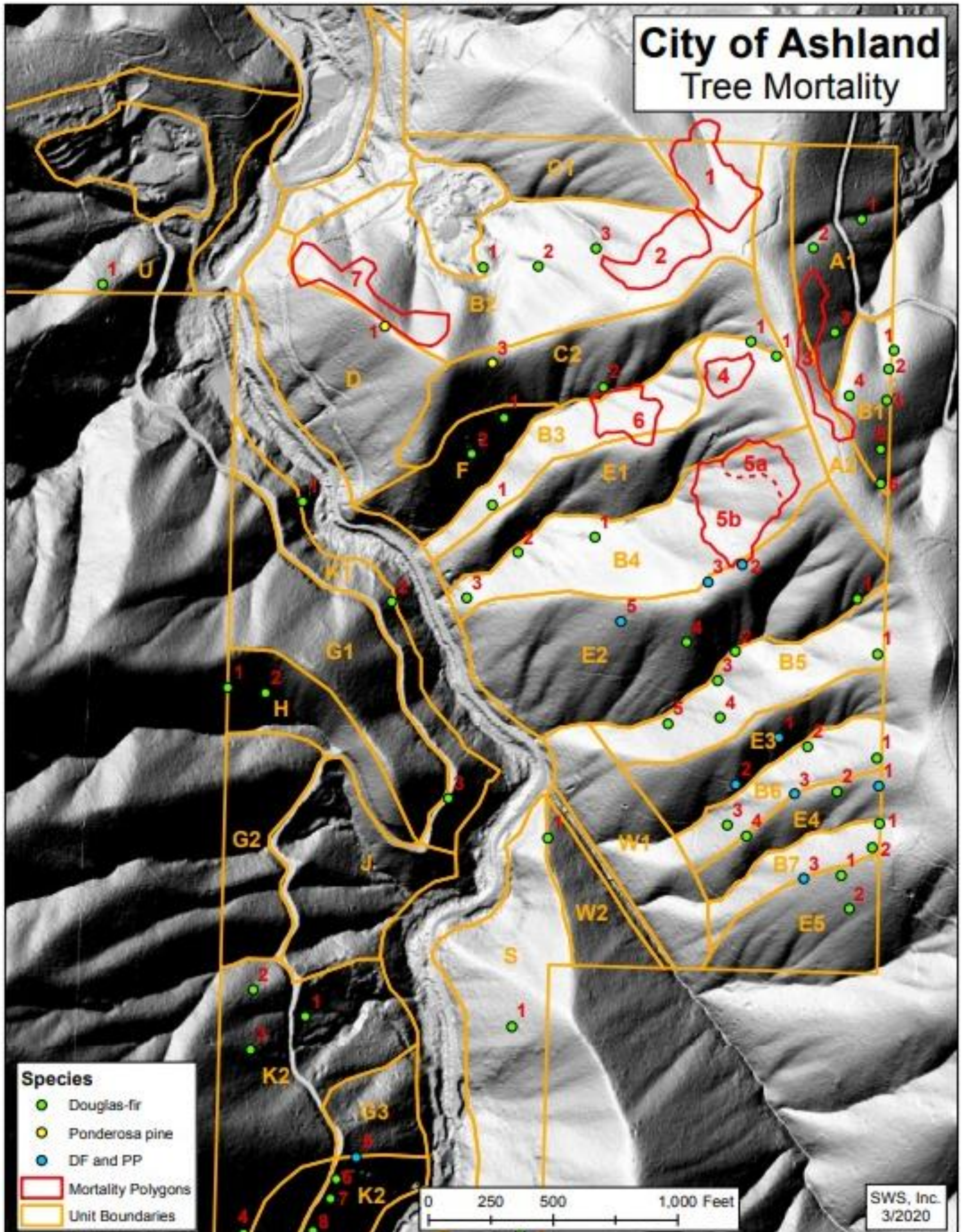


Figure 3: The Rogue Basin Cohesive Forest Restoration Strategy analysis area is 4.6 million-ac across many ownerships and land allocations.


Ashland Forest All-lands Restoration
Project Area
Priority Private Treatments
Planned USFS Treatments
Completed Treatments
Municipal Watershed
0 0.5 1 2 Miles
Ownership
Private
Forest Service
Other Federal
City
Industrial
N
Ashland
Oregon
Ashland Watershed
52,000 acres
14, 500 acres treated
28% of landscape

Map 1b



Individual sites, polygons or units on the City of Ashland ownership

Source: Main and Schmidt 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis

“An inverse relationship exists between the geographic scale of an assessment and the certainty of projections.”

Scanning the Conservation Horizon: A guide to Climate change Vulnerability Assessment

Considering the high amount of uncertainty associated with predicting the effects of climate change on forest ecosystems, the scale of the City of Ashland ownership has a lot to offer in ongoing discussions and deliberations.

Integration of Operational Reality

- Critical link often underestimated or overlooked

- We manipulate vegetation to achieve objectives at the smallest of scales, regardless of the scale that we do our planning at.

Integrate between past experiences, current knowledge, both qualitative and quantitative, and a very uncertain future across multiple frames of reference but in this case, elevating the importance of the local scale.

Manage for system integrity rather than for individual objective

Manage for system health and resilience rather than a collection of individual values or resources. These forest ecosystems are complex adaptive systems and the services they provide should be, as much as possible, considered a logical outgrowth of a functioning ecosystem rather than a driver of management. In essence, "Ask not how we can shift things to achieve our singular objective(s), but rather how we can shift so that our objectives are natural outgrowths of a functioning forest ecosystem."

“Maintaining or even promoting the ability of forests to adapt to diverse and unexpected disturbance(s) without losing ecological integrity should become of the highest priority.”

Source: Puettman et.al. 2009. A Critique of Silviculture: Managing for Complexity.

“The significant problems we face cannot be solved at the same level of thinking we were at when we created them.”

Albert Einstein

Projected Climate-Related Changes

CITY OF ASHLAND, OREGON

Climate Trends & Projections

FINAL REPORT

AUGUST 22, 2016

Prepared by:

Meghan M. Dalton
Oregon Climate Change Research Institute

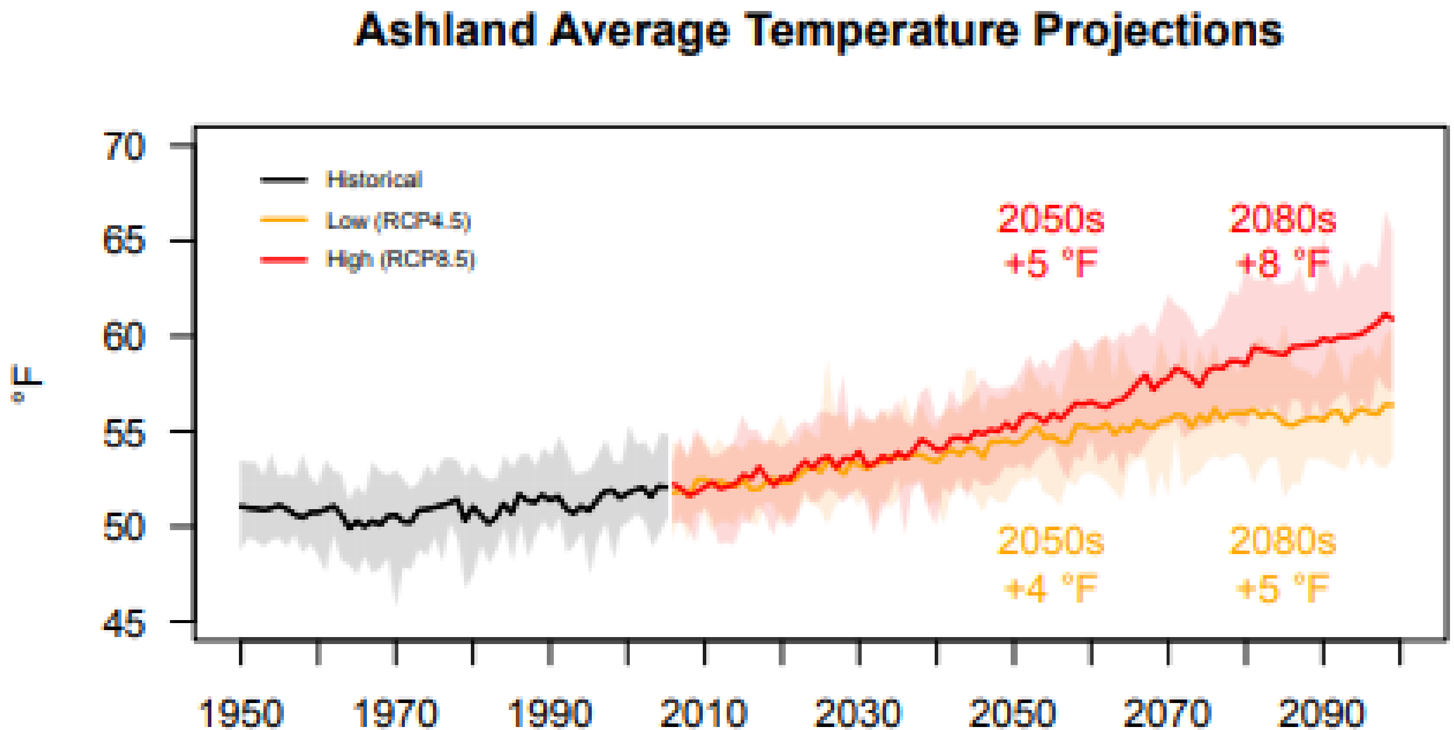
Figure 21. *Some of the many long-term global indicators that demonstrate that the Earth's climate is warming (Walsh et al., 2014b).*

Slide Source: Climate Trends and Projections. Final Report to the City of Ashland by Meghan Dalton, Oregon Climate Change Research Institute. 2016

Projected changes from 1950-2000 baseline for the year 2050 under busine
as usual emissions scenario, for the area around Ashland.

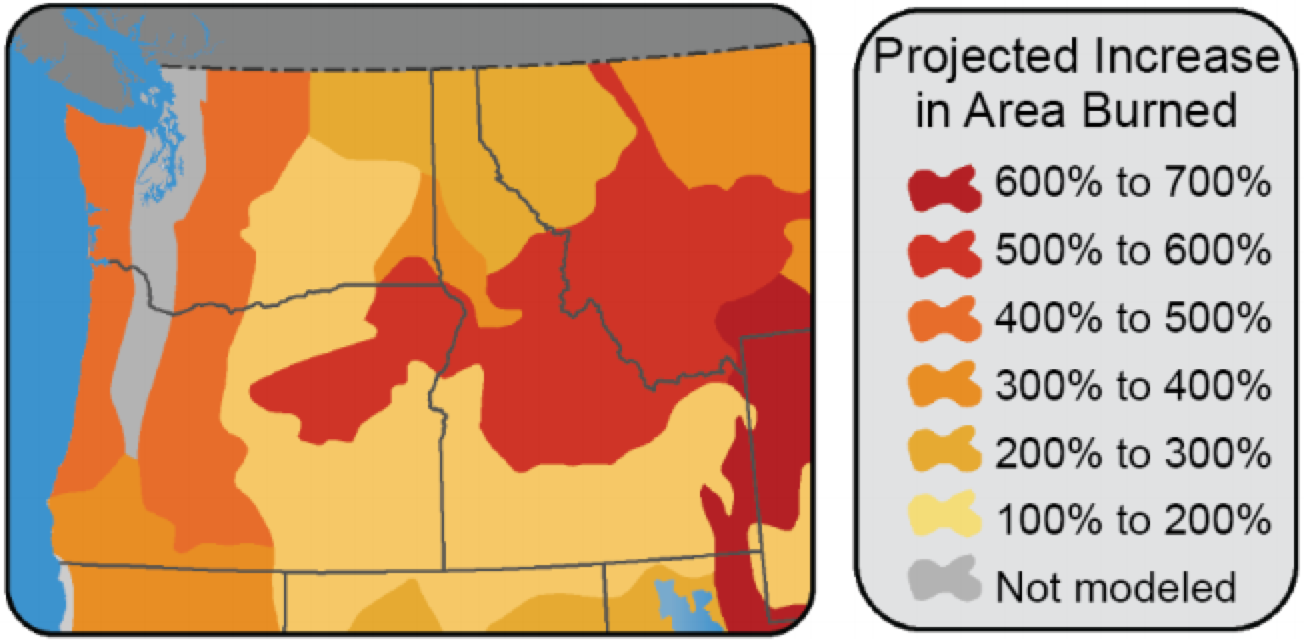
Climate parameter	Change from baseline
Average annual temperature	+ 5°F
Hottest day of the year	+ 7°F
Days over 100°F	+ 11 days
Frost days	- 52 days
Annual precipitation	No change
Winter precipitation	Increase
Summer precipitation	Decrease
Consecutive dry days	+ 5 days
Snow water equivalent (Middle Rogue)	- 66%

Source: Climate Trends and Projections. Final Report to the City of Ashland by Mehgan Dalton, Oregon Climate Change Research Institute.
https://www.ashland.or.us/Files/Ashland_Climate_Report_FINAL.PDF



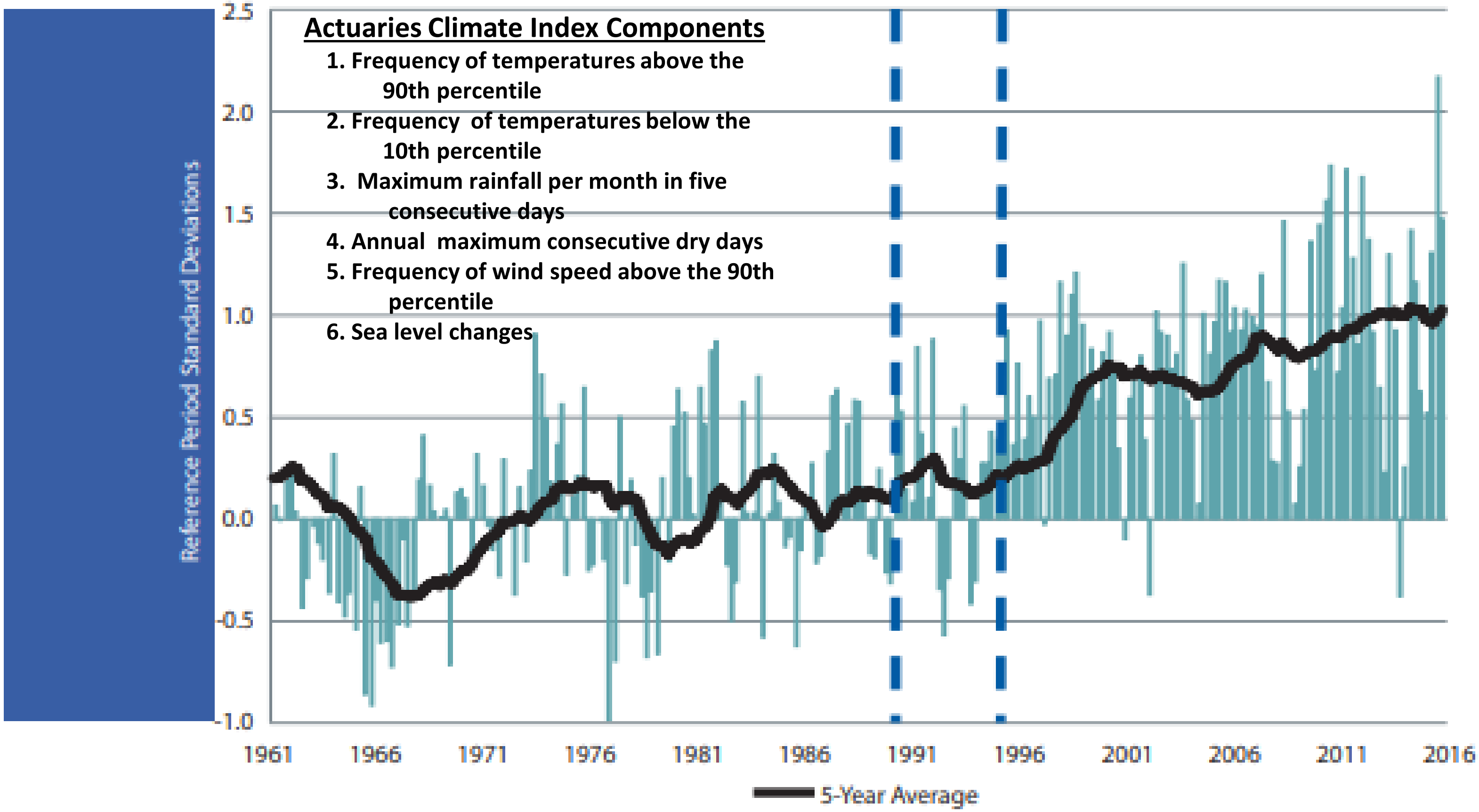
Slide Source: Climate Trends and Projections. Final Report to the City of Ashland by Meghan Dalton, Oregon Climate Change Research Institute. 2016

Figure 20. *Increases in area burned that would result from the regional temperature and precipitation changes associated with a 2.2°F global warming across areas that share broad climatic and vegetation characteristics. Local impacts will vary greatly within these broad areas with sensitivity of fuels to climate (Mote et al., 2014).*



Slide Source: Climate Trends and Projections. Final Report to the City of Ashland by Meghan Dalton, Oregon Climate Change Research Institute. 2016

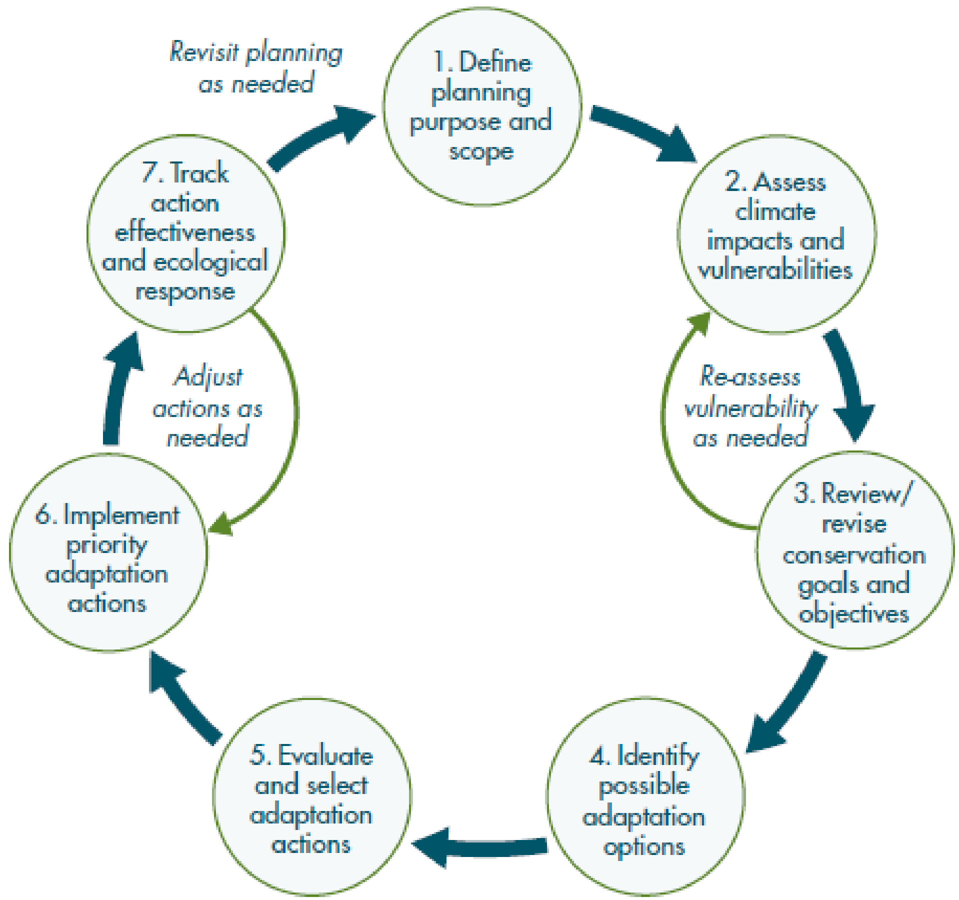
Figure 3. The Actuaries Climate Index for Canada and the United States.



The Actuaries Climate Index™ (ACI) is an educational tool designed to help inform actuaries, public policymakers, and the general public about climate trends and some of the potential impacts of a changing climate on the United States and Canada. Actuaries are risk professionals. They not only measure risk; they assist in mitigating and managing risk. Actuaries apply their expertise and knowledge to a wide range of problems facing people in their everyday lives and businesses in the conduct of their enterprises. Just as climate scientists build models for potential future changes in the climate, actuaries model the likelihood of the financial impact of uncertain future events.

Source: https://actuariesclimateindex.org/wp-content/uploads/2016/04/ACI.ExecutiveSummary5.18.pdf

Current Pathways for Progress



Objectives can be modified if necessary

Figure 4.1. Climate-smart conservation cycle. This cycle can serve as the basis for undertaking a "stand-alone" adaptation planning effort, or can be used to help incorporate climate considerations into existing planning and decision-making processes. The steps in this cycle serve as the basis for the more detailed discussions that are the focus of Part II of this guide.[9]

Source: Stein, B.A., P. Glick, N. Edelson, and A. Staudt (eds.). 2014. *Climate-Smart Conservation: Putting Adaptation Principles into Practice. National Wildlife Federation, Washington, D.C.*

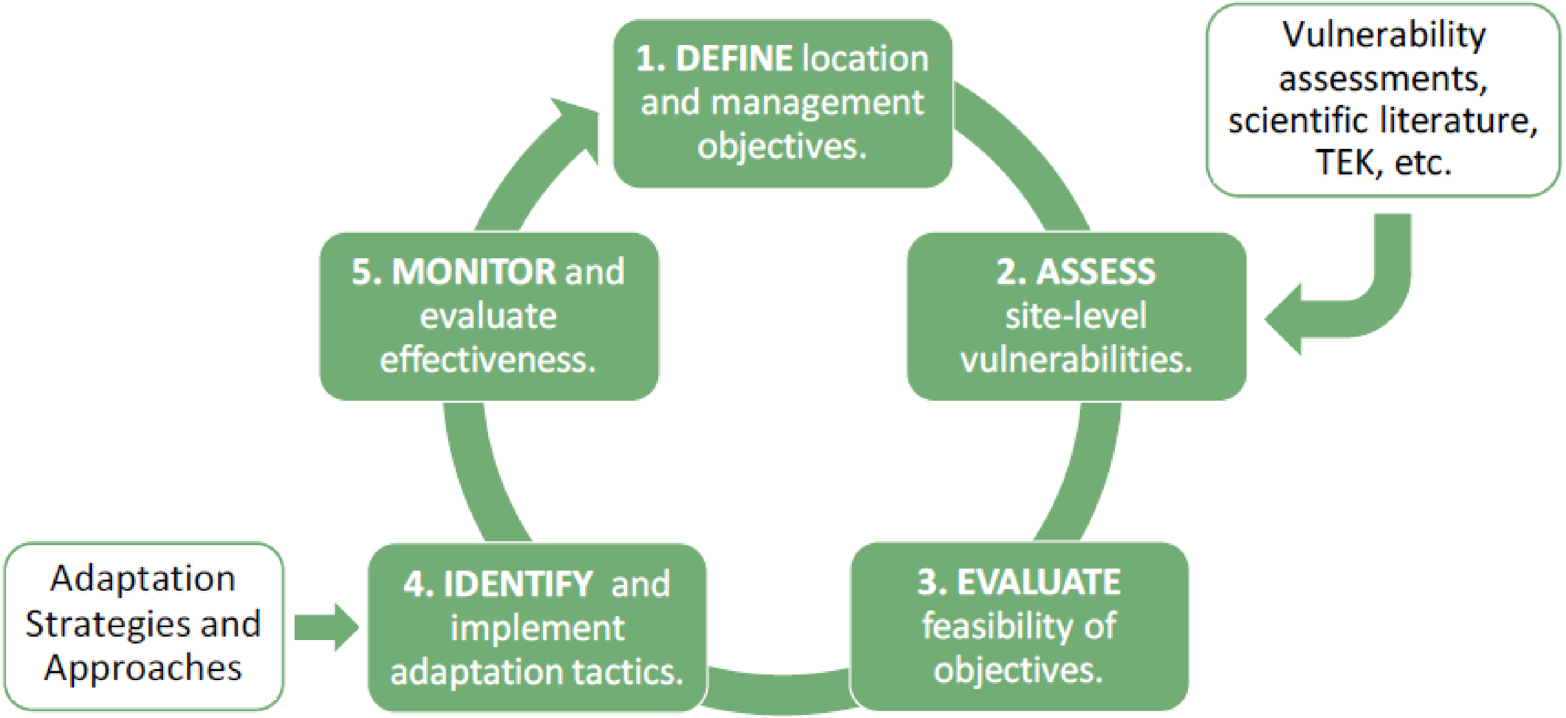


Figure 1. The Adaptation Workbook is a structured process designed to be used in conjunction with vulnerability assessments and adaptation strategies menus to generate site-specific adaptation actions that meet explicit management and conservation objectives under a range of potential future climates. This document is intended to be used with the Adaptation Workbook found in Forest Adaptation Resources: Climate Change Tools and Approaches for land managers, 2nd edition (www.nrs.fs.fed.us/pubs/52760, Swanston et al. 2016) and the corresponding online interactive tool (adaptationworkbook.org). A brief version is in Appendix 1 of this document.

Source: Swanston et.al. 2020. Adaptation Strategies and Approaches for California Forest Ecosystems. USDA California Climate Hub Technical Report CACH-2020-1. Davis, CA: U.S. Department of Agriculture, Climate Hubs.

City of Ashland Management Objectives (1995)

1. Protection of watershed values and maintenance of water quality and quantity.
2. Maintenance and/or promotion of forest and ecosystem health.
3. Reduction in wildfire hazard and risk.

Goals: Chapter 11, 2016 Ashland Forest Plan

Ecological

- Promote healthy, resilient forest ecosystems including appropriate native plant and animal habitat.
- Significantly diminish the likelihood of a high-severity wildfire through active vegetation and fuels management that emulates the historic range of natural disturbances.
- We acknowledge that fire will occur on City lands in the future and that our management efforts are designed to allow it to occur at times, locations, scales and intensities that more closely meet current resource objectives.
- Maintain water quality and quantity for use by the City and enhance aquatic life in the watershed while minimizing the potential for soil erosion and landslide events.

Social

- Encourage citizen input and increase public awareness and education in the process of maintaining the health of the forest lands, the Wildland Urban Interface (WUI) and the broader Ashland Watershed.
- Integrate recreational opportunities into the larger context of active forest management.

Ashland Climate and Energy Action Plan

NS-1.1 - Manage forests to retain biodiversity, resilience, and ecosystem function and services in the face of climate change. Use best available science to inform fire management and planning.

Four Adaptive Strategies for Climate Change

From Millar and Stephenson 2007; Ashland Forest Plan 2016

1. **Resistance** (forestall major impacts and protect highly valued resources)
2. **Resilience** (improve the capacity of ecosystems to return to desired conditions after disturbance)
3. **Response** (facilitate transition of ecosystems from current to new conditions)

From Stephens et.al. 2010.

4. **Realignment** (modifying forests and restoring key ecosystem processes by re-alignment of the disturbed landscape into the range of current and/or expected future conditions rather than restoration to historical pre-disturbance conditions)

Source: Stephens et.al. 2010. Operational approaches to managing forests of the future In Mediterranean regions within a context of changing climates.

Climate change will increasingly necessitate that the conservation community move from a paradigm of not just preservation and restoration to historical conditions (i.e., managing for persistence), but one that is simultaneously open to anticipating and actively facilitating transitions (i.e., managing for change). This notion has previously been described in the adaptation literature in the form of a continuum of strategies that move from resistance, to resilience, to transformation (Millar et al. 2007, Glick et al. 2009). Here we choose to focus on "outcomes" (change/persistence) rather than "strategies" (resistance/resilience/transformation) because any particular adaptation action could contribute to change or persistence depending on context, scale, and application.

Source: Stein, B.A., P. Glick, N. Edelson, and A. Staudt (eds.). 2014. *Climate-Smart Conservation: Putting Adaptation Principles into Practice. National Wildlife Federation, Washington, D.C.*

Vulnerability Assessments and Adaptation Options

1. Soils and Soil Productivity
2. Water and Hydrologic Function
3. Vegetation
    a. Functional Processes and Disturbance
    b. Density/Vigor
    c. Species Composition
    d. Stand Structures and Structural States
4. Wildlife, Habitat Management and Biodiversity Conservation
5. Riparian
6. Recreation
7. Carbon

1. SOILS and SOIL PRODUCTIVITY

“We often forget is that our primary responsibility and overarching goal in forest and resource management is to protect healthy forest soils.”

“Take good care of the land- they ain’t making any more of it”

- Will Rogers

“What I stand for is what I stand on.”

- Wendell Berry

1. Soils and Soil Productivity

1) **Healthy soils are critical to the proper function of forest ecosystems**, as they help regulate important ecosystem process such as nutrient uptake by vegetation, water storage and availability, slope stability, decomposition, and others. Water storage is a particularly important function of soils in southern Oregon as moisture is limiting in these Mediterranean climate.

2) **Soil properties are key determinants of the type, diversity , quantity and vigor of vegetation that can occur on any site.**

3) **Healthy soils have complex physical, biological and chemical processes that are mediated by the type, frequency, intensity and duration of disturbance.**

4) **The impacts of fires tend to increase with the quantity of fuels consumed. Long duration, high severity fire can severely impact forest soils,** including removal of organic matter and heating and changing these biological, chemical and physical features of soils.

5) **High severity reburns can additionally impact long-term site productivity** and encourage transition of forests to other less desirable stable states, compromising ecosystem services and significantly reducing carbon storage and sequestration.

6) **Healthy soils are perhaps the most significant element of resilience that exists in our forests.** With inherent thermal protection, they are less directly impacted than above-ground vegetation by temperature extremes associated with atmospheric processes and climatic warming as well as heat transfer from most fires. The ability of any forest ecosystem to recover and return to similar post-disturbance conditions depends largely on soils characteristics.

7) **Healthy soils retain significant amounts of carbon- roughly half (or more) of the total in forests is stored in soils with another 5-10% on the forest floor.**

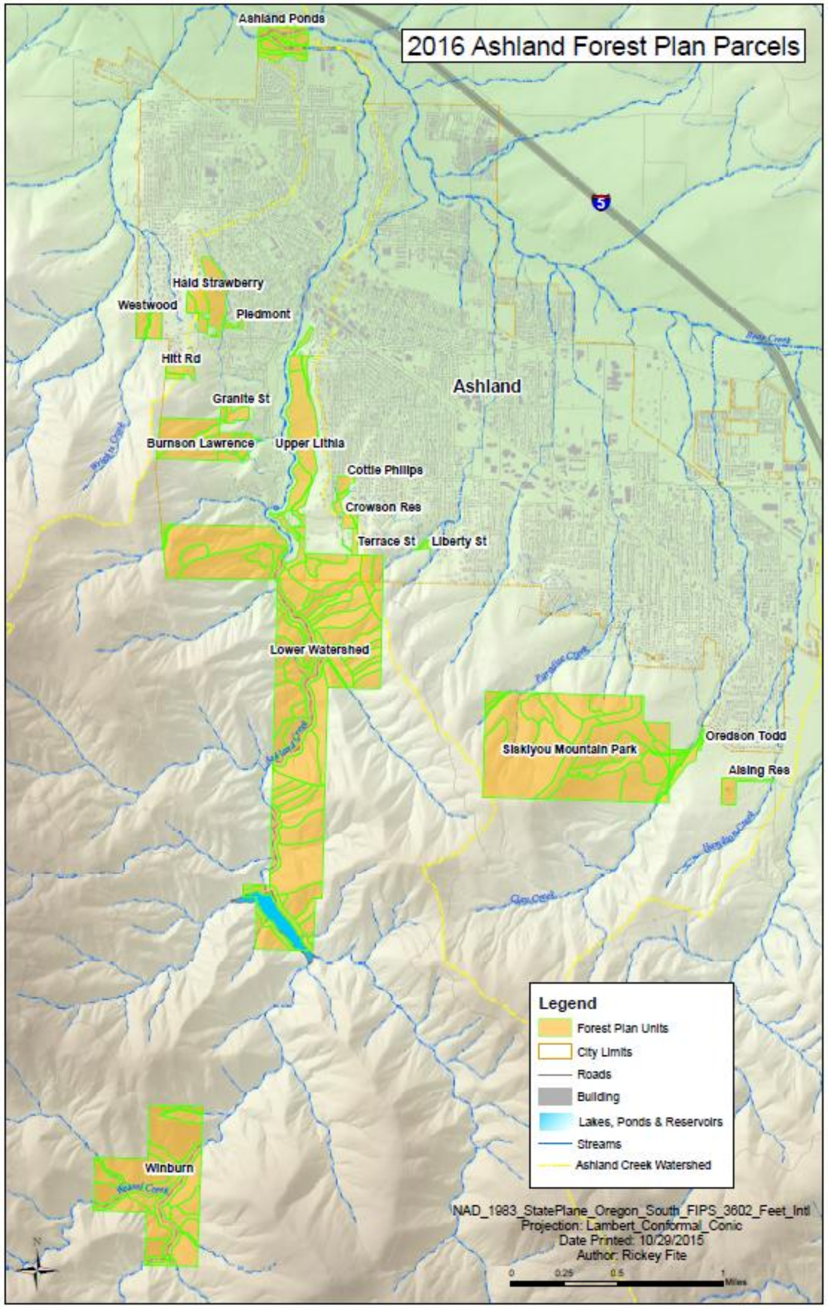
1. Soils and Soil Productivity

Climate Change Key Vulnerabilities

1. **Very erosive soils.** Decomposed granitic soils are very erosive soils and dominate almost all of the City forestland ownership. Surface soil erosion can be easily exacerbated by climate changes.

2. **Steep topography and increased opportunity for landslides.** High percentage of ownership is on steep to very steep topography that periodically results in debris slides, especially during major storm events. Root-holding capacity of vegetation reduces that potential.

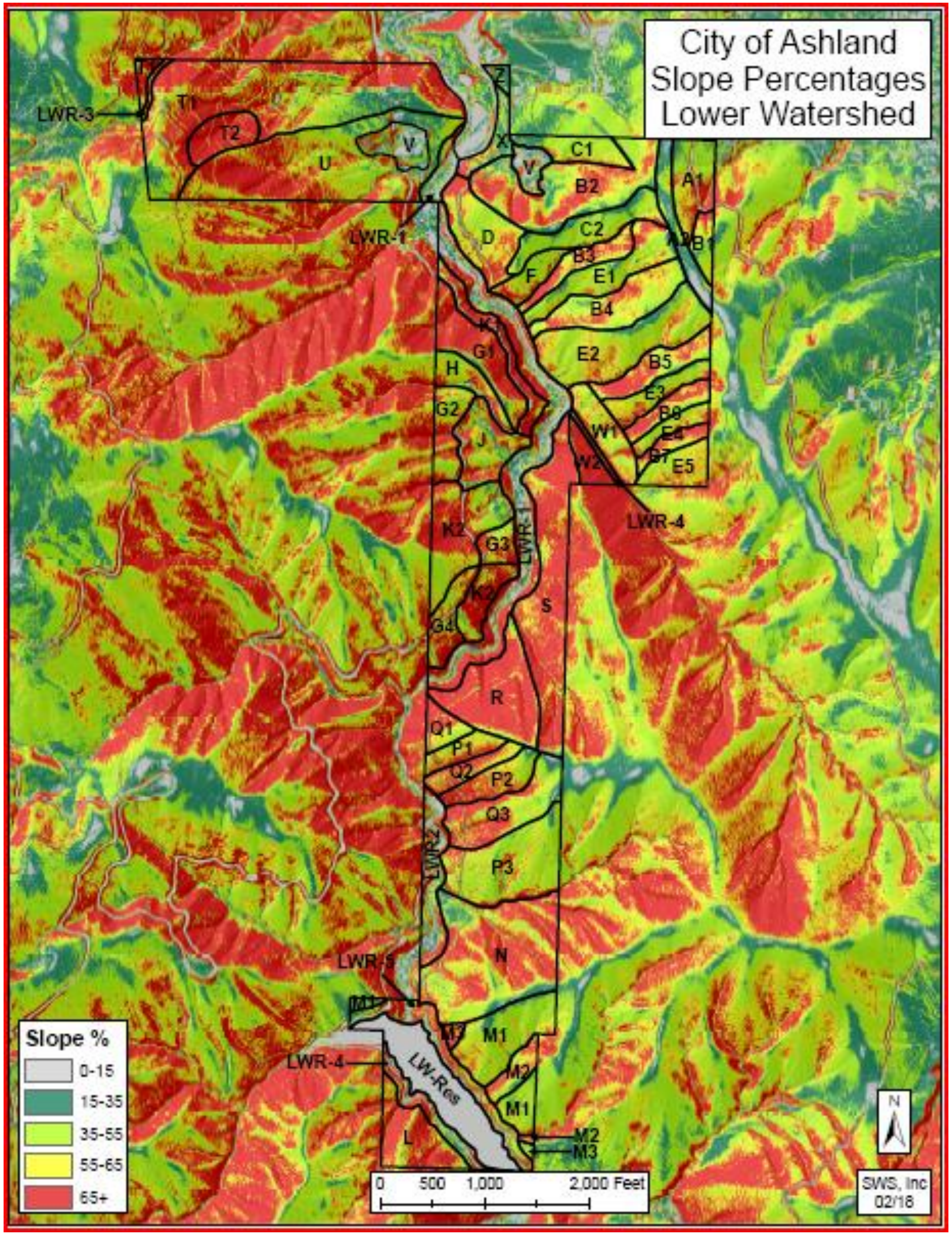
3. **High severity fire (or other high severity disturbance)**
   - -consumption of organic matter and heating and changing the physical, chemical and biological, features in the soil; hydrophobic soils
   - - large scale increase in surface soil erosion (e.g. water repellent soils) and sedimentation in hydrologic network, including Reeder Reservoir
   - - elevated potential for landslide processes with significant potential impacts downstream (loss of vegetation and root holding capacity, increase in peak storm events)
   - - increased potential for reburns and additional soil degradation
   - - long duration fire creates most serious soil impacts (i.e. from excess amounts of snags, large woody debris); most impactful in headwall locations.
   - - loss of plant:soil interactions and impacts on soil biology and biological processes at soil depth, many of which are poorly understood and rarely considered (e.g. mutualistic relationships and resource sharing, including carbon; hydraulic redistribution; etc.)

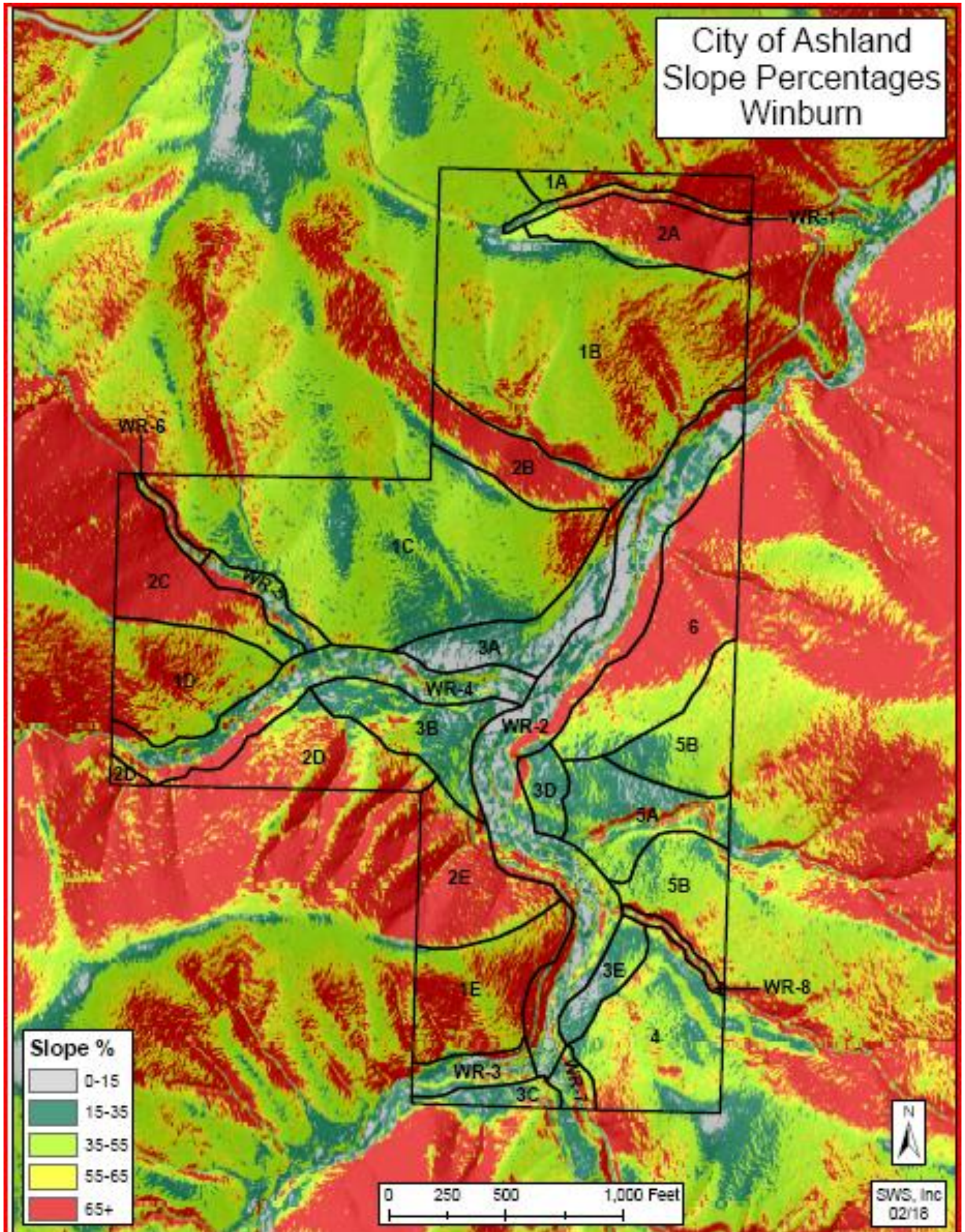


Key Vulnerability- Soil Types

All of City forestland parcels are dominated by decomposed granitic soils, with the exception of several smaller parcels on gentler slopes and lowest elevations within City limits.

Key Vulnerability: steep to very steep topography




City of Ashland
Slope Percentages
Winburn
1A
2A
WR-1
1B
WR-6
2B
1C
2C
WR-5
6
3A
1D
WR-4
WR-2
3B
5B
2D
2D
3D
5A
2E
5B
3E
WR-8
1E
4
WR-3
3C
WR-7
Slope %
0-15
15-35
35-55
55-65
65+
N
0
250
500
1,000 Feet
SWS, Inc
02/16

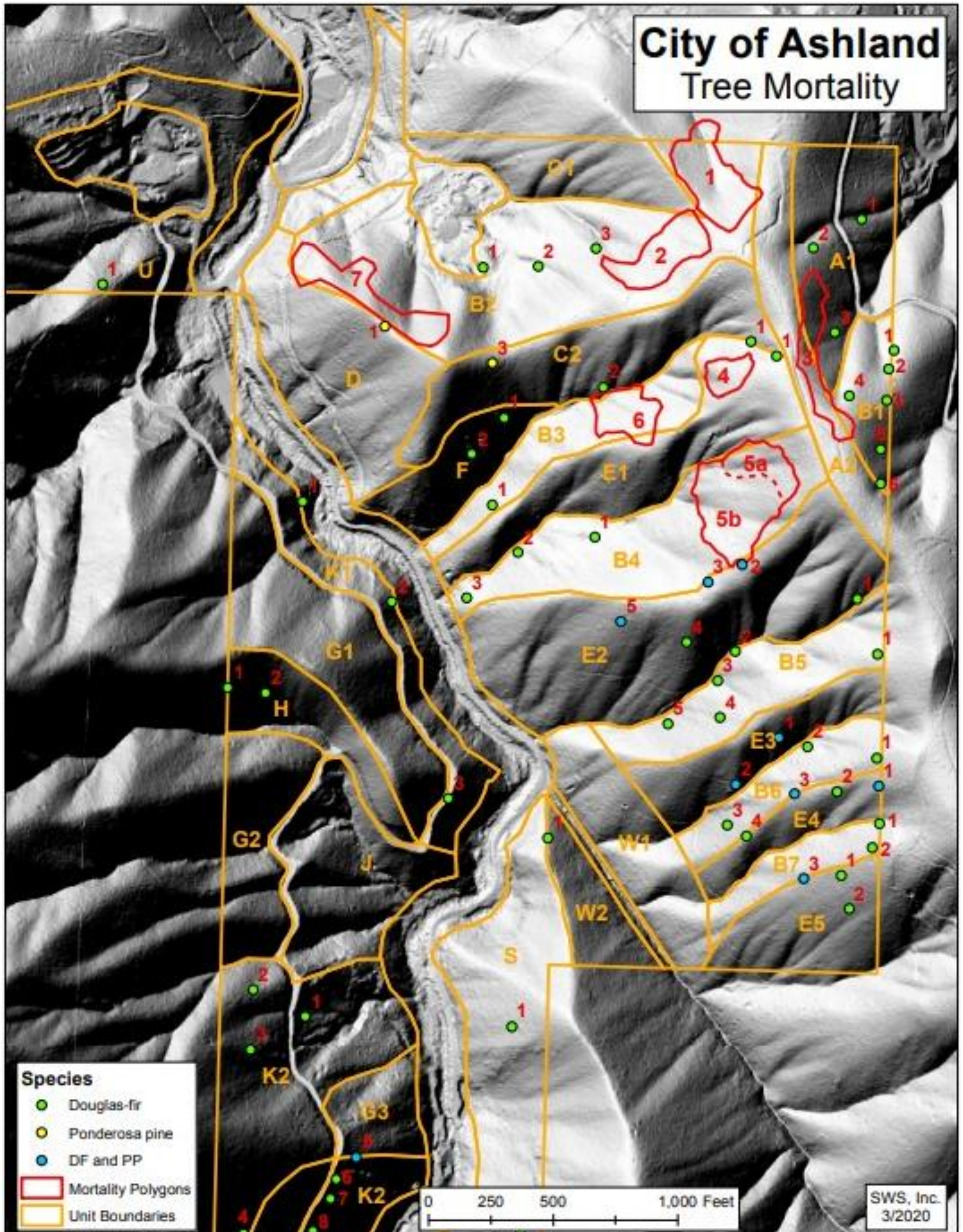
Key Vulnerability- High Severity Fire

Erosion and subsequent sedimentation in Spring Creek after 1996 Buffalo Creek Fire in Colorado

“High densities of both snags and logs were associated with high reburn severity in a subsequent fire, while shrub cover had a marginally insignificant (P = 0.0515) effect on subsequent fire severity. Our results demonstrate that high levels of large dead wood, which is often not considered in fire behavior modeling, corresponded with repeated high-severity fire effects. “

Lyderson et al 2019. Fuel dynamics and reburn severity following high-severity fire in a Sierra Nevada, USA, mixed-conifer forest.

Map 1b



Long Duration Fire with Soils Impacts

Red polygons are locations of high severity disturbance from insect related tree mortality with resulting high accumulation of snags and large woody debris

Source: Main and Schmidt 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis

“While disturbances may dramatically disrupt the ecosystem and kill trees, limited amounts of organic matter are actually consumed or removed. Much of the residual organic matter persists as structures—such as standing dead trees (snags) and tree boles and other woody debris on the ground—that provide critical habitat for organisms and fill other important functional roles in the ecosystem.”

Franklin et.al. 2007. Natural Disturbance and Stand Development Principles for Ecological Forestry

Plant:Soil Interactions- Below-ground Biology

“Compatibility between the belowground mutualists of resident species and the needs of immigrant species will strongly influence the successful transition from one perennial plant community to another during climate change. A hiatus in the overlap between plant species that maintain a positive link with the soil ecosystem could result in site capture by weeds and rapid degradation of the productive capacity of soils.”

Source: Perry et al. 1990. Species Migrations and Ecosystem Stability During Climate Change: The Belowground Connection

“When maximum hydraulic re-distribution rates were observed, redistributed water replenished approximately 40% of the water depleted from the upper soil on a daily basis.”

Source: Brooks et.al 2006. Hydraulic redistribution in a Douglas-fir forest: lessons from system manipulations.

A rich body of literature exists on the structural and physiological adaptations of trees for avoiding, tolerating and resisting drought. Nevertheless, we lack a fundamental understanding of why tree species of similar age and exposure (to water stress) differ in their drought sensitivity (Weltzin et al., 2003). One possible reason for this relates to a ‘‘surface bias”; specifically, most investigations of tree species and drought have focused on the hydraulic properties of leaves and stems (Ryan et al., 2006; Meinzer et al., 2009), with limited consideration of belowground traits and processes and their consequences for whole-tree water relations. Trees possess myriad belowground strategies for dealing with drought (Sperry et al., 1998; Breda et al., 2006), and these strategies likely interact with soil properties (e.g., soil texture, gravel content and effective rooting depth) and soil biota (e.g., mycorrhizal fungi) to determine forest sensitivity to drought. For theses reasons, classifying tree species based on their aboveground sensitivity alone – without consideration of belowground traits and site conditions – may lead to incorrect projections of the consequences of drought on C cycling.

Source: Phillips et al 2016. A belowground perspective on the drought sensitivity of forests: Towards improved understanding and simulation

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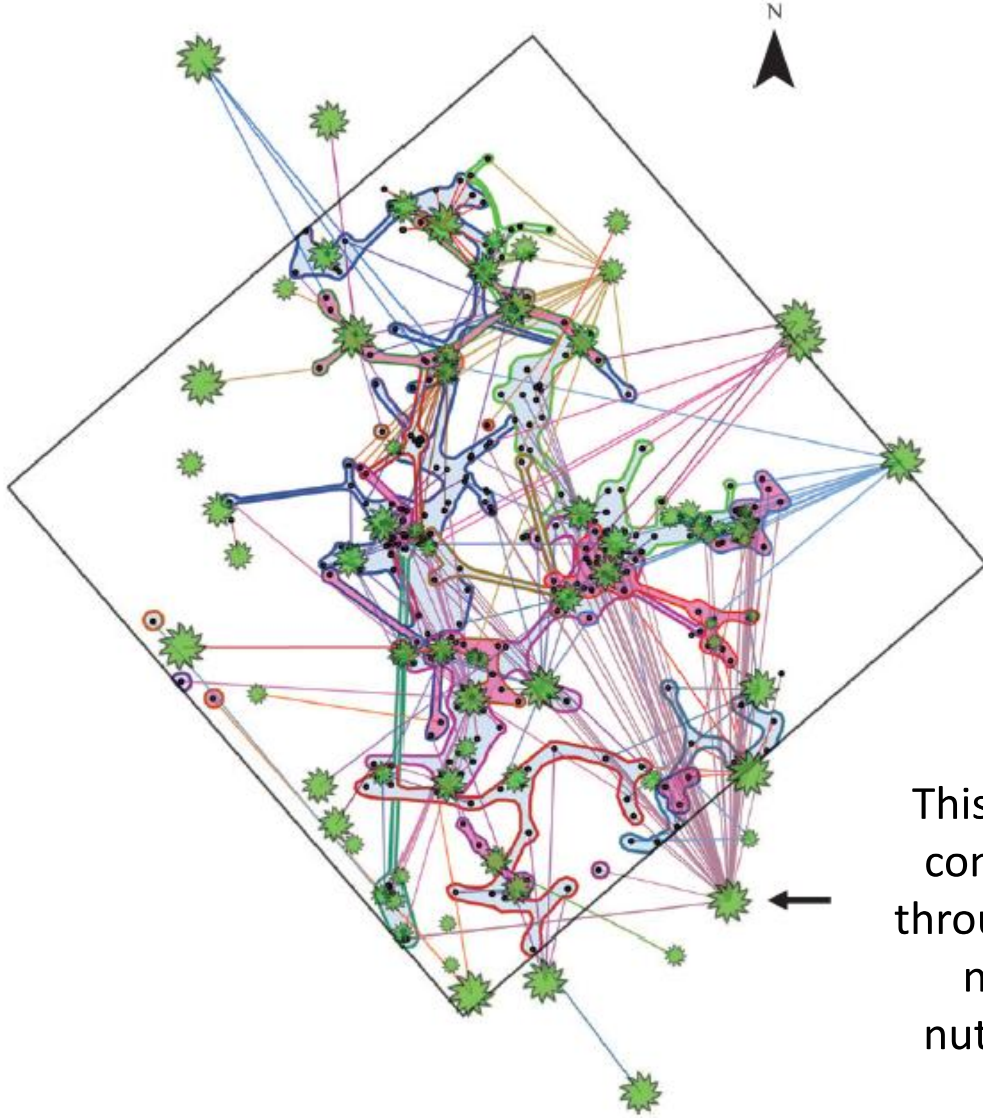
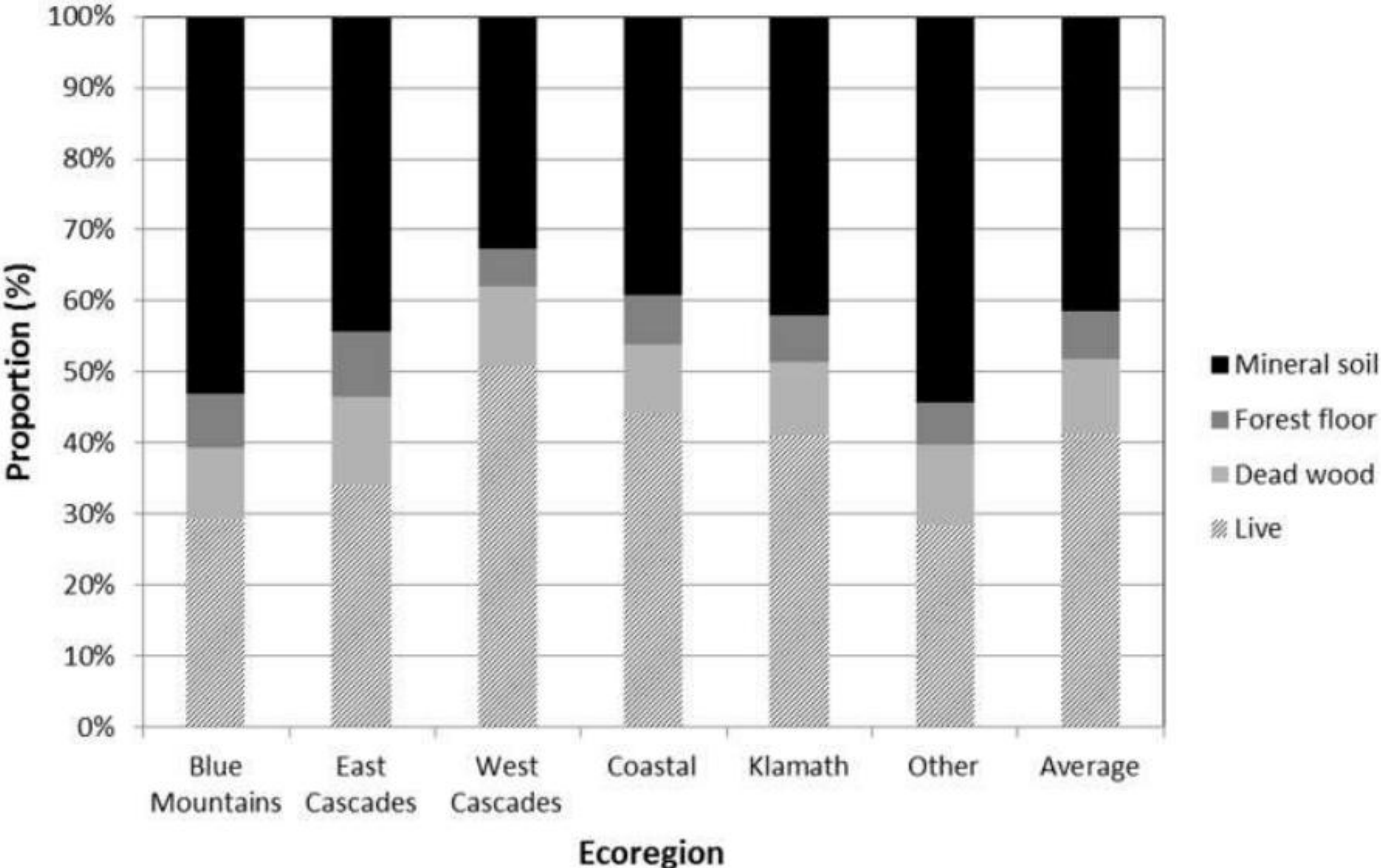


This one tree was found to be connected to 47 other trees through complex below-ground networks, sharing water, nutrients, carbon and others

Source: Beiler et al. "Architecture of the wood-wide web: Rhizopogon spp. genets link multiple Douglas-fir cohorts." New Phytologist 2009

Total Carbon Stores by Pool for Each Oregon Ecoregion



Source: Oregon Global Warming Commission:
Forest Carbon Accounting Project Report. 2018

1. Soils and Soil Productivity

Adaptation Options for Management

1. **Persist in trying to prevent large scale, high severity fire or insect-related mortality (Persist)**

2. **Minimize management on slopes > 55-65% to reduce the likelihood of slope failure in storms of increasing intensity . Consider decreasing importance of fire management objectives on steeper slopes. (Persist)**

3. **Avoid long duration fire and excess high amounts of snags and LWD; manage to encourage for endemic rather than outbreak levels of insect-related mortality. Maintain adequate amounts of snags and LWD for soil health, wildlife habitat and other ecosystem level needs. Reduce excess amounts of snags and LWD when they occur; especially in more hazardous spatially explicit locations (Persist, Change)**

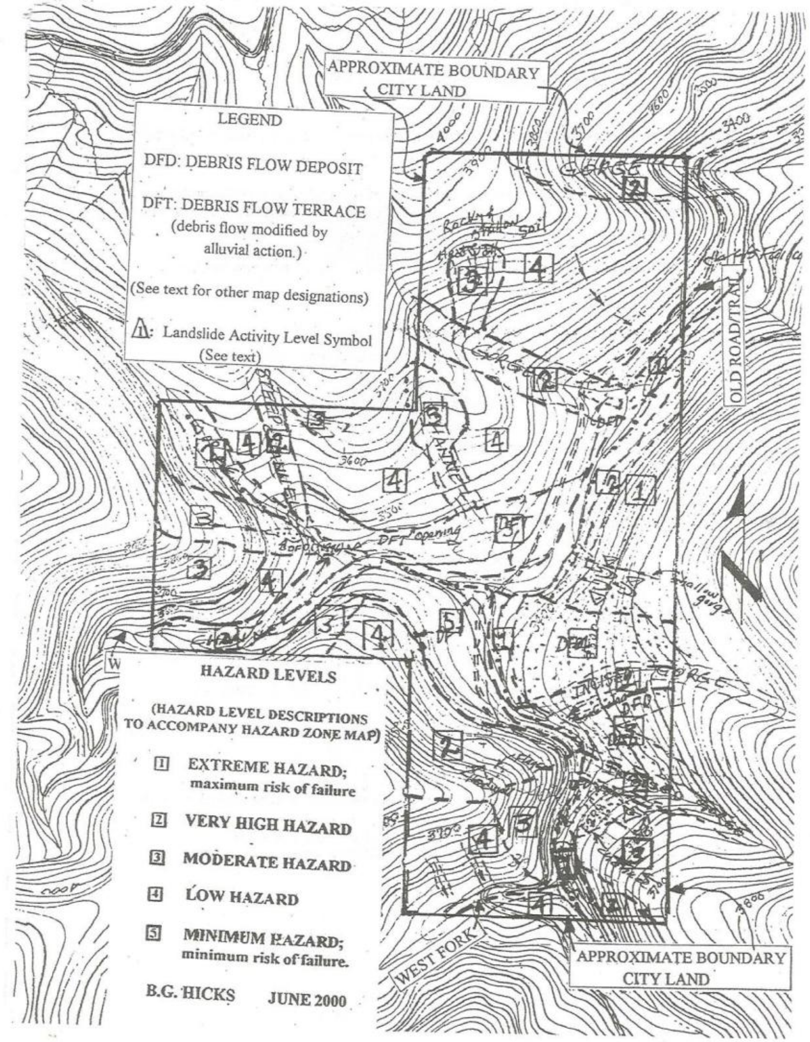
4. **Elevate amounts of prescribed underburning to decrease possibility of high severity fire; burn in ways that minimize potential surface soil erosion. Minimize bare soil exposure through retention of duff, litter and protective understory vegetation. Burn cool at least initially; retain unburned patches (mosaic burning). Carefully monitor (Persist, Change). Biochar?**

5. **Avoid ground-based disturbance except of gentlest of slopes; remove merchantable fuel through utilization of helicopters on steeper slopes. No new roads. Consider other types of logging systems (Persist, Change)**

6. **Elevate the importance of understanding below-ground processes in guiding management, particularly when considering water and carbon. (Change)**

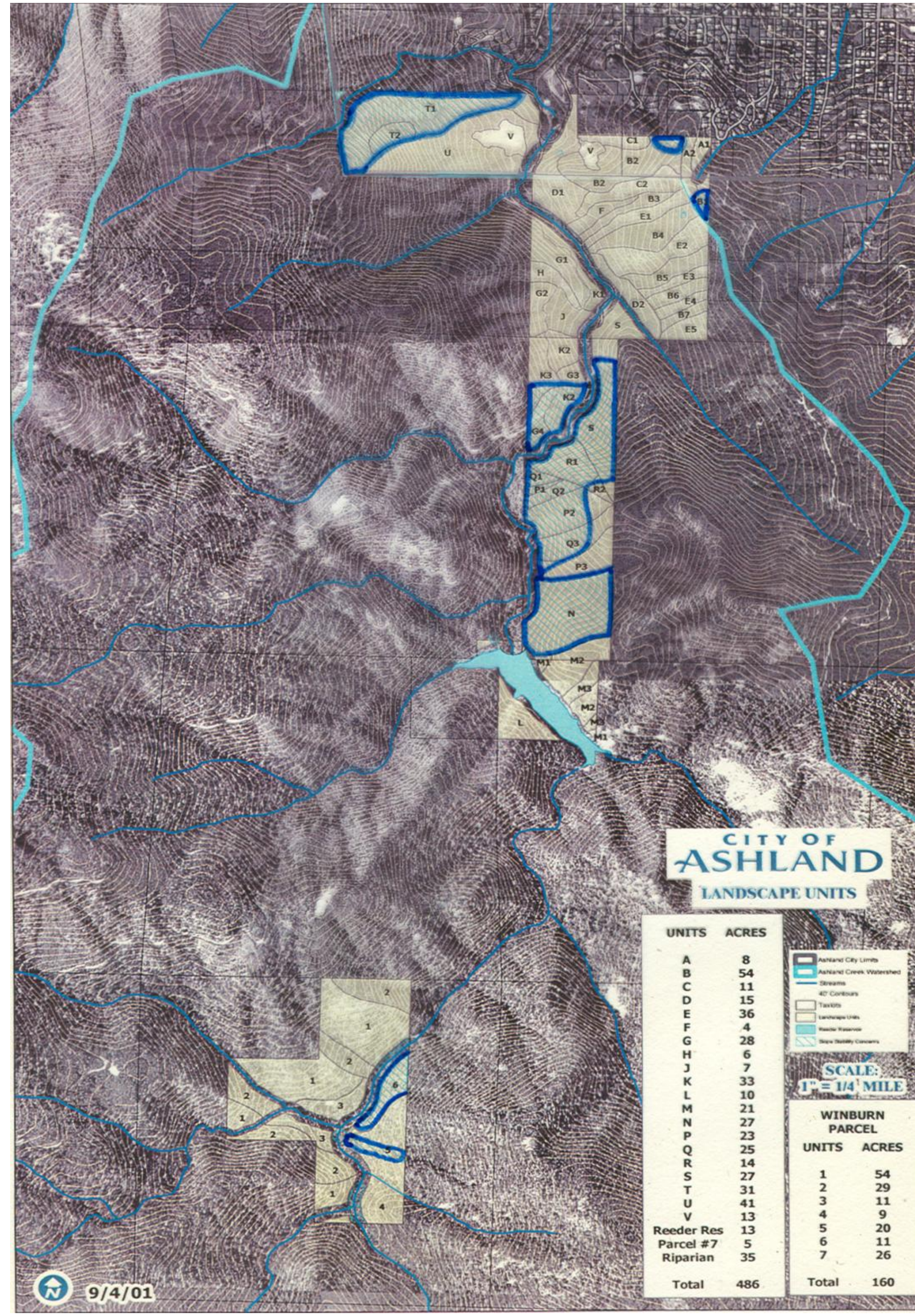

Squires Fire 2002
Snags and large woody debris play critical roles in functioning forest ecosystems but can also contribute to additional high severity reburns.

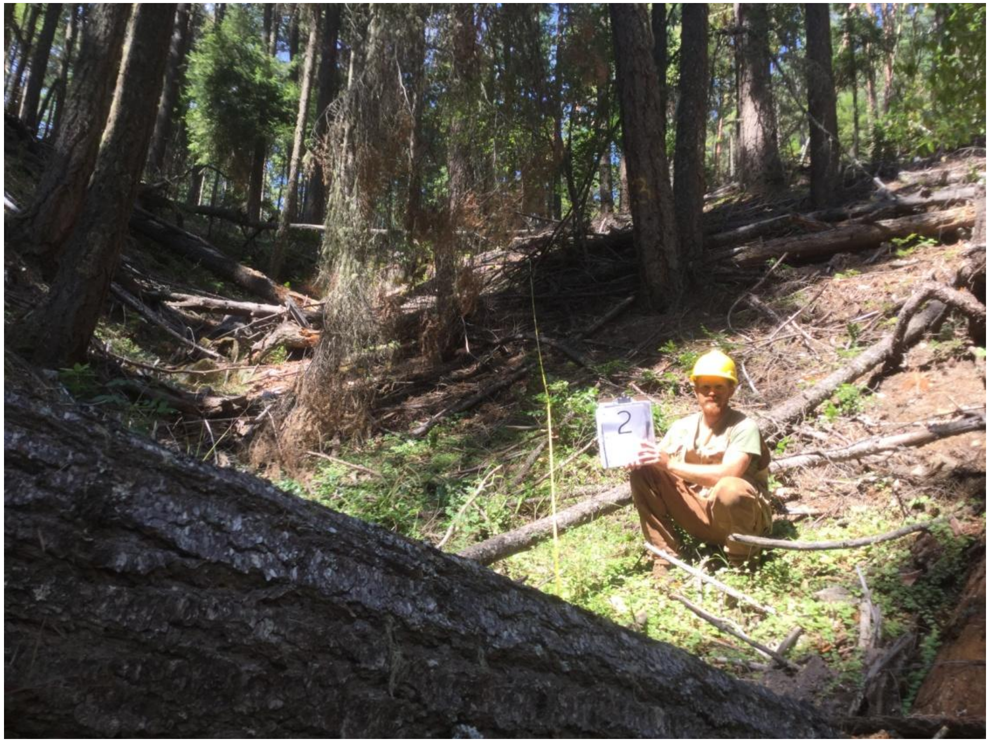
Original slope stability and geologic hazard mapping for City of Ashland Ownership by Engineering Geologist Bill Hicks, 1996



City of Ashland

1996
Geological
Priorities
(by unit)





Winburn large woody debris inventory, 2017

"The temporal and spatial dynamics of large, dead woody material in areas where pre–suppression fire regimes are characterized by frequent, low- to mixed-severity fires is not known but it is probably very different than those identified by current standards and guidelines used by both federal and state agencies. Quantities of large woody material for standards and guidelines were developed from contemporary old-growth forests that had experienced many decades of fire suppression. These quantities of woody material were probably unusually high compared to typical pre–fire-suppression values. Consequently, a management emphasis on meeting or exceeding standards and guidelines for dead woody material has and will increase fire hazard over time and threatens the very habitat the standards and guidelines were designed to improve (Skinner 2002b)."

Source: Skinner, C.N.; Taylor, A.H.; Agee, J.K. (2006) Klamath Mountains bioregion. In: Fire in California's Ecosystems.

Unit E2, City of Ashland, 2013

- 1996-97 – Non-commercial thinning, piling, burning
- 2004 – Helicopter logging, piling, burning; plant pines
- 2013 – Prescribed underburn; plant pines (2014)

Prescribed Underburning When Duff Retention and Protection of Erosive Soils Is a Priority

- Avoid fall burning
- Make sure lower duff layers are moist
- Prioritize burning in areas that minimize direct sediment input into hydrologic network
- Maintain medium to large woody debris, preferably on contour, to trap sediment
- Mosaic burning
- “Cool” burning

City of Ashland Prescribed Underburn

Unit LW-A2, 2013

COA 2017 Bare Soils and Duff Depth

Lower watershed

Unit	# of Plots	CMA Bare Soil %	Transect Bare Soil %	Duff Depth (inches)
A1	3	3	5	0.7
B	14	7	8	1.2
C	5	9	16	0.5
D	2	3	3	1.0
E	9	11	18	0.8
F	2	5	11	1.3
G	15	5	7	1.5
H	4	4	11	0.4
J	6	7	2	2.1
K	13	4	8	1.6
L	6	6	4	0.9
M1	4	4	8	0.7
M2	3	10	11	0.8
N	8	8	4	1.2
P	11	8	19	0.3
Q	6	4	7	0.9
R1	5	5	6	1.6
S	6	9	10	1.0
U	6	N/A	5	1.0
W1	3	11	16	1.2
W2	4	9	11	0.7
Total	135	7	10	1.1

Winburn

Unit	CMA Bare Soil %	Transect Bare Soil %	Duff Depth (inches)
1	2	2	1.9
2	5	6	2.7
3	1	1	2.6
4	1	<1	3.3
5	2	2	3.2
6	1	1	2.0
Total	2	2	2.3

<u>2017 Inventory Results</u>

1. **Bare soil percent (CMA) averaged 2% at Winburn and was less than 2% on all units except Unit 2 (5%); bare soil percent (CMA) averaged 7% In Lower Watershed, varying from 3-11 % by unit.**
2. **In the Lower Watershed, bare soil percent is generally higher and duff depth lower in units on west/southwest aspects and in recent prescribed burn units.**
3. **Duff depth was higher at Winburn (2.3”) than in the Lower Watershed (1.1”); prescribed burning is more likely to expose bare soil in the Lower Watershed, increasing the likelihood of surface soil erosion.**

“The reintroduction of fire using these restoration treatments in the region represents the first potential addition of Pyrogenic Carbon to these ecosystems over a 100- years period. Although the primary reasons for implementing restoration or fuel reduction treatments are for reducing wildfire risk and restoring historical ecosystem structure and function, there is clearly an additional benefit in that Rx fire generates a surprisingly large pool of highly stable C, particularly when it is applied in combination with forest thinning. And while the immediate effect of Rx fire is to release C, in the long term this approach may promote C sequestration.”

DeLuca et.al 2020. Pyrogenic Carbon Generation from Fire and Forest Restoration Treatments

Biochar (charcoal)

- Important and long term stable form of carbon storage
- **Increases water holding capacity**
- Improves cation exchange capacity; prevents nutrient loss and influences nutrient cycling
- Influences microbial processes
- Increases rates of decomposition of organic matter

Table 2. Soil properties for biochar and wood ash amendments.

Treatment	Water volume θv		Field capacity		Bulk density		pH		CEC	
	%	SE	%	SE	lb ft^{-3}	SE	pH	SE	cmol kg^{-1}	SE
Biochar										
Biochar + manure	20.3a	1.4	43.5a	2.7	59.74a	3.81	5.1a	0.1	22.5a	2.0
Biochar	14.6a	0.8	44.1a	3.5	60.87a	4.18	4.9a	0.1	19.6a	2.0
Manure	15.0a	1.3	47.7a	2.6	63.74a	3.12	5.2a	0.2	19.5a	2.4
Control	11.7b	0.7	28.8b	1.1	96.20b	3.31	4.8a	0.0	15.9b	1.6
Wood ash										
Pre-wood ash	24.6a	2.9			57.12a	15.42	4.8a	0.1		
Post-wood ash	17.0b	1.0			58.62a	9.80	5.4b	0.3		
NRCS Soil Survey										
Sarona-Vilas (range)	9–12				84.3–106.1		4.5–6.5		5.1–14.2	

Pre-wood ash soils were sampled in December 2014 and post-wood ash and biochar soils were sampled in late July 2015. Ranges for dominant soil types at the planting sites are also presented (Sarona-Vilas complex). Different letters denote significant differences in biochar or wood ash treatments.

Source: Richard et.al. 2018. Biochar and Wood Ash Amendments for Forestry in the Lake States: Field Report and Initial Results

City of Ashland Helicopter thinning (2004): using best management practices to protect soils while removing dead and dying insect killed trees and reducing wildfire potential

2. Water and Hydrologic Function

Clean water and clean air are the two most important products provided worldwide by forests.

We have long known about the first, and its been the highest priority for the City of Ashland. With climate change, we are increasingly learning about the importance of the second.

2. Water and Hydrologic Function

Climate Change Key Vulnerabilities

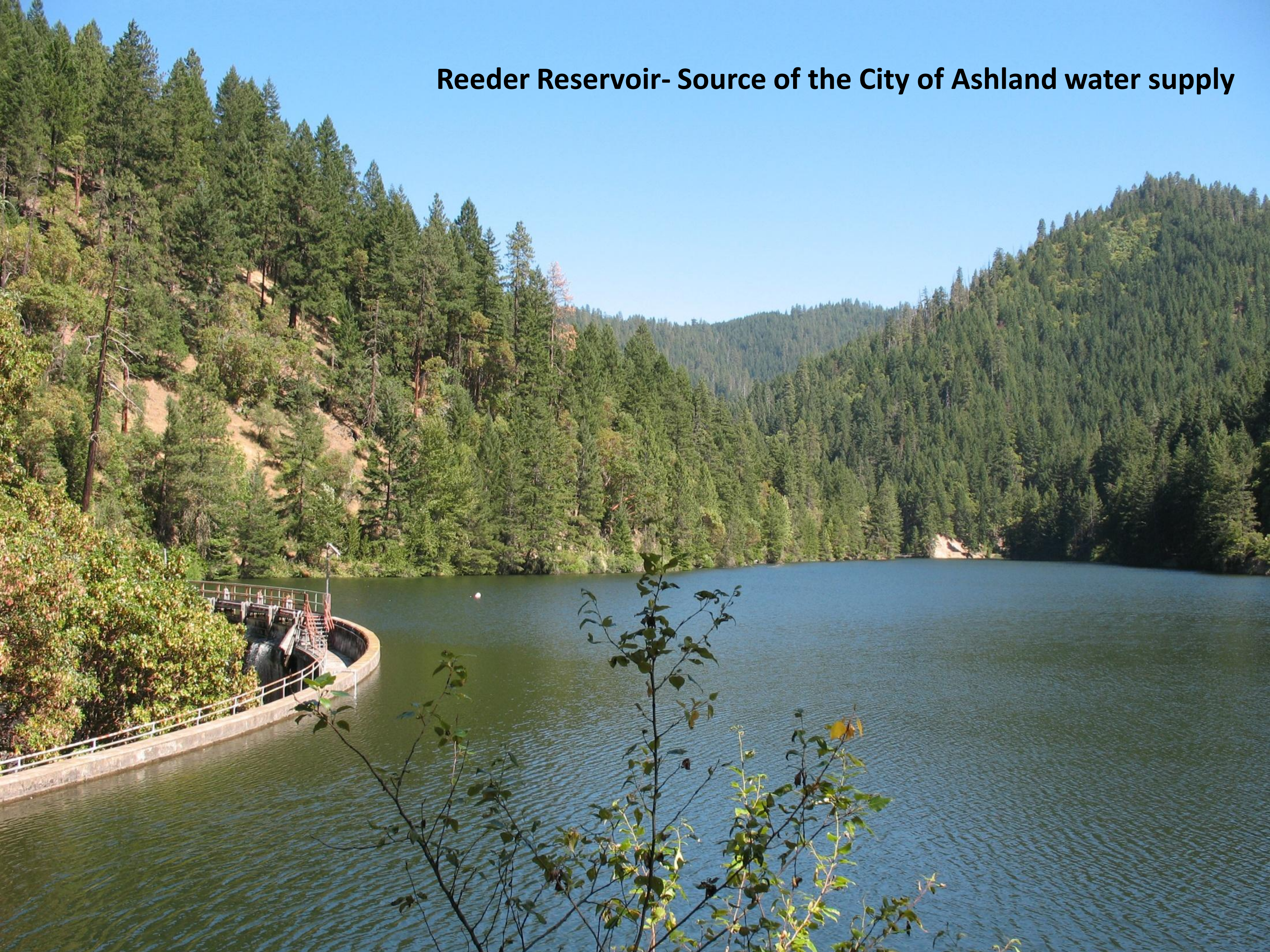
1. Decreased seasonal municipal water supply from longer drier summers, decreased snowpack.

2. Changes in peak stream flows, with more extreme precipitation in winter and earlier spring snowmelt; importance of rain-on-snow events; downstream flooding of increased magnitude and effects on infrastructure.

3. Changes in aquatic, hydrologic and riparian functions
    - Increasing stream temperatures (potentially moderated by outflows from Reeder Reservoir) downstream effects- effects on water quality, fisheries
    - Reduced summer flow- shrinking of perennial and intermittent stream network and making them more available to upland disturbance processes (fire, insects, tree mortality, etc)
    - More extreme winter storms resulting in increased sedimentation, scouring, etc

4. Road impacts on hydrology from aging infrastructure (1960's engineering) perhaps not well-suited to handle upcoming peak storm events.

5. Direct effects on vegetation from longer, drier summer droughts
    - increased stress on vegetation affecting growth, vigor, insect and disease susceptibility, mortality
    - longer fire season, more starts, decreased foliar moisture, more severe fires
    - reduction in C uptake by trees – potentially large consequences for regional-scale carbon cycling



Reeder Reservoir- Source of the City of Ashland water supply

Figure 18. *April 1 snow water equivalent projections averaged for the Middle Rogue (USGS17100308) as simulated by 10 downscaled global climate models under a low (RCP4.5) and high (RCP8.5) greenhouse gas emissions scenario. Solid line and shading depict the 10-model mean and range, respectively. The multi-model mean differences for the 2050s (2040-2069 average) and 2080s (2070-2099 average) compared to the historical baseline (1950-2005) are also displayed.*

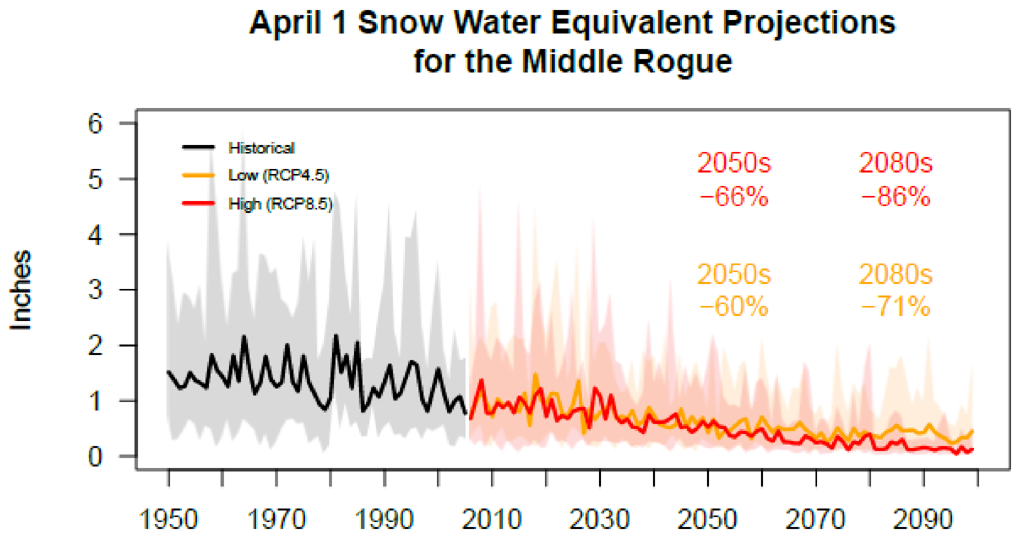
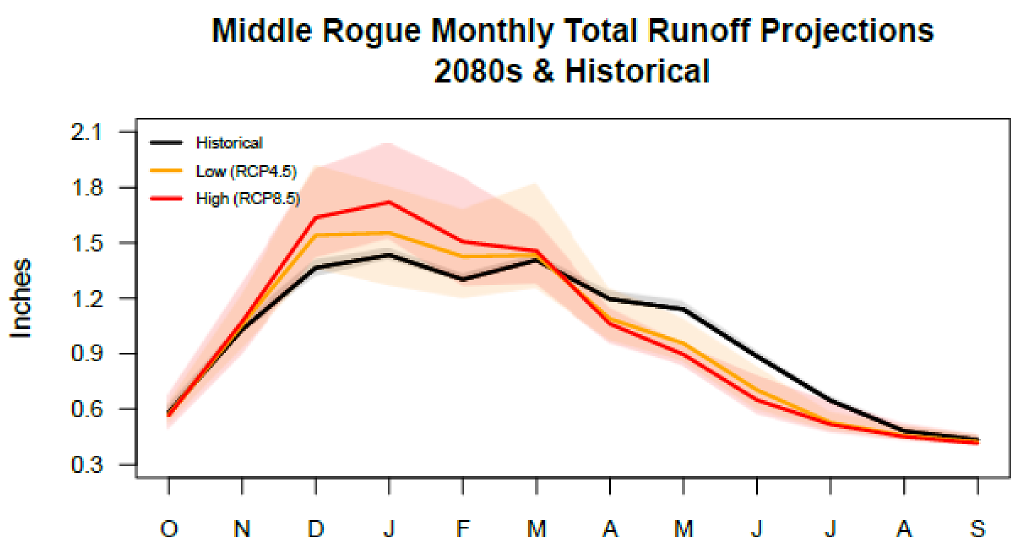
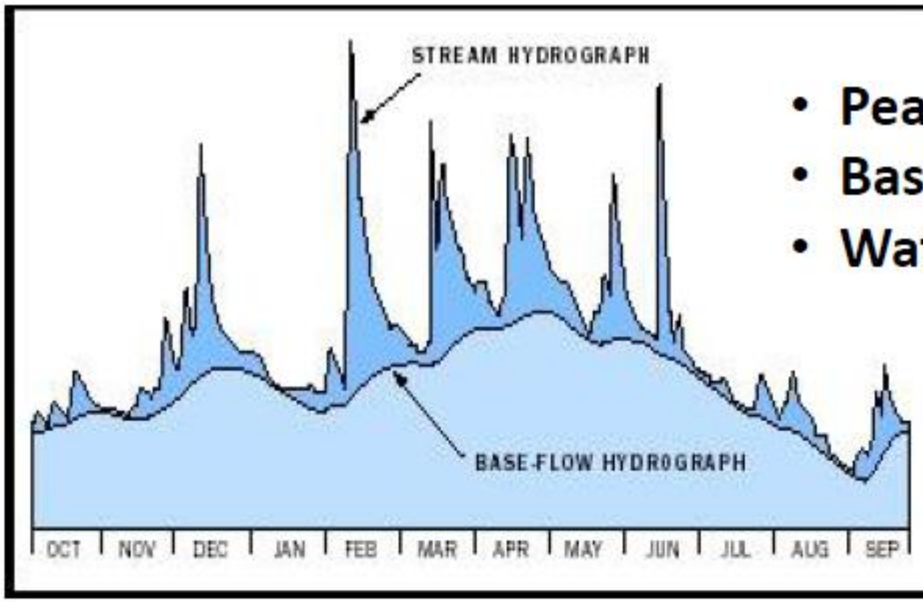


Figure 19. *Monthly total runoff projections averaged over the Middle Rogue as simulated by 10 downscaled global climate models and a hydrological model for the historical period (1950-2005) and 2080s (2070-2099) under a low (RCP4.5) and high (RCP8.5) greenhouse gas emissions scenario. Solid line and shading depict the 10-model mean and range, respectively.*



Slide Source: Climate Trends and Projections. Final Report to the City of Ashland by Meghan Dalton, Oregon Climate Change Research Institute. 2016

Water Cycle Regulation

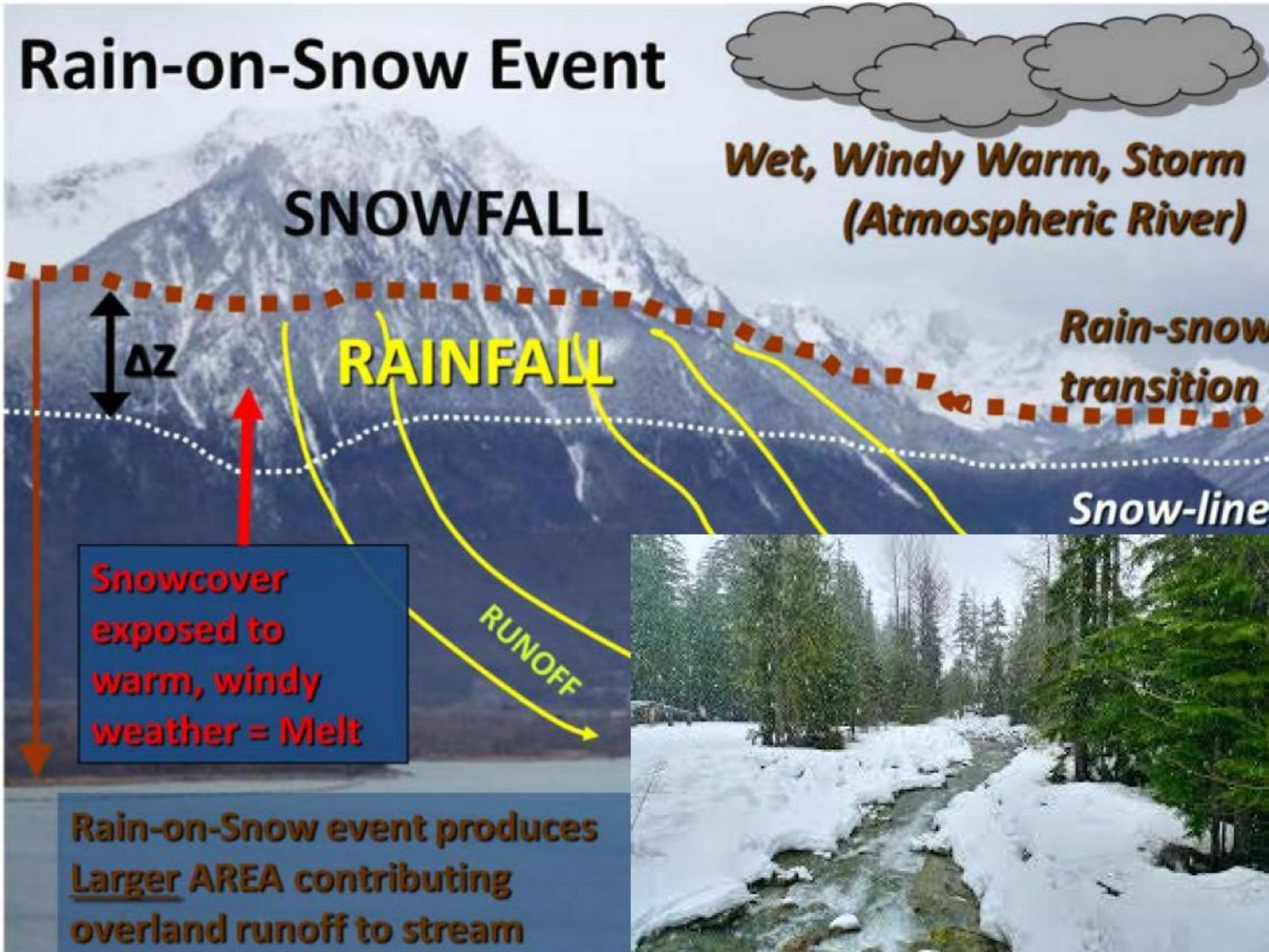


- **Peak Flow**
- **Base Flow**
- **Water Quantity**

waterencyclopedia.com and waterontheweb.org

Slide Credit: Rolf Gersonde, Watershed Management Division, Seattle Public Utilities


(C) Louis Ruth Photography
"Applegate Lake Drought 2014



Slide Credit: Rolf Gersonde, Watershed Management Division, Seattle Public Utilities

January 1, 1997

Ashland, Oregon

Erosion and subsequent sedimentation in Spring Creek after 1996 Buffalo Creek Fire in Colorado

Major Point:

Soils (erosion), Water/Hydrology (sedimentation) and Vegetation (mortality) are integrally linked!

Roads

- Roads act as extensions of the hydrologic network in major storm events and intercept surface water flow, groundwater and precipitation, redirecting it more quickly into the hydrologic network. Consequently, they concentrate water and accelerate flows, particularly in major storm events.
- This water concentration increases erosion and the potential for slope failures and debris slides in the Ashland Watershed
- Resulting negative effects on aquatic ecosystems with larger and more rapid peak flows include excess sediment delivery, channel re-configuration and changes in fluvial dynamics, often translated far from the initial point of entry.
- During peak storm events, landslides can become a major form of disturbance and contribute to downstream flooding and effects in urban and semi-urban areas below

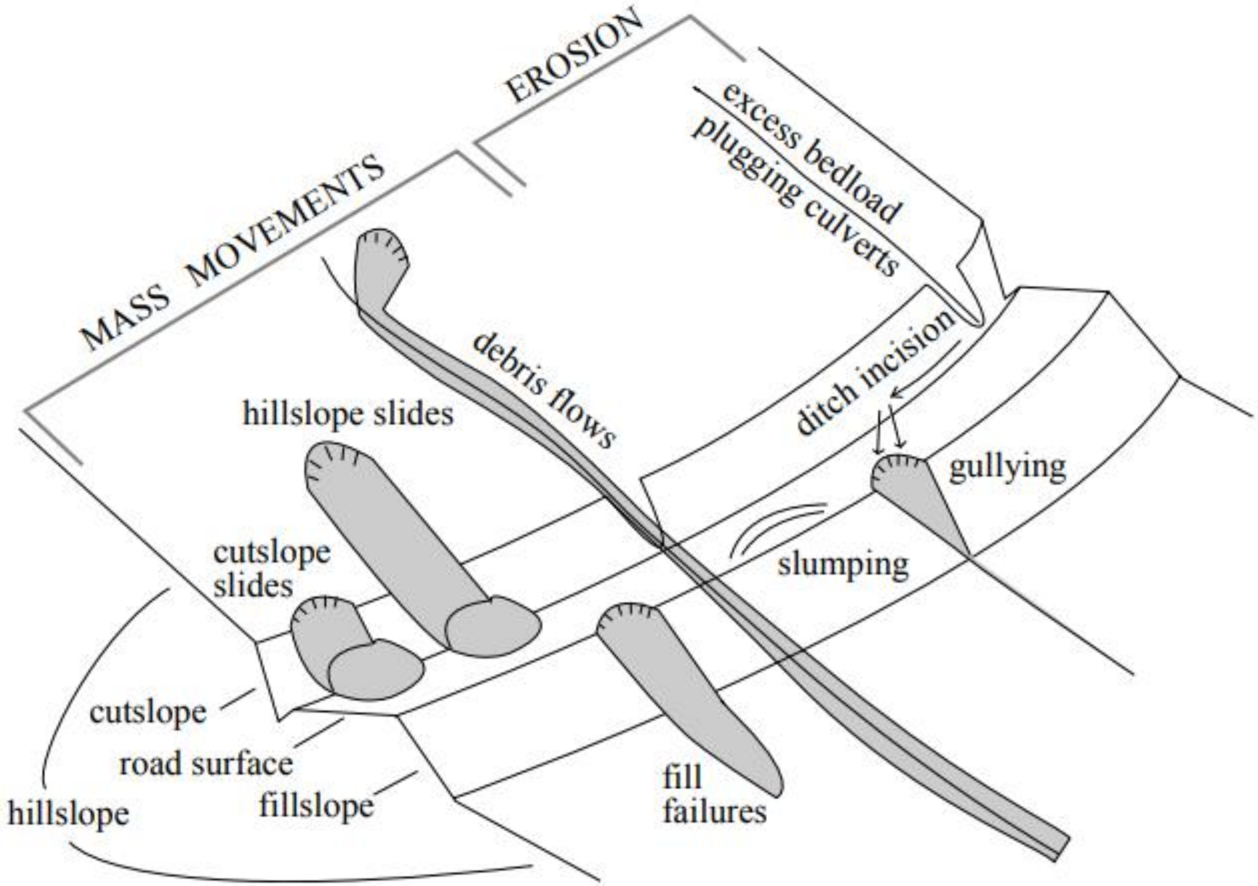


Figure 8.2. Eight types of road failures inventoried in the Lookout Creek and Blue River watershed (from Wemple et al., 2001).

Slide Credit: Swanson and Jones 2001. Geomorphology and Hydrology of the HJ Andrews Experimental Forest, Blue River, Oregon

Logging and Forest Roads Related to Increased Debris Slides in Southwestern Oregon.

Amaranthus et.al 1985.

Debris slides over a 20-year period were inventoried on 137,500 acres of forested land in the Klamath Mountains of southwest Oregon.

- ***Frequency during the study period was about one slide every 4.3 years on each 1,000 acres-an erosion rate of about 1/2 yd3 per acre per Year***
- ***Debris slide erosion rates initiated on roads and landings Were 100 times those on undisturbed areas, while erosion on harvested areas was seven times that of undisturbed areas.***
- ***Three quarters of the slides were found on slopes steeper than 70 percent and half were on the lower third of slopes.***
- ***Nine geomorphological erosion response units exhibited profound differences in natural erosion rates and responses to disturbance.***

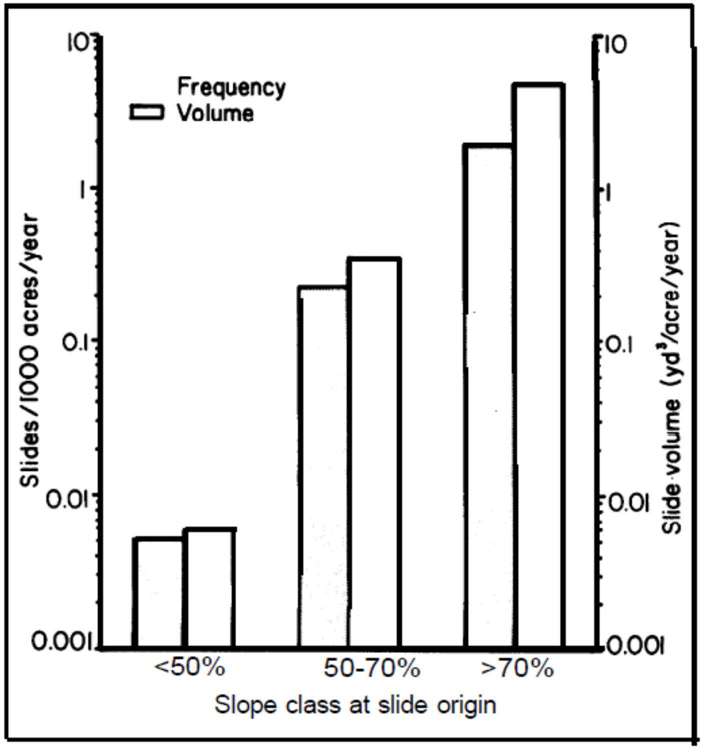
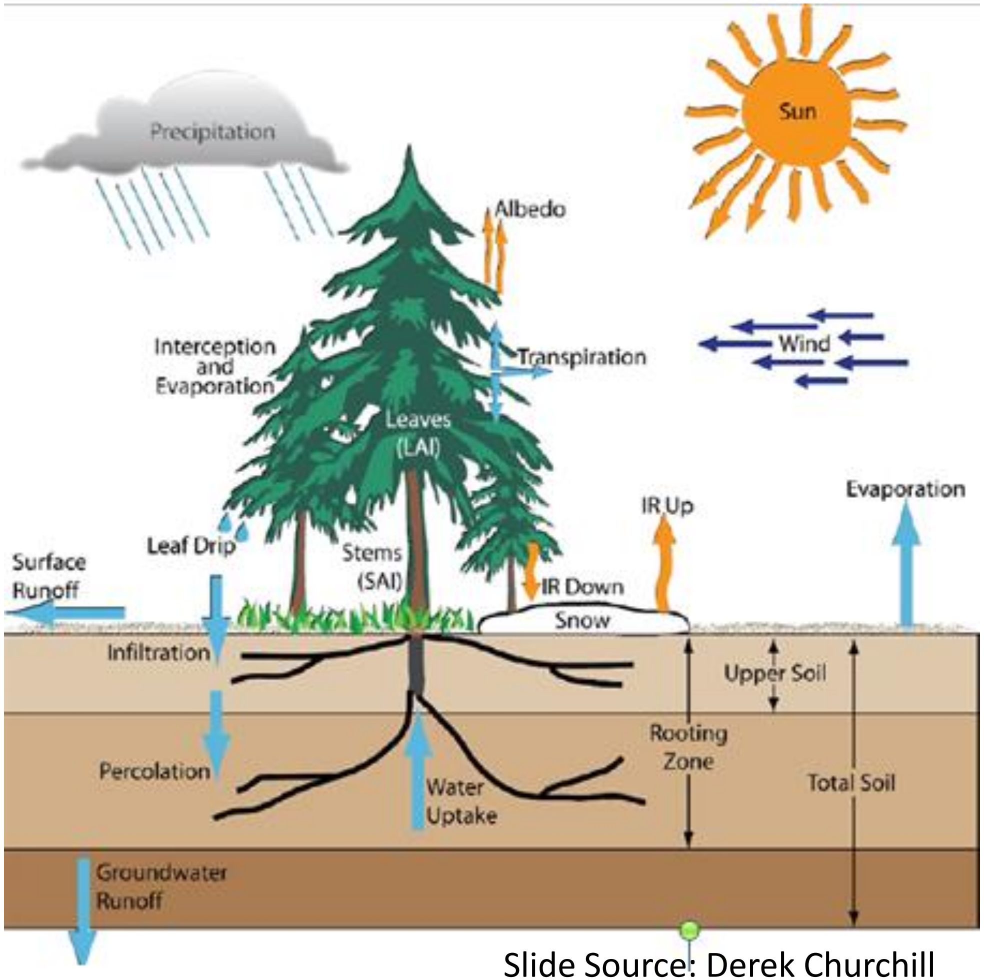


Figure 1. Debris slide frequency and erosion rate on the Siskiyou National Forest, 1956-1976. The rates were strongly associated with slope class.

Drought Stress on Individual Plant Level

• Has both aboveground and belowground mechanisms which interact with their environments in quite different ways, changing with species, age, sites and other factors

• Appropriate management response for individual trees will depend on an increased understanding of these two biological mechanisms and integrating them amidst rapidly changing climatic factors. For example, increasing available water by increasing space alone may not always be as important as understanding methods by which trees access and uptake additional water belowground and transpire it aboveground.



Slide Source: Derek Churchill

City of Ashland Unit LW-A2: Flatheaded borer related mortality, late 1990's

Correlation between wildfire frequency, mean temperature timing of spring snowmelt and fire season length

Source: Westerling et.al 2006. Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity

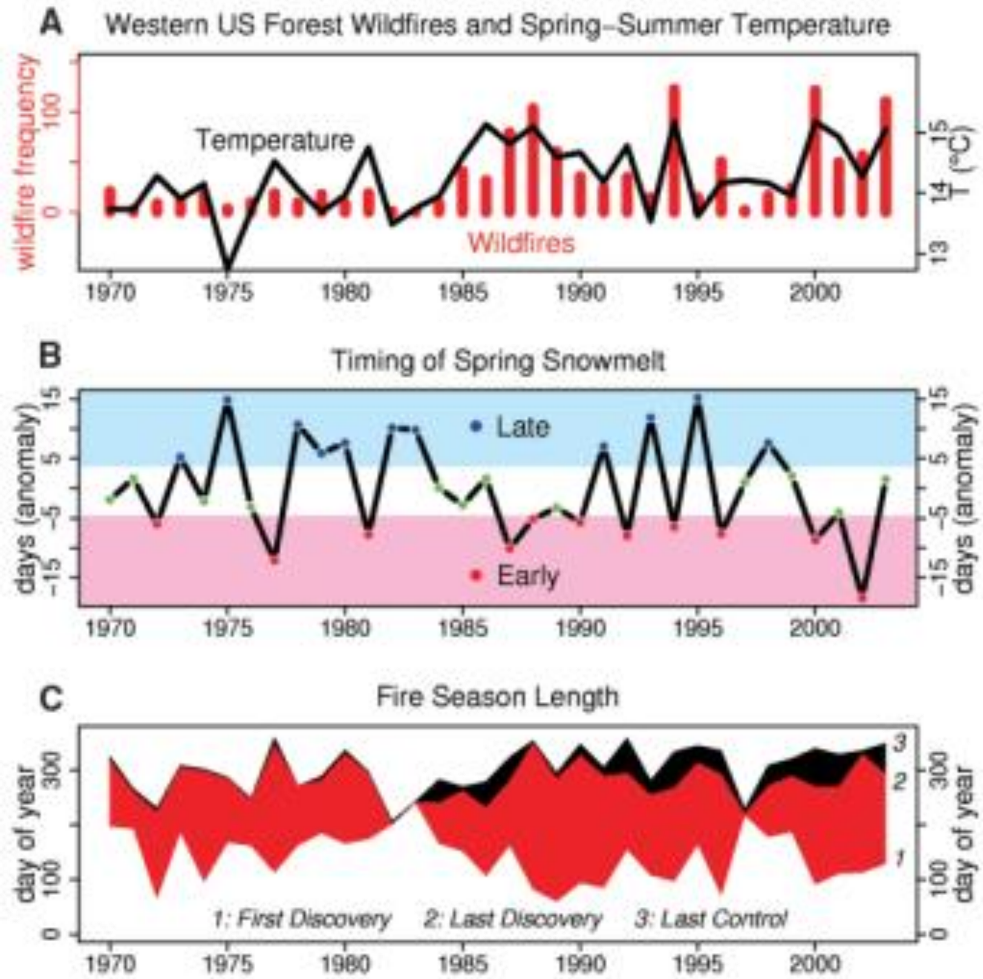


Fig. 1. (A) Annual frequency of large (9400 ha) western U.S. forest wildfires (bars) and mean March through August temperature for the western United States (B) First principle component of center timing of streamflow in snowmelt dominated streams (line). Low (pink shading), middle (no shading), and high (light blue shading) tercile values indicate early, mid-, and late timing of spring snowmelt, respectively. (C) Annual time between first and last large-fire ignition, and last large-fire control.

2.Water and Hydrologic Function

Adaptation Options for Management

1. Continue management to decrease the likelihood of large scale, high severity fire **(PERSIST)**

2. Increase water availability to individual plants and on watershed scale
   - Ongoing stand management to pre-determined desired densities **(PERSIST)**
   - Reduce understory vegetation through prescribed underburning while maintaining for inherent values, including reduced surface soil erosion **(PERSIST, CHANGE)**
   - Manage downed wood, slash, non-tree vegetation, & soil organic matter **(PERSIST, CHANGE)**
   - Emphasize protection of complex below-ground soil biology, plant:soil relationships, importance for water delivery to plants **(CHANGE)**
   - Increase water holding capacity- manage organic matter amounts and inputs, biochar? **(CHANGE)**

3. Minimize likelihood of landslides
   - Maintain full site occupancy of vegetation and subsequent root holding capacity on steeper sites; avoid operating on steeper slopes whenever possible and minimize openings in these steeper locations **(PERSIST)**

4. Stand management
   - Create and maintain more openings resulting in longer snow retention **(CHANGE)**
   - Encourage older forests and/or longer rotations- more summertime flow **(PERSIST)**

5. Roads
   - Stormproof road system; improve drainage systems for likely increase in peak flows; increase culvert size **(CHANGE)**
   - Disconnect roads and ditches from hydrologic network; install more engineered rolling dips **(CHANGE)**
   - More frequent and scheduled road maintenance **(CHANGE)**
   - Prepare urban environment including existing water treatment plant **(CHANGE)**
   - City road along Ashland Creek- decrease sediment delivery into creek **(CHANGE)**


Continue management to decrease the likelihood of large scale, high severity fire (PERSIST)

Non-commercial thinning

City of Ashland Unit B4

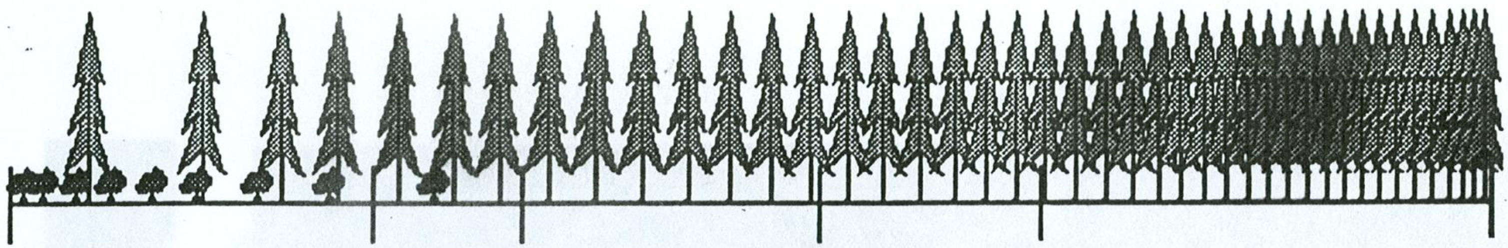
1997-98

- Moisture is limiting to tree growth and vigor and redistribution onto fewer trees increases tree and stand vigor.

- Fewer trees reduces interception and transpiration potentially increasing water yield.

Figure 5

Stand Development and Density



RECRUITMENT

Individual tree growth maximized. Recruitment of new trees & shrubs onto forest floor.

EXCLUSION

New recruitment stops. Trees begin to compete.

Understory is suppressed. Competition increases between trees. Individual tree growth begins to slow.

COMPETITION

Tree competition slows individual tree growth. Stand growth maximized. Trees will be differentiating.

IMMINENT MORTALITY

Trees begin to die from competition. Intermediates become suppressed. Weaker Co-dominates fall to intermediate.

MAXIMUM DENSITY

Maximum stand density. All but dominate and strongest co-dominate have died or are near death. Replacement by more shade tolerant trees as mortality occurs.


City of Ashland, Unit U
April 26, 2019

Jim Janousek, SWS inventory specialist, monitoring large woody debris at Winburn, 2007 inventory

Summer streamflow deficits from regenerating Douglas-fir forest in the Pacific Northwest, USA

Perry and Jones 2016

"Average daily streamflow in summer (July through September) in basins with 34- to 43-year-old plantations of Douglas-fir was 50% lower than streamflow from reference basins with 150- to 500-year-old forests dominated by Douglas-fir, western hemlock, and other conifers. Study plantations are comparable in terms of age class, treatments, and growth rates to managed forests in the region".

"Young Douglas-fir trees appear to have higher rates of evapotranspiration than old trees of conifer species, especially during dry summers."

-higher sapwood area
-higher sapflow per unit of sapwood area
-higher concentration of leaf area in the upper canopy
-less ability to limit transpiration.

Transpiration Differences between Young and Old Stands

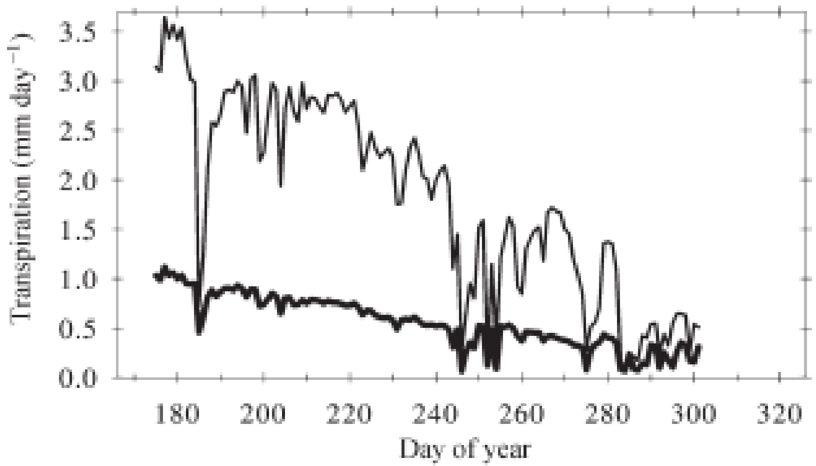


Figure 7. Estimated water use per unit ground area (transpiration; mm day^{-1}) in the young stand (thin line) and the old growth stand (thick line) from late June until late October 2000.

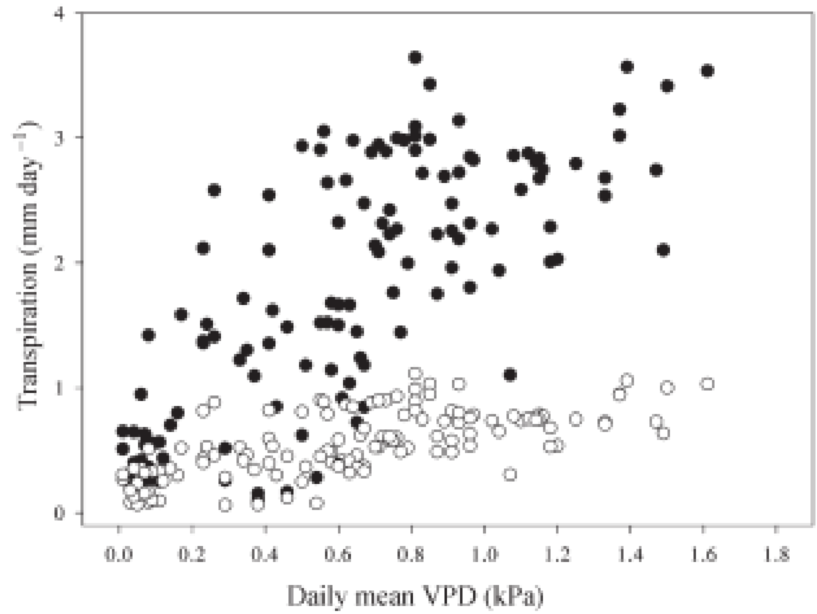
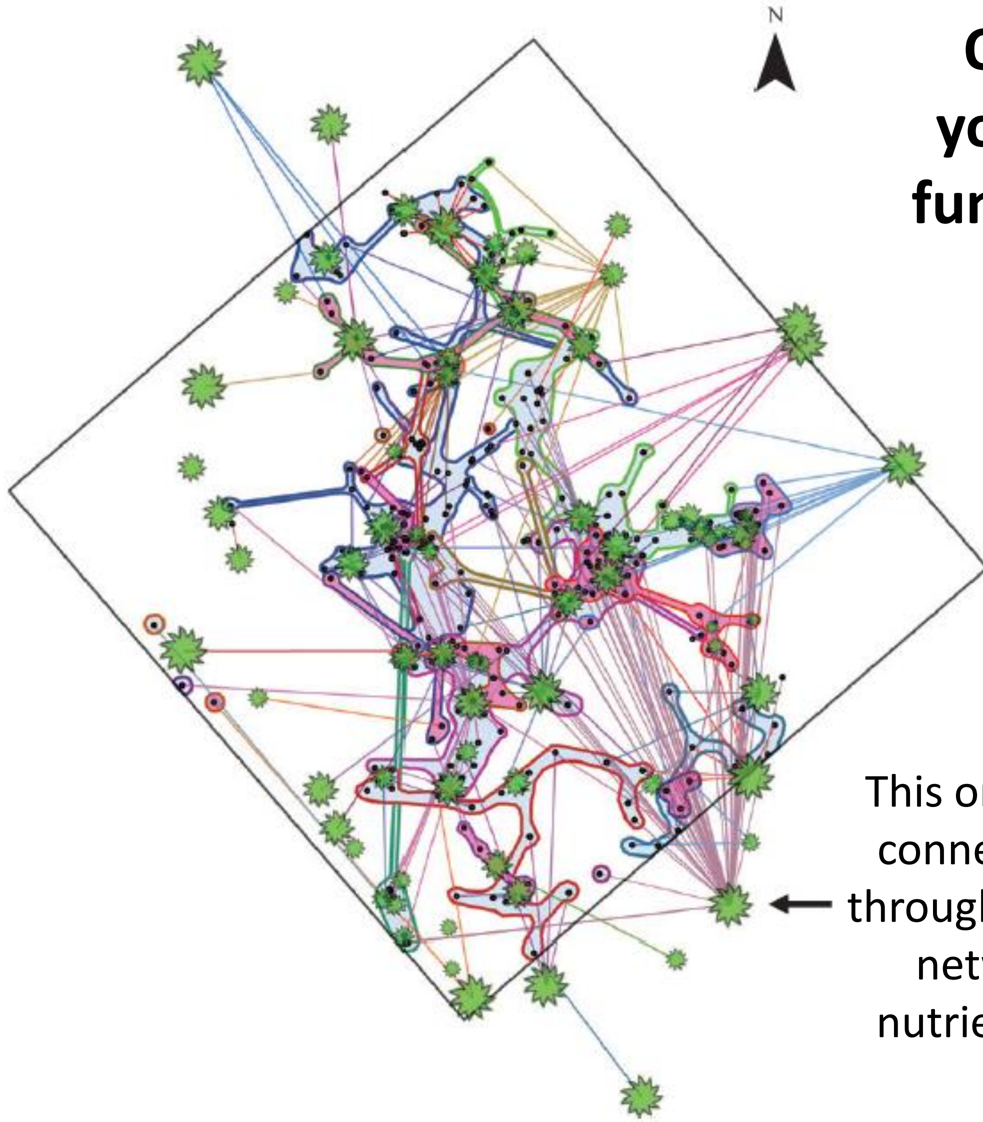


Figure 8. Relationship between daily transpiration (mm day^{-1}) in the young stand (●) and old stand (○) and mean daily vapor pressure deficit (VPD; kPa), as measured at a nearby weather station.

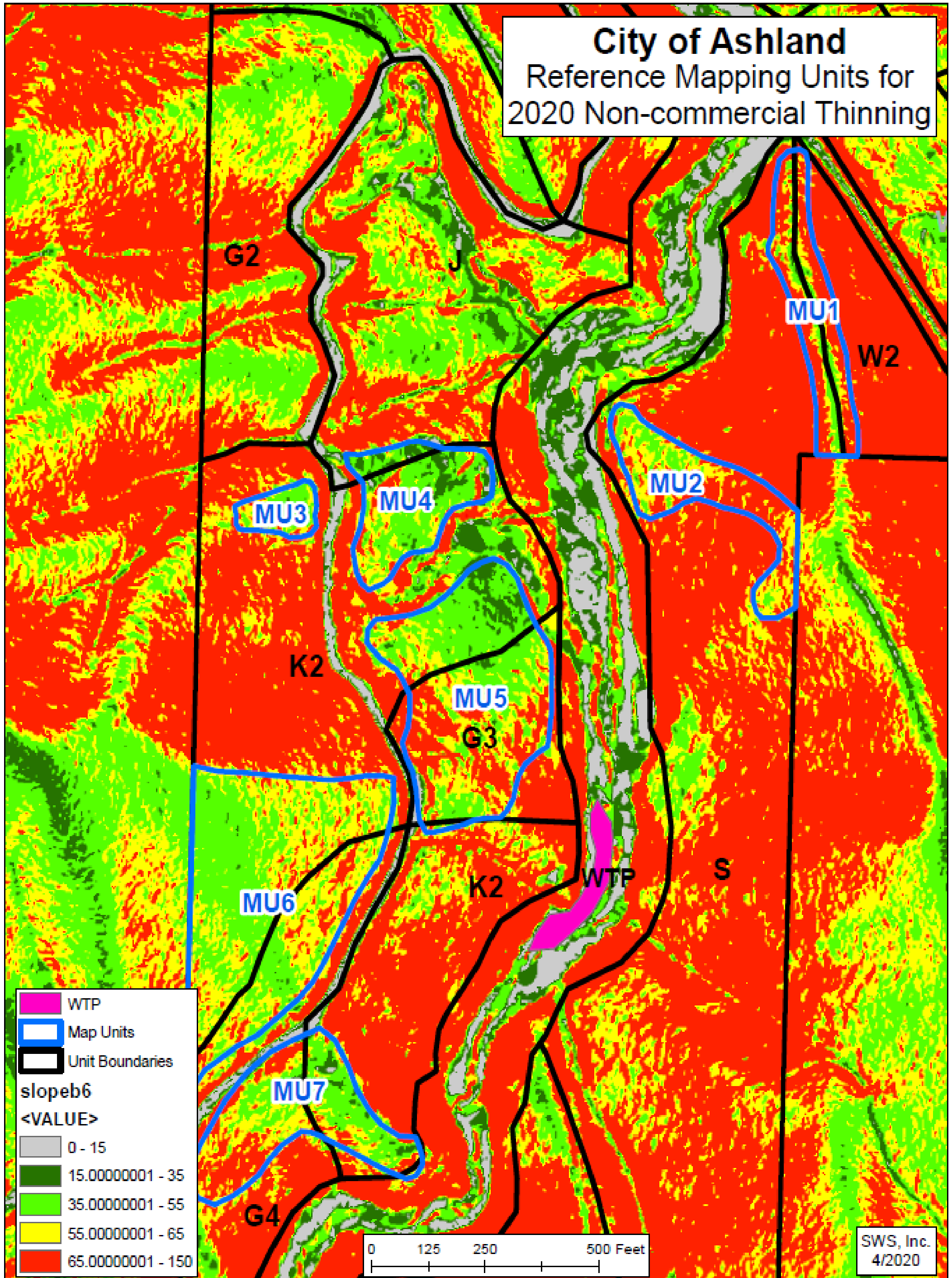
Source: Moore et.al. 2004. Structural and compositional controls on transpiration in 40- and 450-year-old riparian forests in western Oregon, USA

Older forests and younger forests are functionally different



This one tree was found to be connected to 47 other trees through complex below-ground networks, sharing water, nutrients, carbon and others

Source: Beiler et al. “Architecture of the wood-wide web: Rhizopogon spp. genets link multiple Douglas-fir cohorts.” New Phytologist 2009


City of Ashland
Reference Mapping Units for
2020 Non-commercial Thinning
G2
J
MU1
W2
MU2
MU3
MU4
K2
MU5
G3
MU6
K2
WTP
S
MU7
G4
WTP
Map Units
Unit Boundaries
slopeb6
<VALUE>
0 - 15
15.00000001 - 35
35.00000001 - 55
55.00000001 - 65
65.00000001 - 150
0 125 250 500 Feet
SWS, Inc.
4/2020

Openings/Gaps

- Largest level of plant diversity
- Horizontal discontinuity of fuels
- Necessary for establishment of shade intolerant species
- Wildlife habitat values
- **Less interception, evapotranspiration- more snow retention and seasonal availability**
- Others

Conflict: Openings can reduce root holding capacity on steep slopes and increase the potential for landslide development.

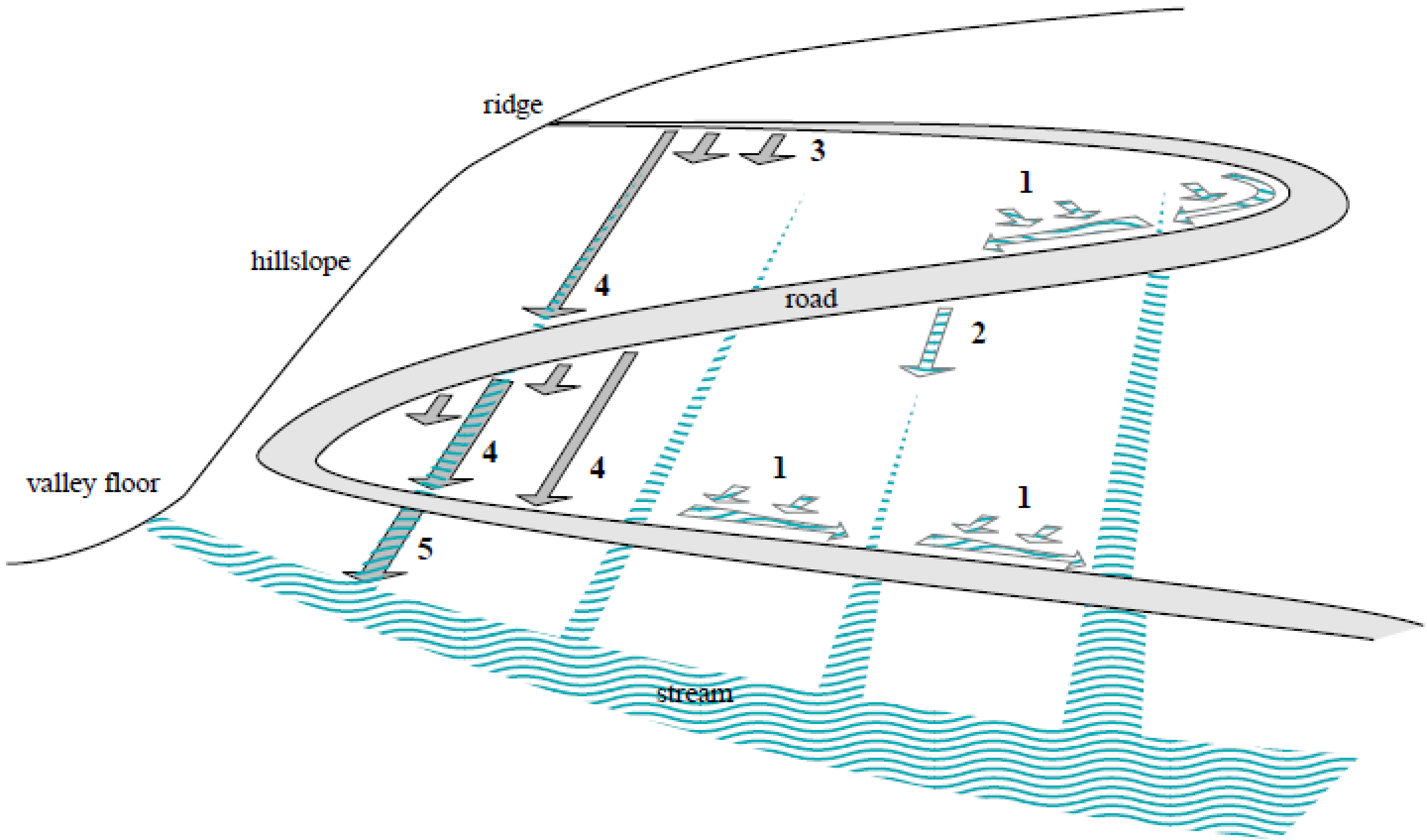


Figure 8.1. Interactions between road and stream networks. The road network consists of a valley floor road segment parallel to a large stream, hillslope road segments perpendicular to streams, and near-ridge roads without streams. Roads (1) intercept water in surface and subsurface flowpaths, (2) alter water flowpaths and extend the channel network, (3) initiate mass movements of sediment in unstable roadfills, (4) deposit sediment moved by mass movements on roads and (5) on valley floors. Overall, roads function to divert water and sediment from paths followed in roadless landscapes, and they initiate multiple new cascading flowpaths.

Source: Swanson and Jones. 2001. Geomorphology and Hydrology of the H.J. Andrews Experimental Forest, Blue River, Oregon

Incorporating Climate Change into the Design of Water Crossing Structures

A WDFW project conducted with funding support from the North Pacific Landscape Conservation Cooperative

FINAL PROJECT REPORT

September 2016

George Wilhere (WDFW)
Jane Atha (WDFW)
Timothy Quinn (WDFW)
Lynn Helbrecht (WDFW)
Ingrid Tohver (Climate Impacts Group)

Washington Department of Fish and Wildlife
Habitat Program – Science Division

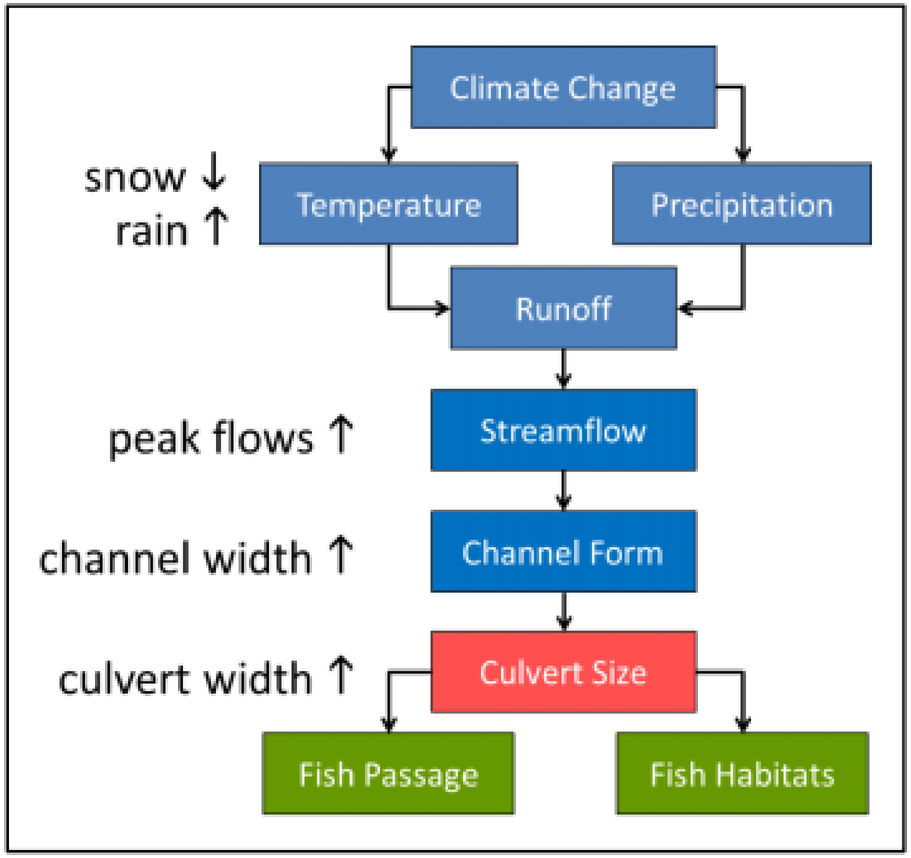


Figure 2. Causal relationships between culverts and climate change. Climate change is projected to increase the proportion of precipitation that falls as rain rather than as snow. As a result, winter peak flows in western Washington are expected to increase in volume. Increased peaks flows are known to alter channel morphology. Wider channels require wider culverts.

3. Vegetation

Humans have been manipulating vegetation to achieve objectives for millenia. Silviculture is the art and the science of manipulating forest vegetation to achieve objectives.

The line between silviculture and ecology has increasingly become blurred. In this case, silvicultural management of vegetation to achieve objectives is best thought of as "planned disturbance" that emulates historical ecologically relevant disturbance patterns…

and makes adjustments for future changes in new climate induced disturbance regimes!

Franklin et.al 2007. Natural Disturbance and Stand Development Principles for Ecological Forestry

"Foresters use natural disturbances and stand development processes as models for silvicultural practices in broad conceptual ways"

"Incorporating an understanding of natural disturbance and stand development processes more fully into silvicultural practice is the basis for an ecological forestry approach. Implementing such an approach successfully requires that prescriptions be founded on a conceptual basis that links stand disturbance and dynamics to the development and maintenance of ecological complexity of stands, as expressed in structure, composition, and heterogeneity of these features in space and time."

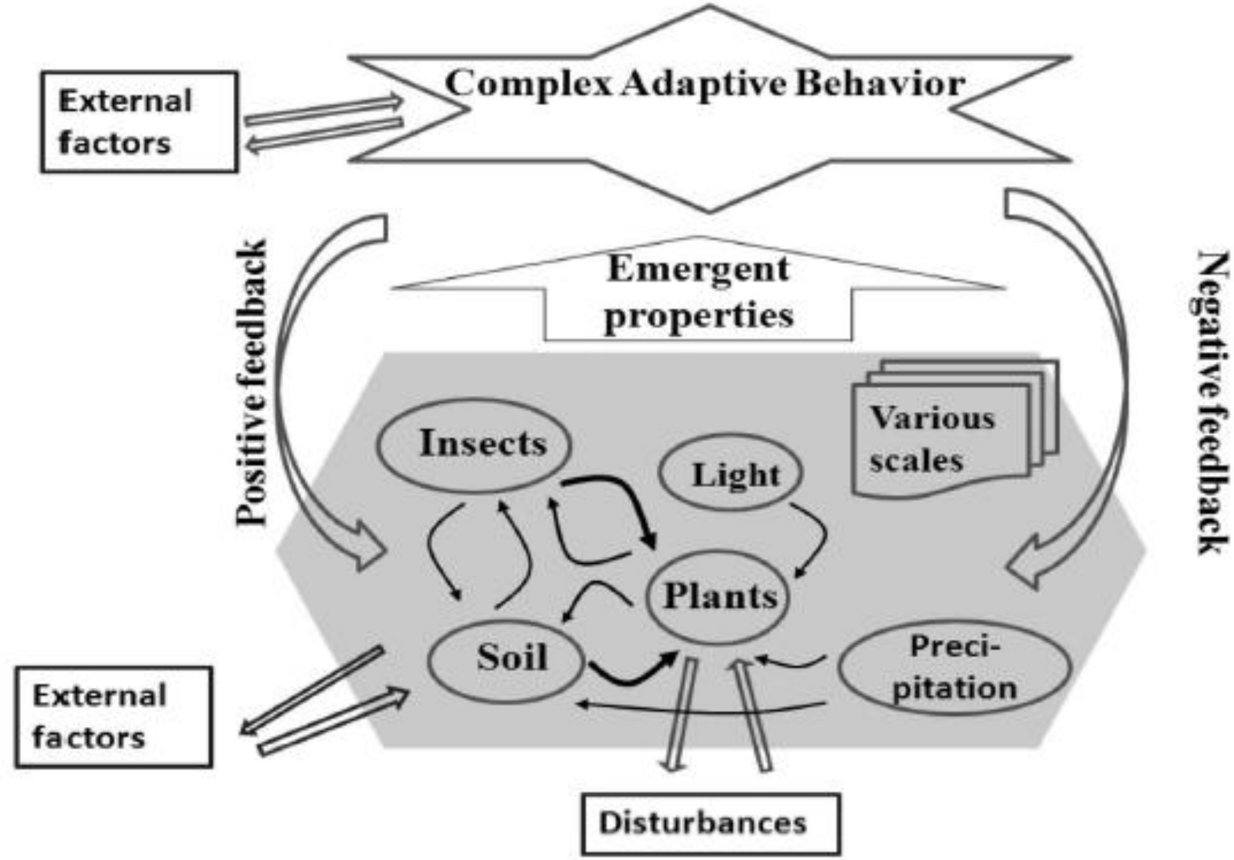


Figure 1. Simplified diagram depicting forests as complex adaptive systems (modified from Wikipedia.com). Low-level interactions include nonlinear relationships and positive and negative feedback loops, which, at higher scales, lead to emergent properties. Ecosystem behavior, including responses to global change, is meditated by the bottom-up, decentralized control, i.e., the multitude of agents and interactions at low-level local scales.

Source: Puettman 2010. Silvicultural Challenges and Options in the Context of Global Change: "Simple" Fixes and Opportunities for New Management Approaches

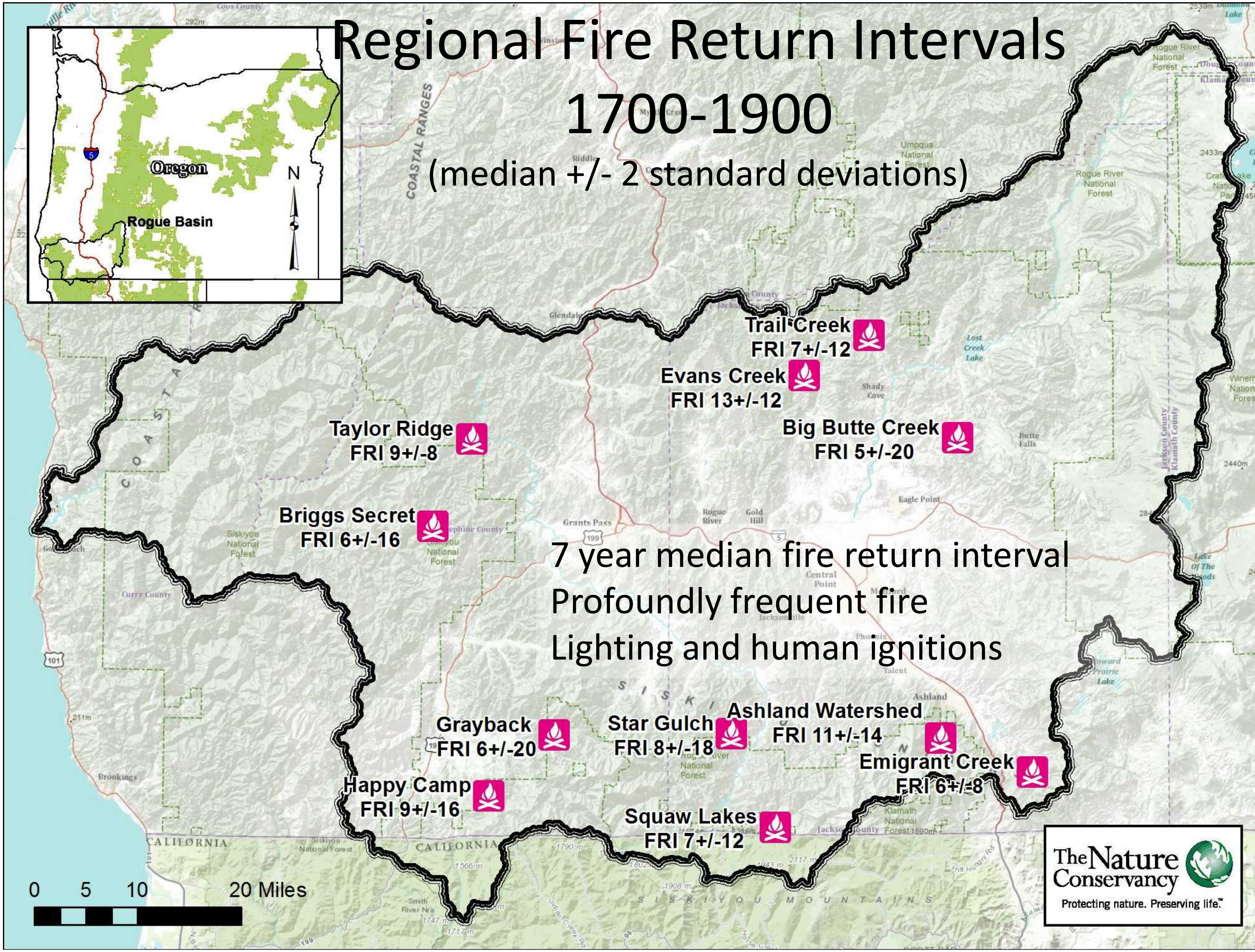
The Human Footprint: Changes in Disturbance Regimes

Natural

- Fire
- Ungulate herbivory
- Diseases
- Insects
- Floods
- Landslides
- Wind
- Volcanic activity
- Glacial
- Drought

Human influenced

- Fire
- Forest management for products
- Livestock herbivory
- Land use
- Invasive, non-native plants
- Climatic changes



Slide credit: Kerry Metlen. More updated information available at Metlen et.al. 2018. Regional and local controls on historical fire regimes of dry forests and woodlands in the Rogue River Basin, Oregon, USA


City of Ashland, Unit U
April 26, 2019


We have vastly changed the type, frequency,
severity and scale of disturbance

Changes in Vegetation Communities as a Result of Changes in Disturbance Regimes in the Last 100-150 years

1. Increased stand densities and stocking levels.
2. Increased likelihood of mortality from insects and disease.
3. Shifts in species composition.
4. Change in stand structure.
5. Changes in fuels and vegetation that have created an increased potential for large scale high severity fire.
6. Decrease in stand and ecosystem level diversity.


1. Increased stand densities and stocking levels.

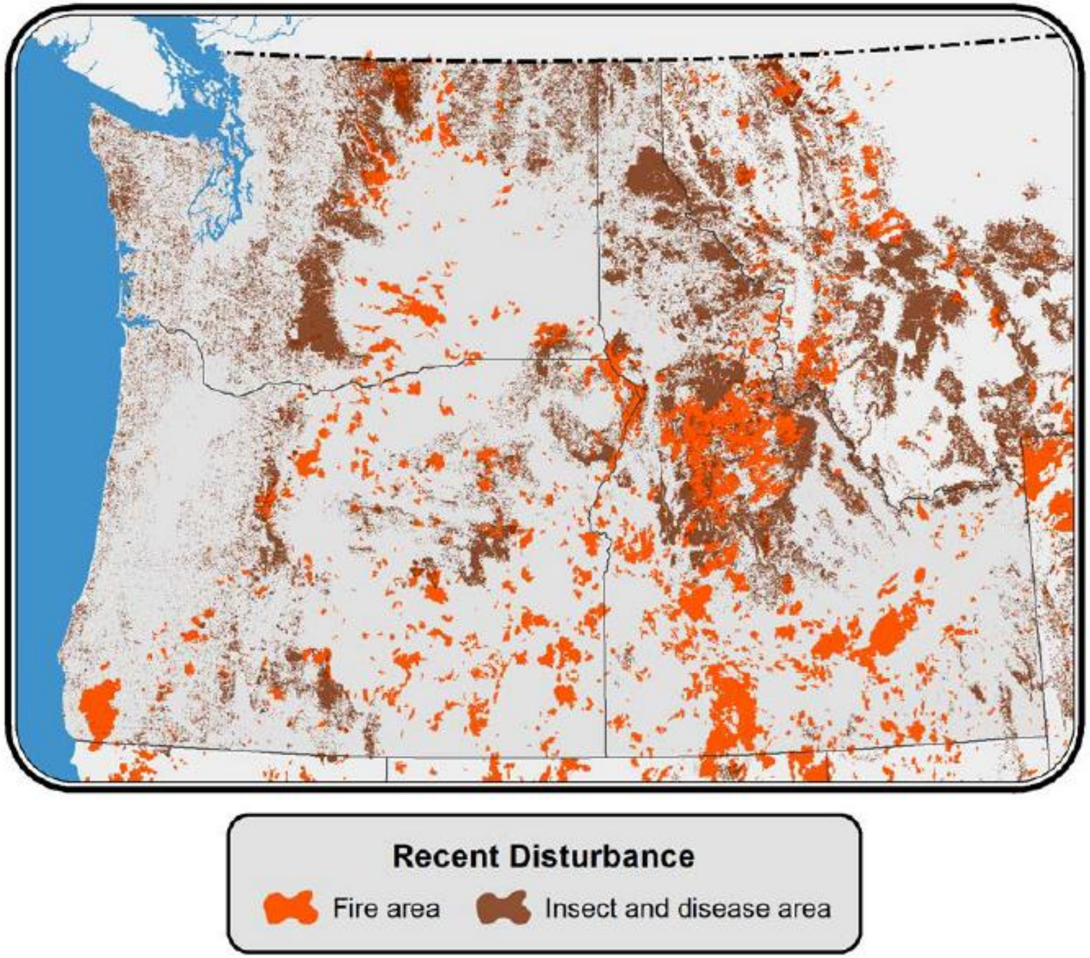

Winburn Unit 1, 2021

2. Major insect and disease-related mortality of conifers

-1988-89
-1993-4
-2001-02
-2014-15

Looking northwest from Crowson Reservoir, ~2001

Large areas have been affected by disturbances in recent years, and climate change is expected to increase the probability of disturbance



Dalton et al [Eds.] (2013) Climate Change in the Northwest.

Dwarfmistletoe disease in Douglas-fir-

Laminated root disease in white fir

One of four primary root diseases in southern Oregon; primarily at Winburn in the City ownership

3. Species Composition Change

Overstory Douglas-fir; understory Pacific madrone

Overstory ponderosa pine; understory Douglas-fir

Species Composition Affected by Change in Disturbance Regime

Township 39 South, Range 1 East
(% basal area by species)

Date	PP	SP	DF	Oak,Madrone
1899	60	15	20	5
2003*		7	64	29
2003**		4	20	76

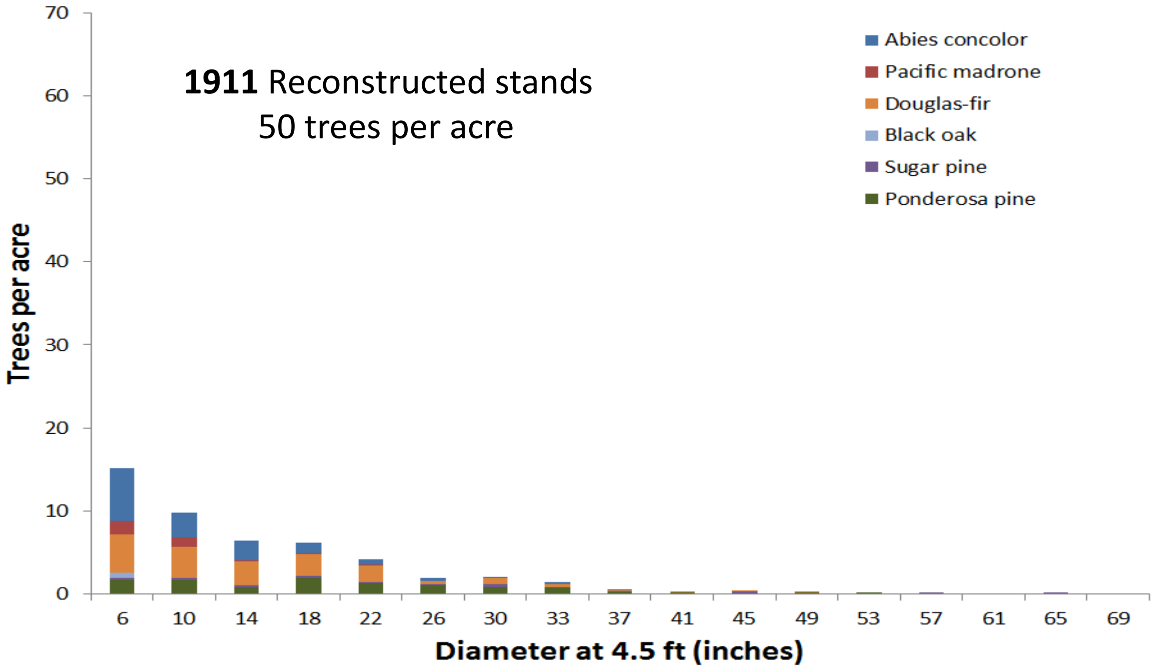
*plots in areas with one major wildfire, 1901/1910
**plots in areas with 2 major wildfires, 1901/10 + 1959

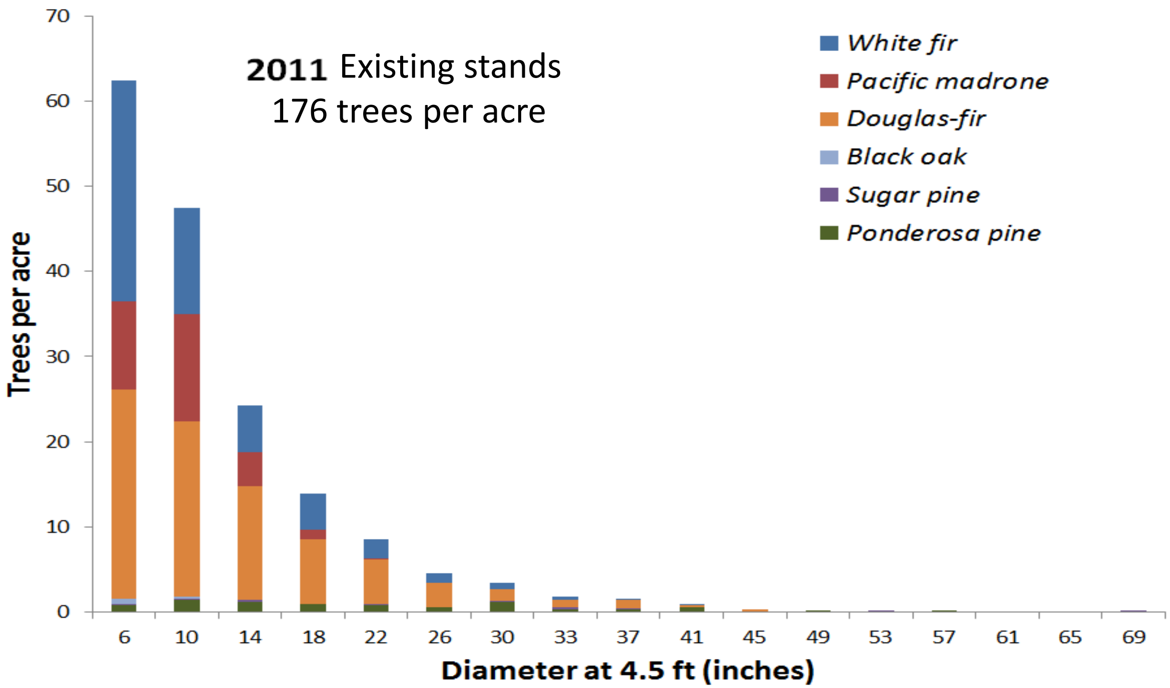
Plant Responses to Disturbance

(Rowe, 1981)

TYPE	DESCRIPTION	EXAMPLE	PREFERRED FIRE TYPE
Invaders	Highly dispersive, short-lived, pioneering	Fireweed, thistles, many grasses	High intensity
Evaders	Long-lived propagules stored in soil or canopy	Serotinous cones (canopy); whiteleaf manzanita, wedge-leaf ceanothus (soil)	High intensity
Avoiders	Shade tolerant, late successional species that slowly invade and have limited adaptation to fire	Hemlocks, western juniper, most true firs	Fire suppression
Resisters	Survive low intensity fires relatively unscathed	Douglas-fir, ponderosa pine	Low intensity
Endurers	Ability to resprout from root crown, lateral roots, or aerial crown	Oaks, Pacific madrone, various shrubs	High intensity

Source: Rowe, 1983. Concepts of Fire Effects on Plant Individuals and Species.





Data on file: Kerry L. Metlen,
The Nature Conservancy

The Nature Conservancy

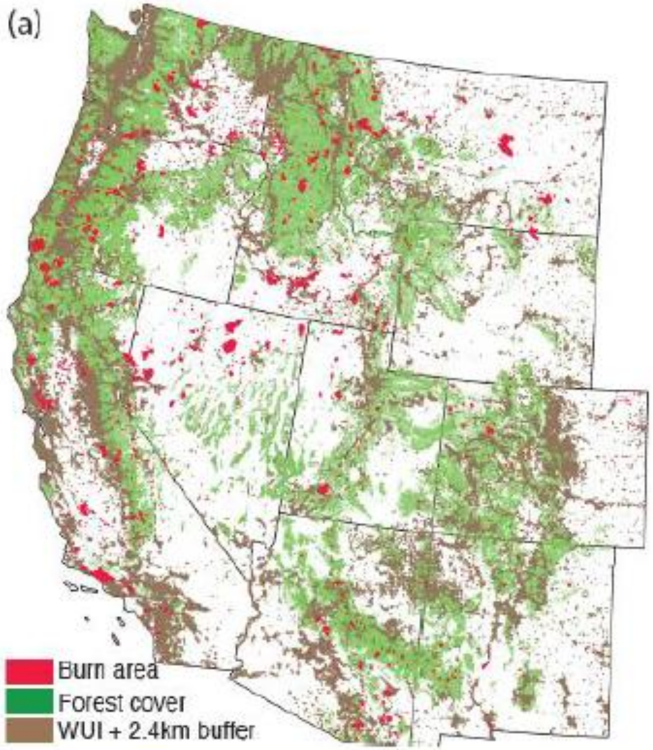

4. Change in stand structure.
Shaded fuelbreak on ridgeline
in Ashland Watershed

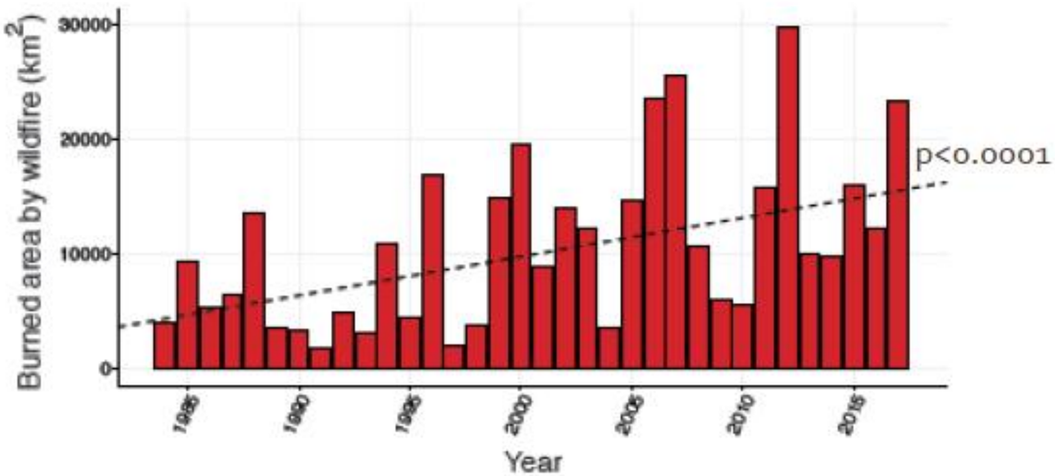
Fig. 8. Old-growth forest structure in two forest regions characterized by low- to moderate-intensity disturbances showing the mosaic of structural patches that collectively form the functional old-growth stand: (a) 200 m × 20 m profile of old-growth stand characteristic of the Sierra mixed-conifer type (Aspen Valley, Yosemite National Park, California); (b) 15 m × 150 m transect of old-growth pure ponderosa pine stand (Bluejay Springs Research Natural Area, Winema National Forest, Oregon) (drawings by R. Van Pelt).

5. Changes in fuels and vegetation that have created an increased potential for large scale high severity fire.

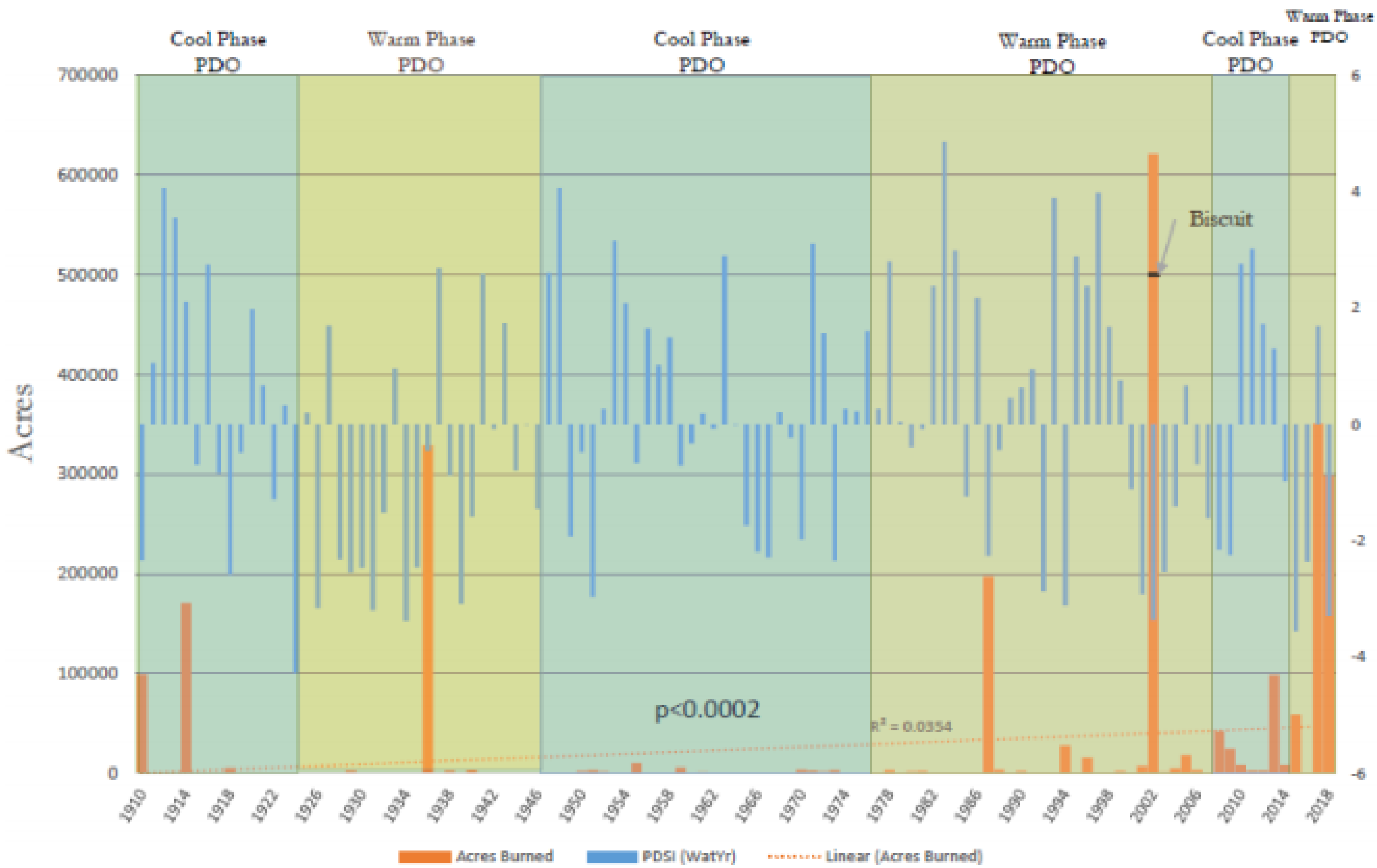
Photo credit: Scott Harding

Wildfire Trends 1985 – 2017: Western U.S.

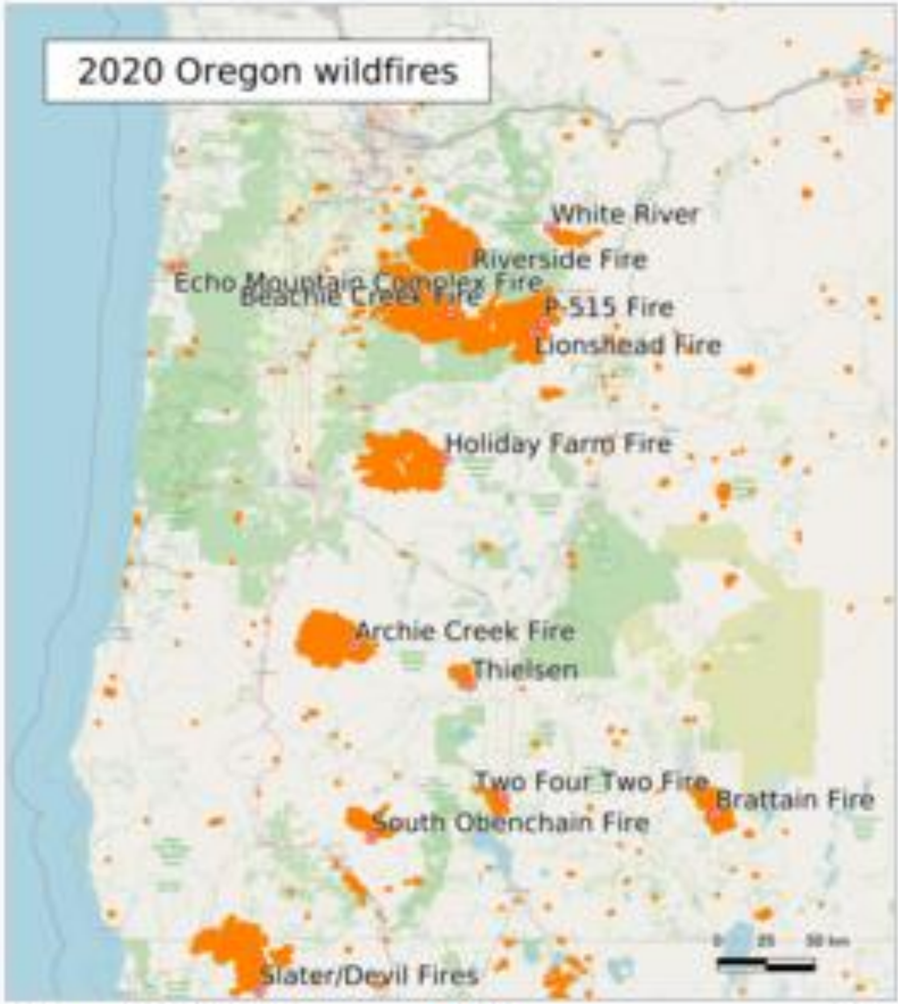




Annual Area Burned in SW Oregon, 1910 - 2018



Significant upward trend



Map of 2020 Oregon wildfires

Significant fires in the western US, loss of lives and property, 1991-2018

Year	Fire Name	Location	Lives Lost	Structures Destroyed
1991	Tunnel/Oakland	Oakland, CA	25	2900
	Firestorm	Spokane, WA	0	108
1993	Laguna Hills	Laguna	0	366
	Old Topanga	Malibu, CA	0	268
2000	Cerro Grande	Los Alamos, NM	0	235
2002	Hayman	Lake George, NM	0	132
	Rodeo-Chediski	Heber-Overgaard, AZ	0	426
2003	Aspen	Summerhaven, AZ	0	340
	Old, Cedar, others	Southern CA	15	3640
2007	Angora	Lake Tahoe, CA	0	245
	Witch, Slide, Grass Valley	San Diego, CA	0	2180
2013	Black Forest	Colorado Springs, CO	0	489
2015	Valley	Lake, Napa Counties, CA	0	1307
2015	Butte	Amador, Calaveras Counties, CA	0	475
2017	Tubbs	Santa Rosa, CA	22	4658
2018	Camp	Paradise, CA	86	13972
2020		**California**	**33**	**10488**
2020		**Oregon**	**11**	**6000+**

California

-15 of the 20 most destructive wildfires (structures lost) in history have been since 2015

-9 of the 20 largest wildfires in history have occurred since 2017, including the 1+ million acre August Complex in 2020

-4.2 million acres burned in 2020, the most in history

Oregon

- 1.22 million acres burned in 2020, the most in history

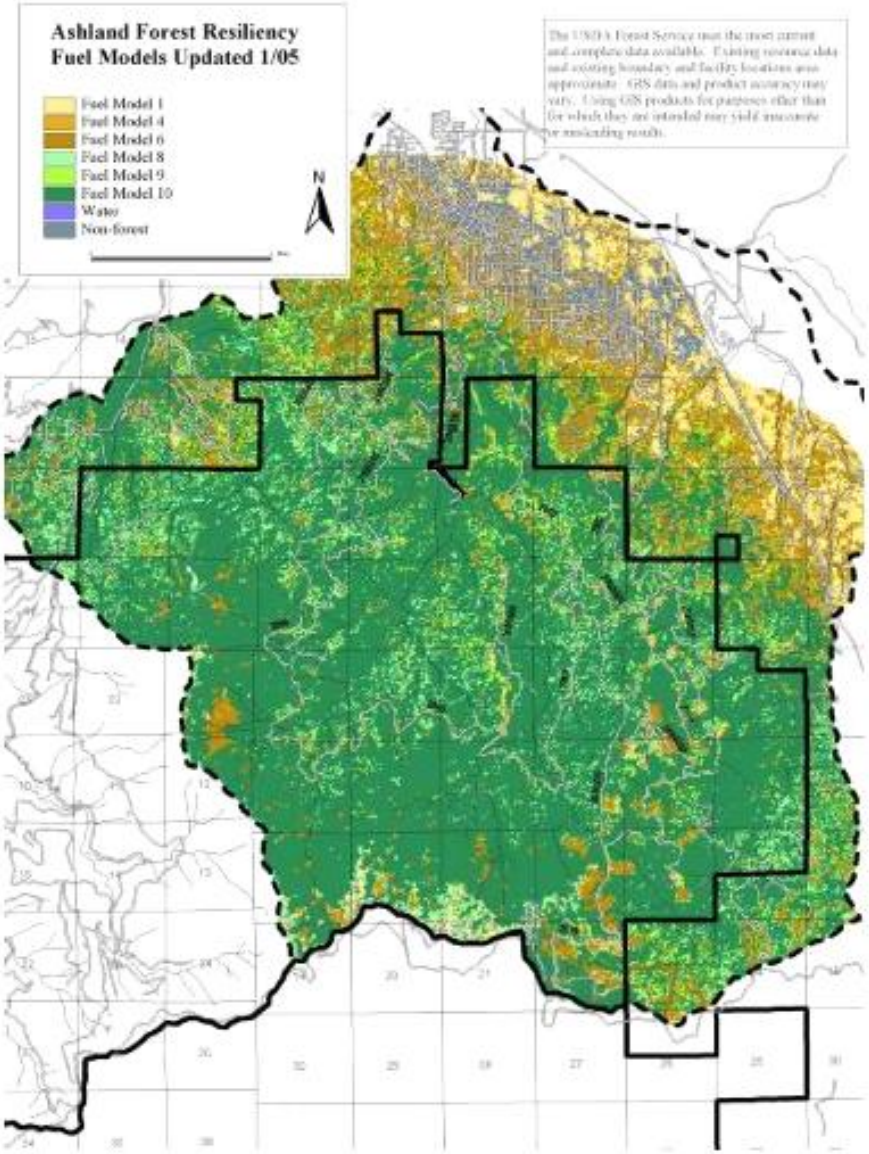
Sources:
https://en.wikipedia.org/wiki/2020_Oregon_wildfires
https://www.fire.ca.gov/stats-events/
Table courtesy of Dr. Bill Kuhn, US Forest Service, Medford, Oregon

When these dry forests do burn, we observed that 36% burned with high-severity compared to 6–9% historically.

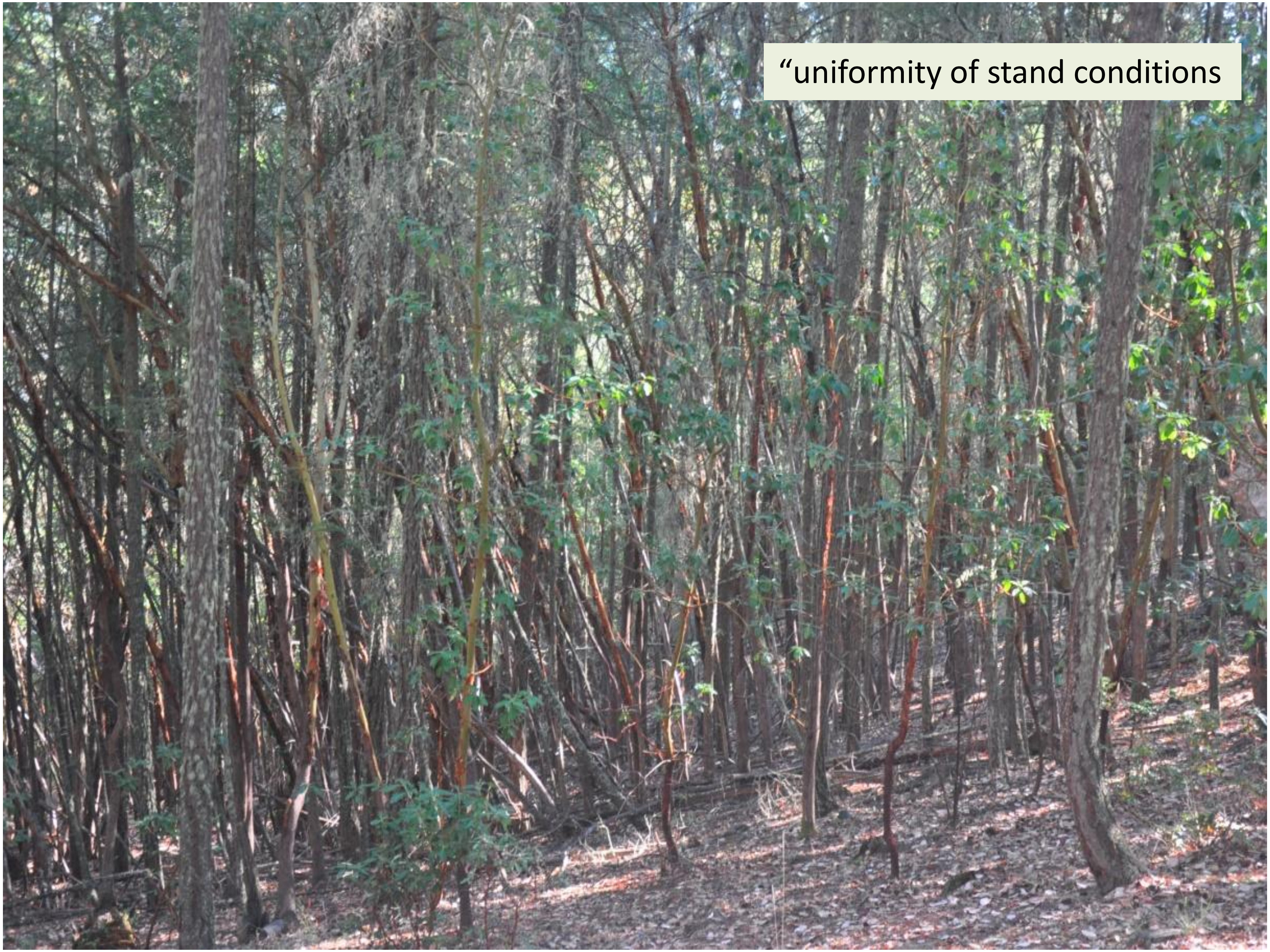
Source: Haugo et. al. 2019. The missing fire: quantifying human exclusion of wildfire in Pacific Northwest forests, USA

6. Decrease in ecosystem diversity.

Map D-3. Fuel Model Updates



From: Ashland Forest Resiliency- Draft Environmental Impact Statement , June 2005


“uniformity of stand conditions

“Multiple disturbances have the potential to create surprising situations and reduce the resilience of an ecosystem. Differential recovery as a result of a “novel disturbance” created by compounding events will likely have long lasting legacies across the landscape.”

Source: Buma and Wessman 2011. Disturbance interactions can impact resilience mechanisms of forests.

What is Traditional Ecological Knowledge (TEK)?

Traditional ecological knowledge refers to the knowledge, practice, and belief concerning the relationship of living beings to one another and to the physical environment, which is held by peoples in relatively nontechnological societies with a direct dependence upon local resources (Berkes 1993). Traditional ecological knowledge is not unique to Native American culture but exists all over the world, independent of ethnicity. It is born of long intimacy and attentiveness to a homeland and can arise wherever people are materially and spiritually integrated with their landscape (Kimmerer 2000). TEK is rational and reliable knowledge that has been developed through generations of intimate contact by native peoples with their lands (Mauro and Hardison 2000). TEK is being recognized as having equal status with scientific knowledge (UNEP 1998) and has been termed the "intellectual twin to science"(DeLoria 1995). This long intellectual tradition exists in parallel to Western science, yet has been historically marginalized by the scientific community (Salmon 1996).

Kimmerer 2002. Weaving Traditional Ecological Knowledge into Biological Education: A Call to Action. BioScience May 2002 / Vol. 52 No. 5.

Comparing TEK and Western Science

(from Barnhardt and Kawagley 2005)

TEK	Western Science
Oral tradition	Written tradition
Holistic approach	Reductionist
Learned from observation and experience	Taught and learned mostly analytically
Environment as part of social and spiritual relationships	Hierarchical and compartmentalized organization
Based on cumulative, collective experience	Based on laws and theories
Mainly qualitative	Mainly quantitative
Data generated by resource users	Data collected by specialists or experts
Long time within one location	Short time-series over a large area
Integrated and applied to daily living and traditional subsistence practices	Hypothesis falsification and model building

Silviculture to achieve forest management objectives basically involves manipulating three characteristics of forest vegetation:

1) **density;**

2) **species composition**;

3) **stand structure.**

The manipulation of these 3 characteristics provides opportunities for development of new, and hopefully more desirable, **functional processes and disturbance regimes.**

Vegetation: Functional Processes and Disturbance

Climate Change Key Vulnerabilities

Main Point- The likelihood of increasing scale and severity of disturbance, particularly fire, and subsequent loss of ecological benefits associated with more frequent low severity disturbance is the most significant climate change induced vulnerability on the City of Ashland Forestlands.

1. **Rising temperature and increased length of summer dry season will produce an Increased likelihood of large scale, high severity disturbance, from multiple interacting agents and disturbances, with increasing loss of green forests. Even with all of the work completed, we are still at an elevated potential for high severity fire. We must continue to reduce that risk, even while recognizing that the risk will continue to increase as climate get s warmer and with longer drier summer fire seasons .**

2. **Increased difficulty of restoring a more frequent, low to moderate disturbance regime upon which these ecosystems were adapted to and were dependent on for millenia. (e.g.fire)**
   a. **Less opportunity to develop multi-layered, more heterogenous stand structures and associated ongoing opportunities for natural regeneration.**
   b. **Loss of systems dominated by older conifers (especially those that are more shade intolerant) that are enhanced by frequent, low severity disturbance.**
   c. **Loss of desired traits and relationships enhanced by more frequent low severity disturbance**
      - **induced defenses to insects, fire(Hood et.al 2017)**
      - **tree stability, wind resistance (height:diameter ratios)**
      - **frequent smoke and induced deterrent to forest diseases**
      - **charcoal production as a soil amendment**
      - **likely many others.**

3. **Frequent, low severity disturbance regimes have been missing from southern Oregon forests for decades and the City forestlands has, in comparison, a relatively long (i.e. 25+ years) running example of encouraging frequent low to moderate severity disturbance as an operating silvicultural framework through implementation of planned disturbances that emulate historical processes and functions.**

The increasing likelihood of large scale high severity fire as a result of with climate related changes in temperature, summer drought and extended fire seasons is the most significant climate change vulnerability to forests on the City of Ashland ownership.

Once lost or significantly altered through a large scale, high severity fire, the considerable ecosystem services and values available from the Ashland watershed will not return, perhaps for decades, if not in some cases, millenia. Additional changes in climate variables will only exacerbate this potential outcome.

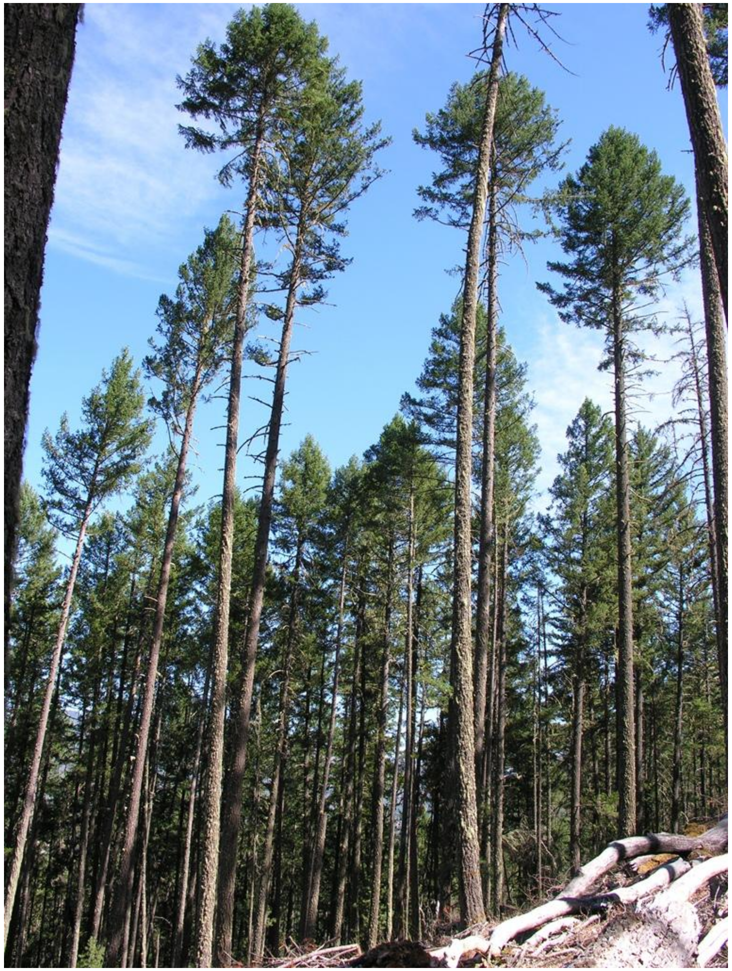
We should not be asking if fire will return to the City of Ashland ownership, but when, in what severity, and what we can do to try to insure that it is a disturbance that fits the ecological underpinnings of so much of what we value (i.e. ecosystem services) in our culture.


City of Ashland, Unit U
April 26, 2019

Height:Diameter Ratio

- 100 ft tall, 12” (1 ft) diameter= **100:1**; usually generated in dense stands free from disturbance.

- Old growth trees often have ratios= **30-50:1**; usually generated in more open stands with frequent, low severity disturbance



Frequent low severity fire builds induced defense in Ponderosa Pine

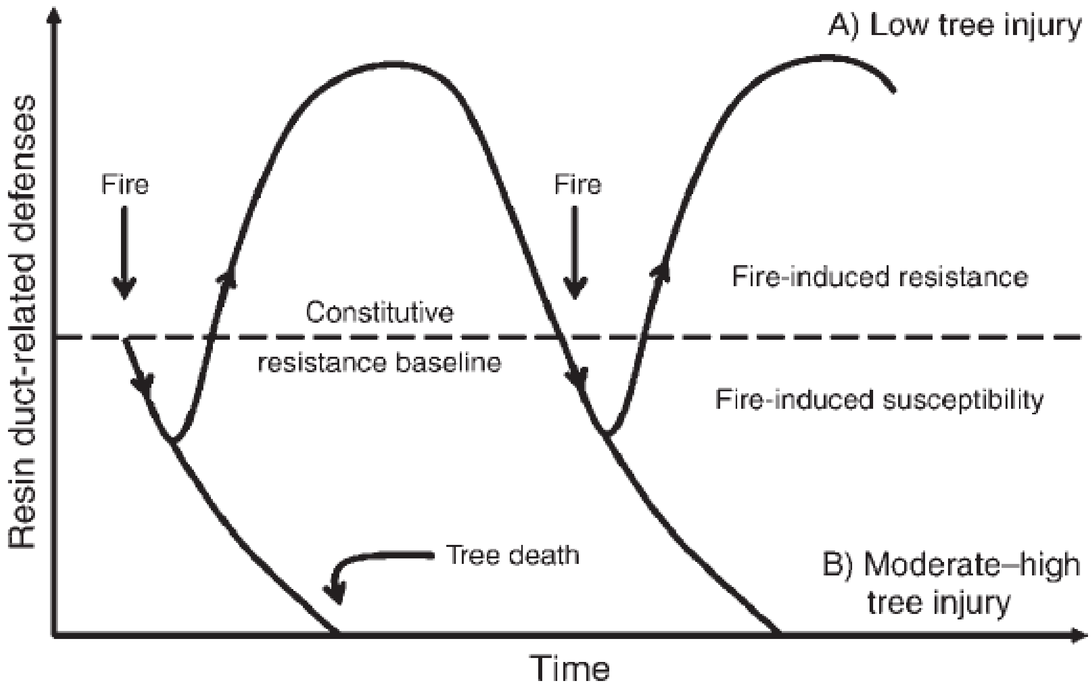


FIG. 4. Hypothesized conceptual model of fire-induced resin duct-related defenses (e.g., resin ducts, flow, and chemistry) in conifers. (A) For trees with low levels of injury, fire causes a brief (days, up to 1 growing season) reduction in resistance to bark beetle attacks (i.e., fire-induced susceptibility) before induced resin ducts form, followed by a period of increased resistance that lasts for several years (i.e., fire-induced resistance) before returning to constitutive levels as induced resin ducts lose connectivity due to annual tree growth. The exact timing and magnitude of this switch is dependent on the specific bark beetle and tree species involved, growing season length, and post-fire climate. (B) Fire increases susceptibility to attack for trees with moderate to high levels of injury and the probability of tree death. Additional research is needed to understand how defense components interact to affect overall fire-induced tree resistance.

Source: Hood et.al. 2015. Low-severity fire increases tree defense against bark beetle attacks.

Smoke Effects on Germination of Western Gall Rust Spores

Length of Exposure (seconds)	0	2.5	5	10
Spore germination (%)	82	24	25	0

Parmeter and Uhrenholdt, 1975. Effect of smoke on Pathogens

Ponderosa pine adaptations to frequent, low severity fire

Survive Fire

Rapid initial growth
Thick bark
Withstands fire scars; resinous
Resistant to rot from bole wounds
Deep rooted
Crown high above ground
Flared butts
Hardened buds resist fire damage
Open crowns do not trap heat

Encourage Fire

Very flammable needles when dry
Thrive on drier, more fire prone southerly aspects
Prefers more open forests typical of sites that have more frequent, low severity fire regimes
Natural regeneration best on mineral soil that occurs more regularly with frequent fire

In the absence of frequent, low severity fire, shade intolerant ponderosa pine numbers have plummeted in the denser forests of today. This is particularly unfortunate given the species general adaptation for warmer drier sites that will become more common with climate change and the likelihood that fire will continue to be a major ecosystem level force in our forests. A key question is: to what extent are the advantages of ponderosa pine from a climate change perspective available without an associated change to a more frequent, low severity disturbance regime in which they originally came to prominence?

The future of ponderosa pine (and several other species), based on current stocking surveys on City of Ashland forestlands, is sobering!

Table 1: Conifer stocking (trees <4.5' tall)

Parcel	Trees per acre by species						
	DF	WF	PP	SP	IC	PY[4]	Total
LW	42	1	10	1	21	3	78
Winburn	160	277	11	8	147	55	658

Table 2: Hardwood stocking (trees <4.5 tall)

Parcel	Trees per acre by species						
	Pacific Madrone		Black Oak		Chinquapin		Total[3]
	Seedlings	Clumps	Seedlings	Clumps	Seedlings	Clumps	
LW	222	96	12[1]	7[1]	0	0	337
Winburn	303	49	0	0	0	5[2]	357

1: QUKE was only found in 6 units - A1, E, F, G, K, and R.
2: CACH was only found on one plot.
3: Totals are the sum of all seedlings and clumps.
4. PY=Pacific Yew

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Vegetation: Density/Vigor

Climate Change Key Vulnerabilities

Main Point- Tree and stand vigor declining and mortality increasing from cumulative stress is a key vulnerability moving forward. Cumulative stress is already high in many areas and this will only increase with longer, warmer, drier summers .

1. **Tree decline and mortality from cumulative stress.** A host of factors are involved, but in the dry forests on the COA ownership, loss of tree vigor has primarily been associated with increased moisture stress aggravated by a host of factors. Continued projected increases in temperature and extended dry seasons with climate changf will add to cumulative stress. Lowering existing stressors and key vulnerabilities will increase the likelihood that trees and stands will best be able to withstand future increases in climate-related stressors.

2. **Density-related decline in tree and stand vigor. W**ell established in research literature and in practice, density-related decline continues unabated without disturbance, planned or otherwise. Densities are high in places on the City ownership but have been reduced significantly with management over the past 25 years on the City ownership.

3. **Insect and disease related factors in tree and stand decline and mortality**. Often, insect-related decline and mortality is closely associated with excessive density or other cumulative stressors. Well established in research literature and in practice.

4. **Drought**. Tree decline and mortality often associated with drought as a final stressor exceeding the vegetation/tree/stand abilities to overcome moisture stress; expectations for more droughty conditions with future increasing temperature and longer dry seasons.

5. **Site and species relationships.** Loss of tree vigor and subsequent mortality also has both site and species relationships (Main 2006, Main and Schmidt 2020).

6. **Increasing Vapor Pressure Deficit (VPD) and "hot drought"** . With climate warming, temperature is increasing linearly but VPD goes up exponentially. Increasing VPD has the potential to become a much more important stressor and thereby affecting possibilities for management to reduce its potential impact.

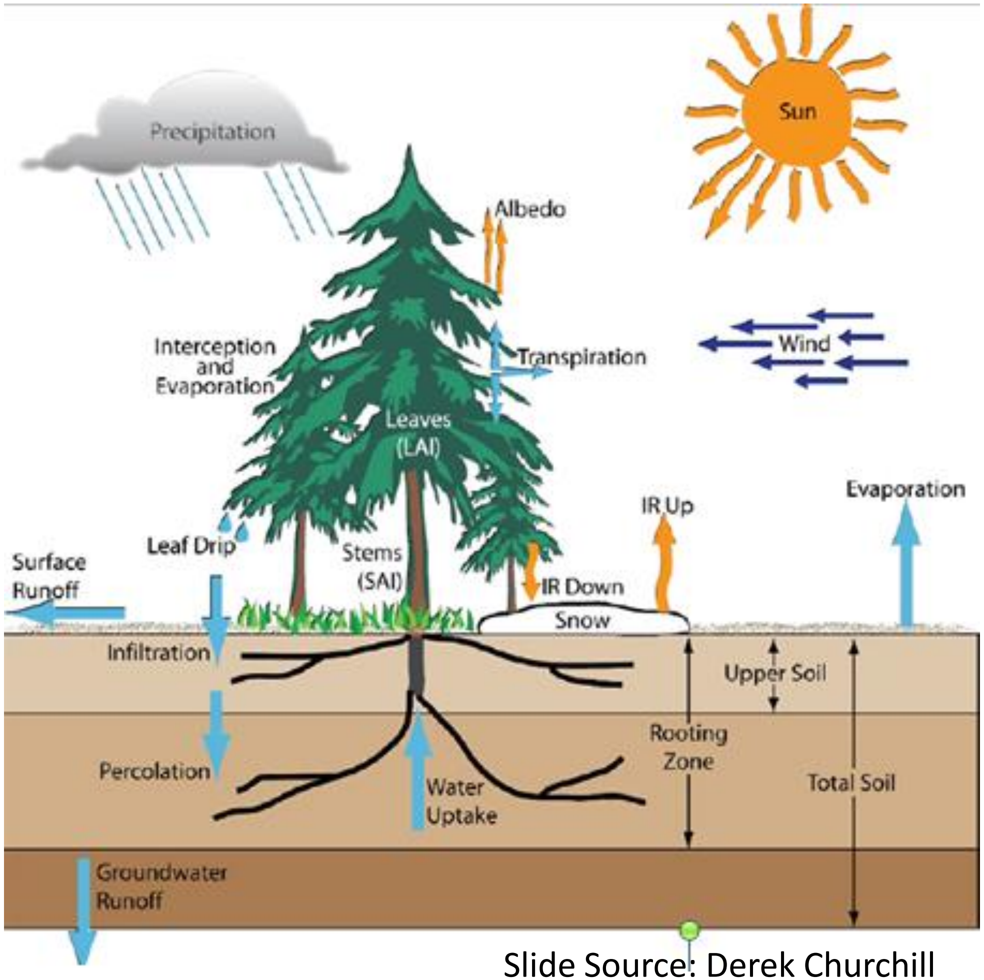
7. **Water availability decrease**. Increased total transpiration on from high stand densities on a landscape level means less water availability as an ecosystem service.

8. **Decreased foliar moisture .** Foliar moisture is a landscape level form of resistance to high severity fire. At decreasing amounts from high vegetation density, drought, and warmer, drier, extended summer seasons, very low live vegetation moisture is a significant contributor to elevated fire behavior on a landscape level.

Drought Stress on Individual Plant Level

• Has both aboveground and belowground mechanisms which interact with their environments in quite different ways, changing with species, age, sites and other factors

• Appropriate management response for individual trees will depend on an increased understanding of these two biological mechanisms and integrating them amidst rapidly changing climatic factors. For example, increasing available water by increasing space alone may not always be as important as understanding methods by which trees access and uptake additional water belowground and transpire it aboveground.

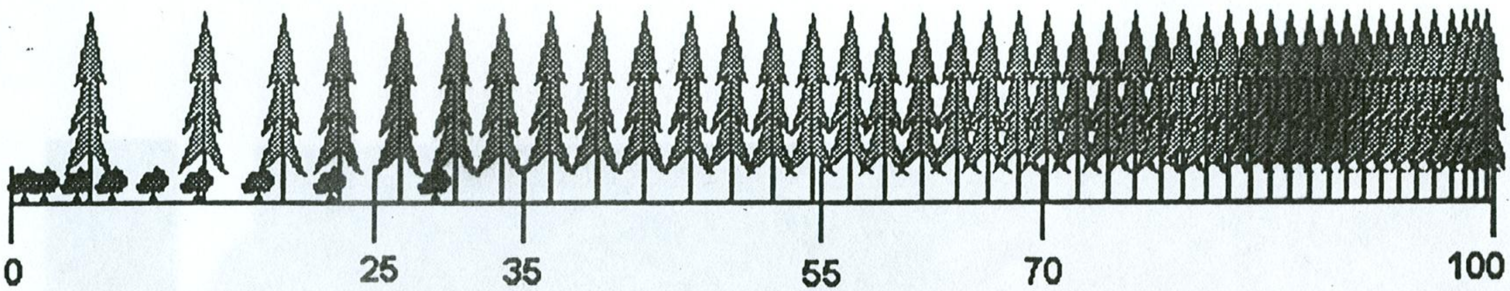


Slide Source: Derek Churchill


Density related decline in tree and stand vigor

Figure 5

Stand Development and Density



RECRUITMENT

Individual tree growth maximized. Recruitment of new trees & shrubs onto forest floor.

EXCLUSION

New recruitment stops. Trees begin to compete.

Understory is suppressed. Competition increases between trees. Individual tree growth begins to slow.

COMPETITION

Tree competition slows individual tree growth. Stand growth maximized. Trees will be differentiating.

IMMINENT MORTALITY

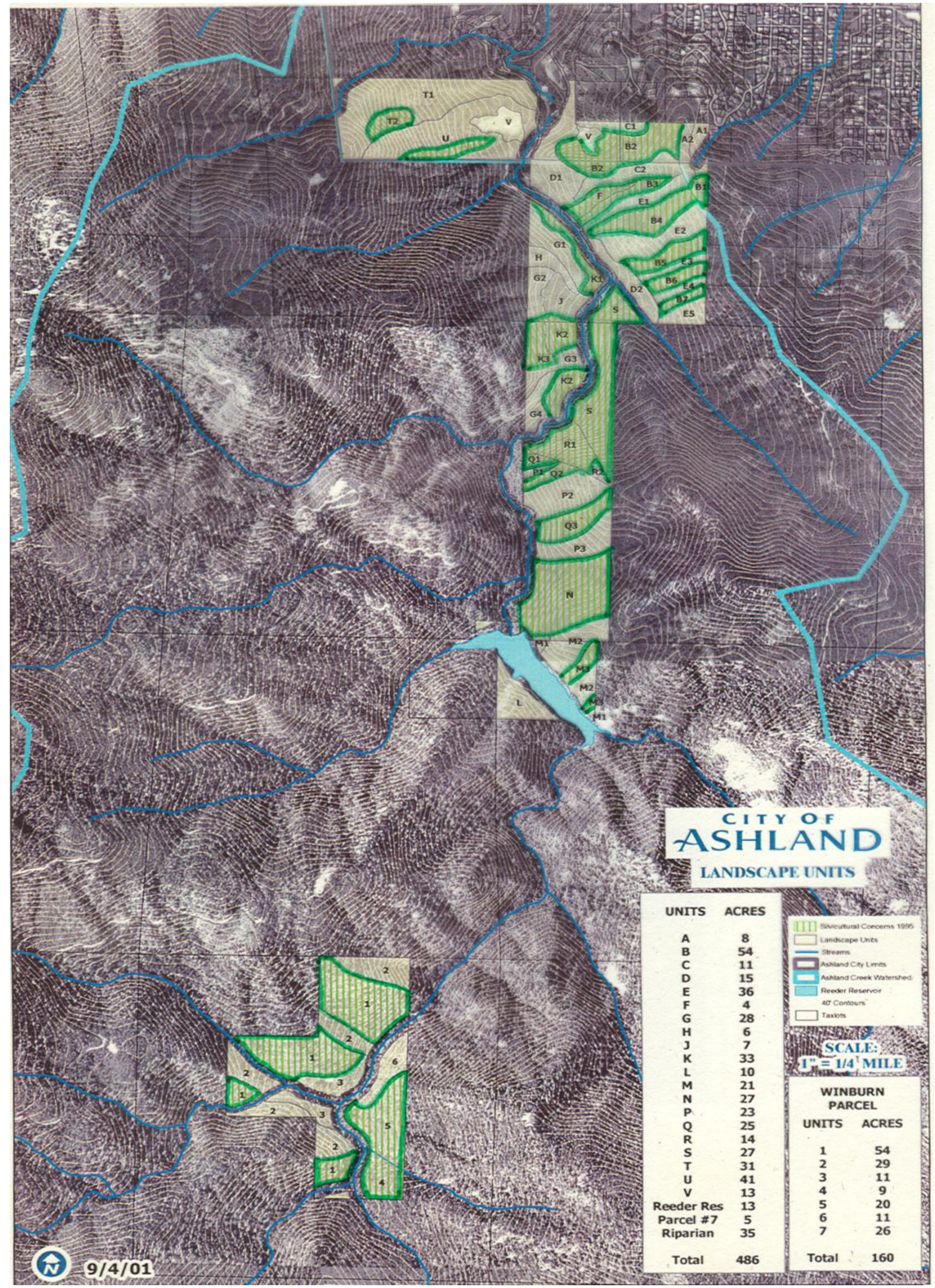
Trees begin to die from competition. Intermediates become suppressed. Weaker Co-dominates fall to intermediate.

MAXIMUM DENSITY

Maximum stand density. All but dominate and strongest co-dominate have died or are near death. Replacement by more shade tolerant trees as mortality occurs.

City of Ashland

Silvicultural
Concerns
(Main 1996)

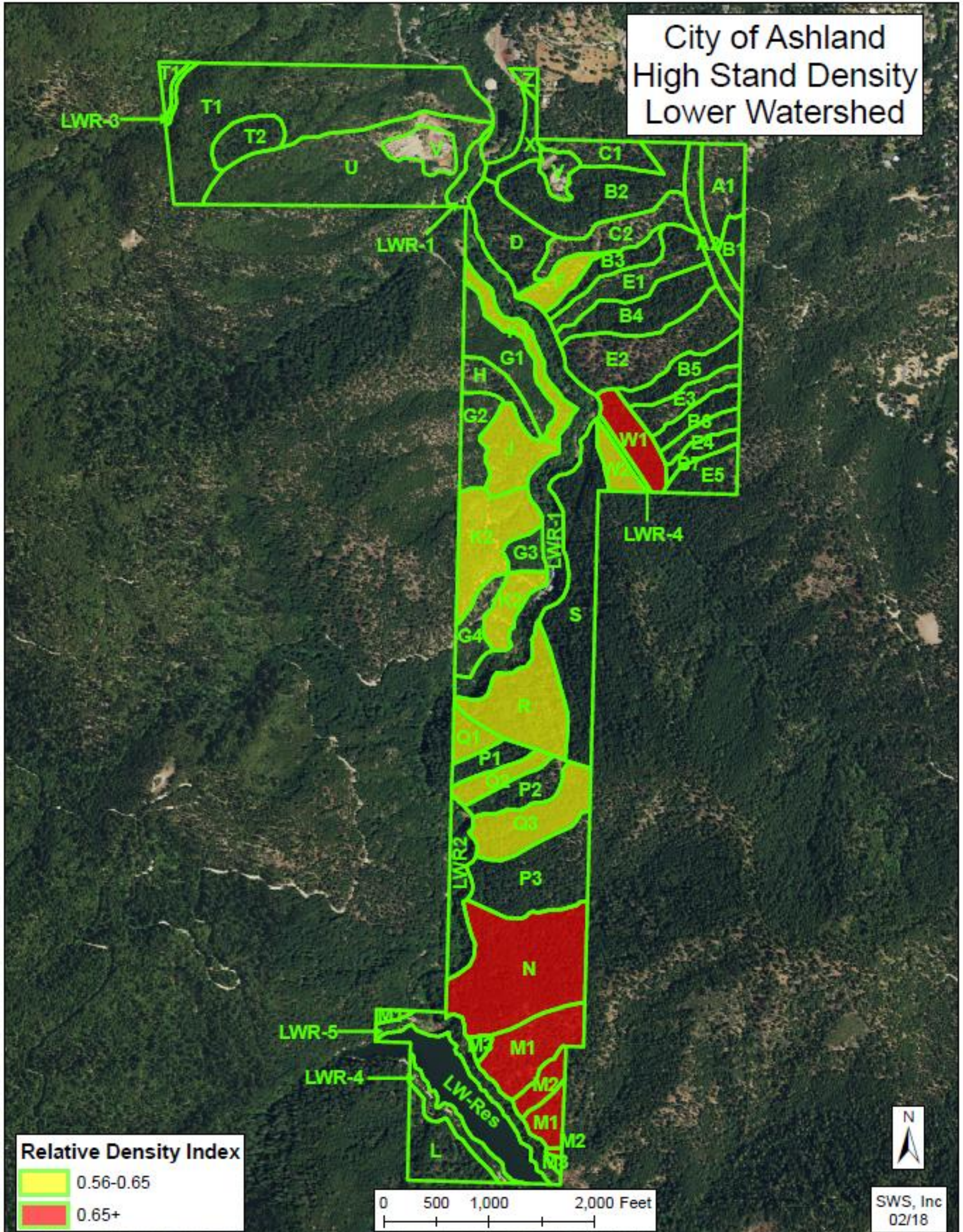


2017 Lower Watershed Tree Data Summary

Unit	Acreage	# of Plots	TPA	BA	QMD	SDI	RDI	Crown Closure (%)
A1	5.01	3	319	110	7.9	220	0.47	58
B	51.73	14	574	124	6.3	272	0.50	68
C	12.16	5	139	79	10.2	143	0.29	43
D	9.94	2	122	104	12.5	175	0.32	44
E	33.03	9	173	88	9.7	164	0.30	49
F	4.34	2	522	139	7.0	294	0.57	72
G	18.17	15	719	131	5.8	299	0.54	86
H	4.51	4	266	122	9.2	232	0.41	58
J	6.97	6	437	186	8.8	358	0.62	83
K	24.69	13	578	163	7.2	340	0.62	85
L	8.97	6	394	154	8.5	302	0.53	84
M1	14.20	4	308	206	11.1	362	0.69	73
M2	3.65	3	410	250	10.6	449	0.77	87
N	31.44	8	300	234	12.0	399	0.69	88
P	23.04	11	177	161	12.9	267	0.50	75
Q	16.50	6	256	220	12.6	369	0.62	82
R	18.52	5	421	178	8.8	342	0.61	86
S	16.09	6	312	142	9.1	270	0.46	84
W1	8.00	3	899	170	5.9	384	0.72	82
W2	4.63	4	476	197	8.7	382	0.62	86
Total*	315.59	129	390	154	9.2	293	0.55**	73

*Totals were weighted by unit acreages
**RDI total was estimated

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations


City of Ashland
High Stand Density
Lower Watershed
Relative Density Index
0.56-0.65
0.65+
0 500 1,000 2,000 Feet
SWS, Inc
02/18
N
LWR-3
LWR-1
LWR-4
LWR-5
LWR2
LW-Res
T1
T2
U
V
X
Y
Z
C1
B2
A1
D
C2
B3
E1
B4
E2
B5
E3
E4
E5
G1
H
G2
J
W1
K2
G3
S
G4
R
Q1
P1
P2
Q3
P3
N
M1
M2
L

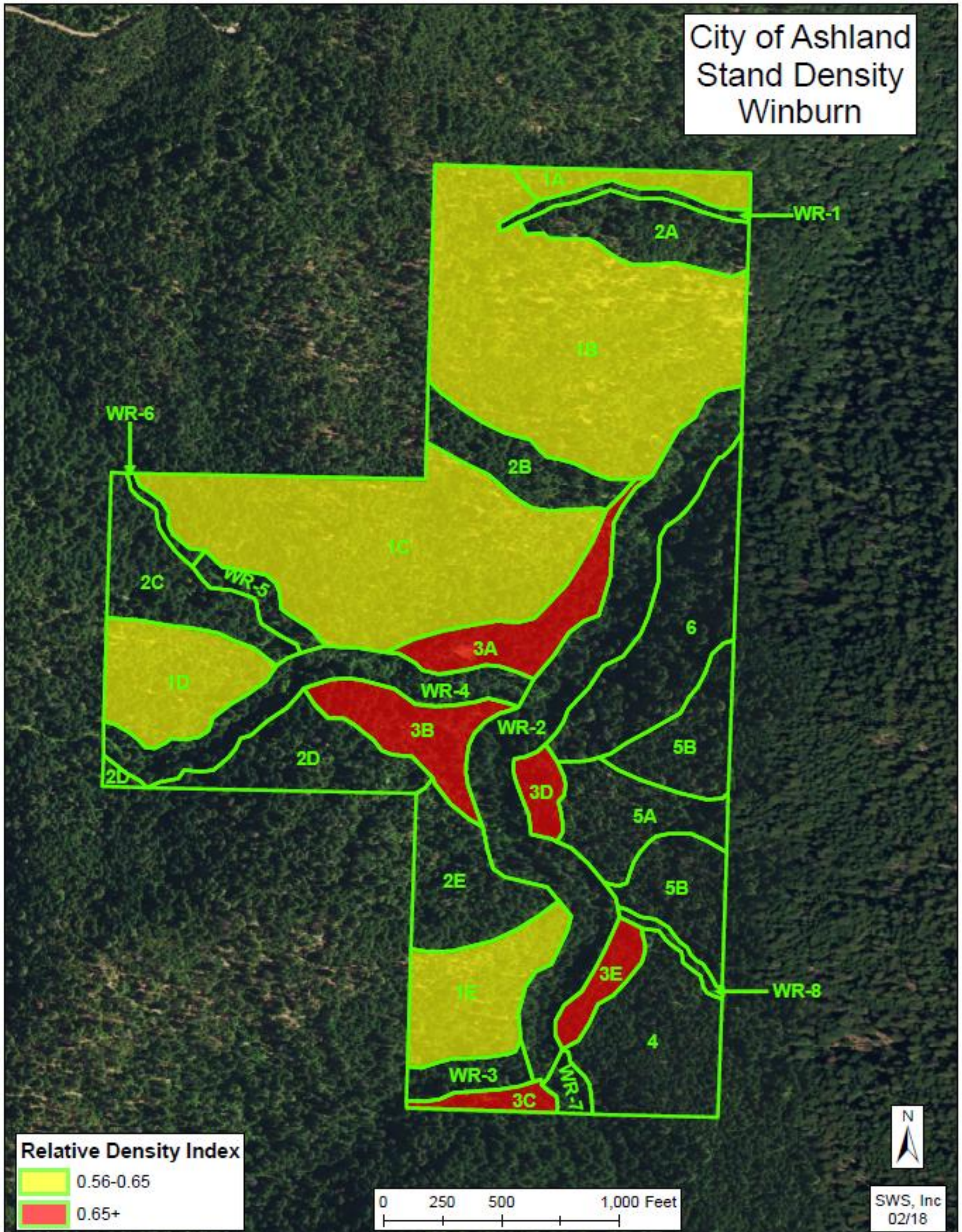
2017 Winburn Tree Data Summary

Unit	Acreage	# of Plots	TPA	BA	QMD	SDI	RDI	Crown Closure (%)
1	62.22	33	402	192	9.4	361	0.62	76
2	27.24	9	570	146	6.8	310	0.49	76
3	13.08	8	420	257	10.6	460	0.80	79
4	8.04	3	88	253	22.9	335	0.55	74
5	13.27	10	240	210	12.7	350	0.55	76
6	9.91	6	672	159	6.6	344	0.47	89
Total*	133.76	69	423	192	9.9	356	0.58**	77

*Totals were weighted by unit acreages
**RDI total was estimated

TPA= trees per acre
BA = Basal area
QMD= Quadratic mean diameter
SDI= Stand Density Index
RDI= Relative Density Index

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations


City of Ashland
Stand Density
Winburn
1A
WR-1
2A
1B
WR-6
2B
1C
2C
WR-5
6
3A
1D
WR-4
WR-2
3B
5B
2D
2D
3D
5A
2E
5B
3E
WR-8
1E
4
WR-3
WR-7
3C
Relative Density Index
0.56-0.65
0.65+
0
250
500
1,000 Feet
N
SWS, Inc
02/18

Ongoing Density Monitoring on City of Ashland Ownership

-Average basal areas for the lower City ownership have dropped approximately 25% from 1998 to 2017 (from 211 to 158 ft^2/acre), even with considerable ingrowth, and occurring at a wide range across a combination of both treated and untreated units.

-Eighteen out of 22 units were above a relative density index of 0.65 in 1998 (Main 1998); 4 out of 21 units were above that density threshold in 2017 (Main and Schmidt 2020)

The Importance of Active Management: Change in Tree Data Variables in Managed and Unmanaged Units, Winburn Parcel, 2007-2017

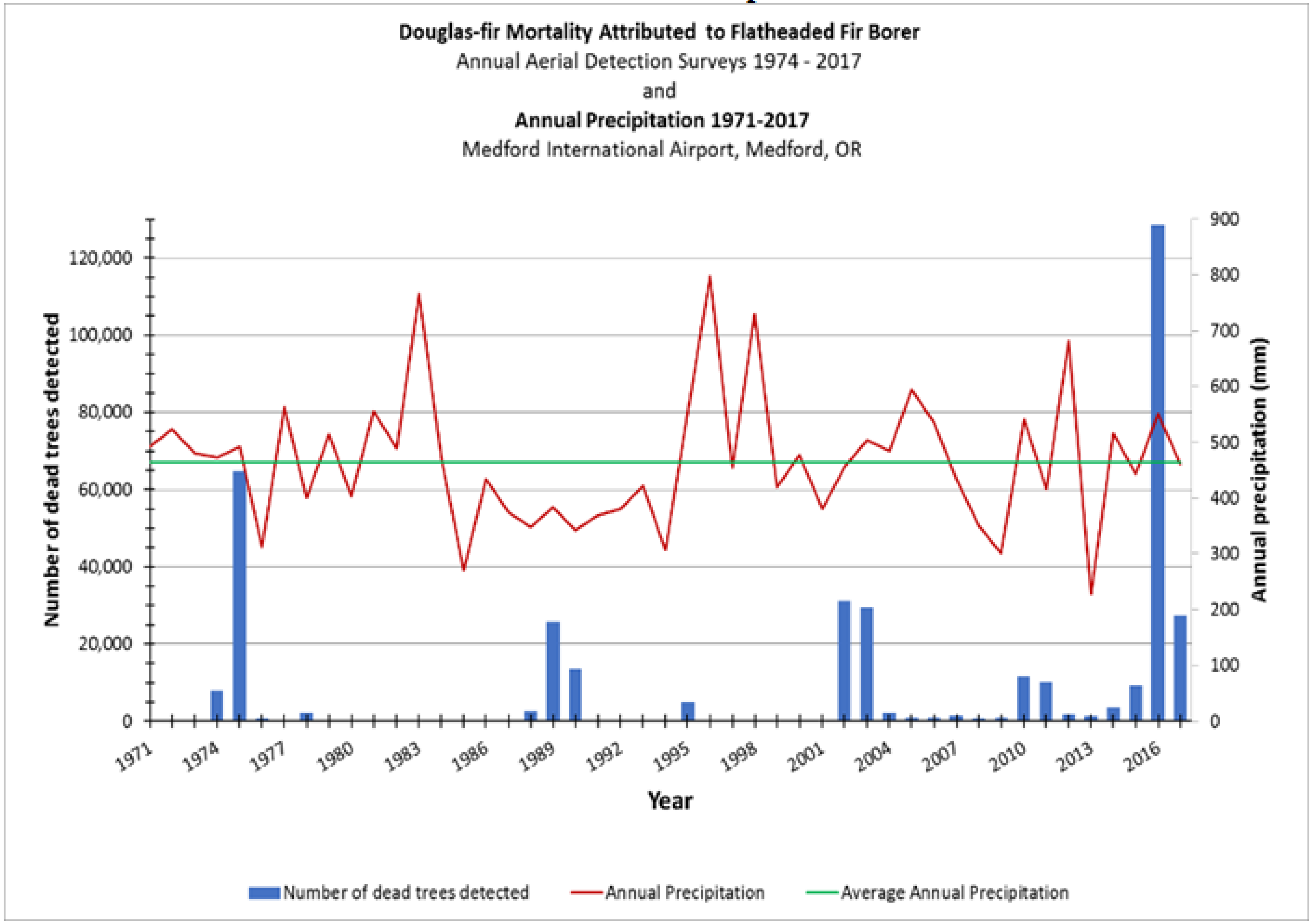
Parcel	Unit	Percent change from 2007-2017				
		TPA	BA	QMD	SDI	Crown Closure
Winburn Managed Units	1	+1.0	-8.6	-4.1	-6.7	-8.4
	4	-19.2	+2.4	+10.9	-1.8	-8.6
	5	-10.1	-10.3	+2.4	-6.9	-8.4
	Total[1]	-9.4	+5.5	+3.1	-5.1	-8.5
Winburn Unmanaged Units	2	+42.1	+1.4	-16.0	+8.4	-5.0
	3	+37.6	+12.4	-9.2	+17.0	+8.6
	6	+54.5	+13.6	-14.2	+20.7	+5.9
	Total[1]	+44.7	+9.1	-13.1	+15.4	+6.4

Important Points

1. All density-related variables (except QMD) have decreased in managed units, particularly as compared with those units in which no stand management has occurred.
2. Quadratic mean diameter (QMD) has actually increased in managed units due to non-commercial thinning of suppressed ladder fuels and thinning-from-below of larger merchantable sizes in the 2013 helicopter thinning.
3. Unmanaged units retain some important values (riparian, wildlife, slope stability, etc)

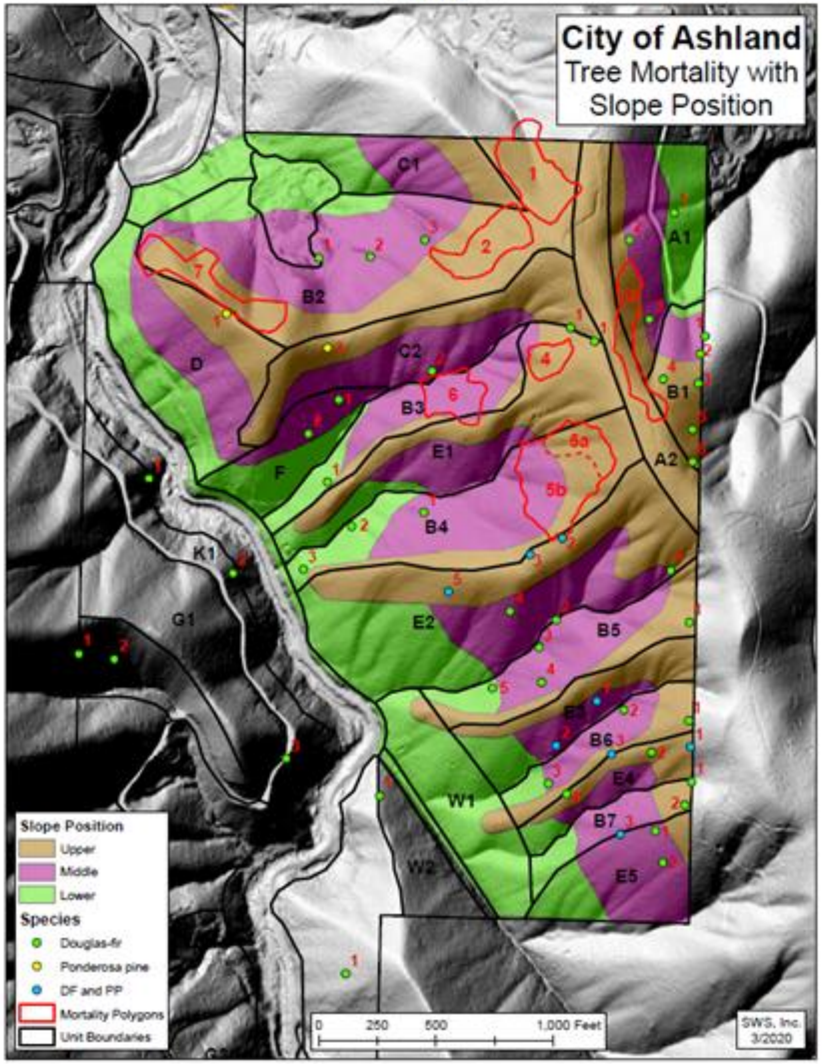
Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Graph 3



Source: Schaupp 2017

Map 5



Estimated conifer snags 8"+ DBH by slope position, Units A-F, W1

Slope Position	Acres	Doug-fir	Pine	Total	Snags/Ac
Upper	60.2	429	10	439	7.3
Middle	51.4	175	6	181	3.5
Lower	37.6	35	0	35	0.9

Source: Main and Schmidt. 2020. City of Ashland: 2020 Mortality Monitoring Results and Analysis

Douglas-fir Mortality, Key Variables, City of Ashland

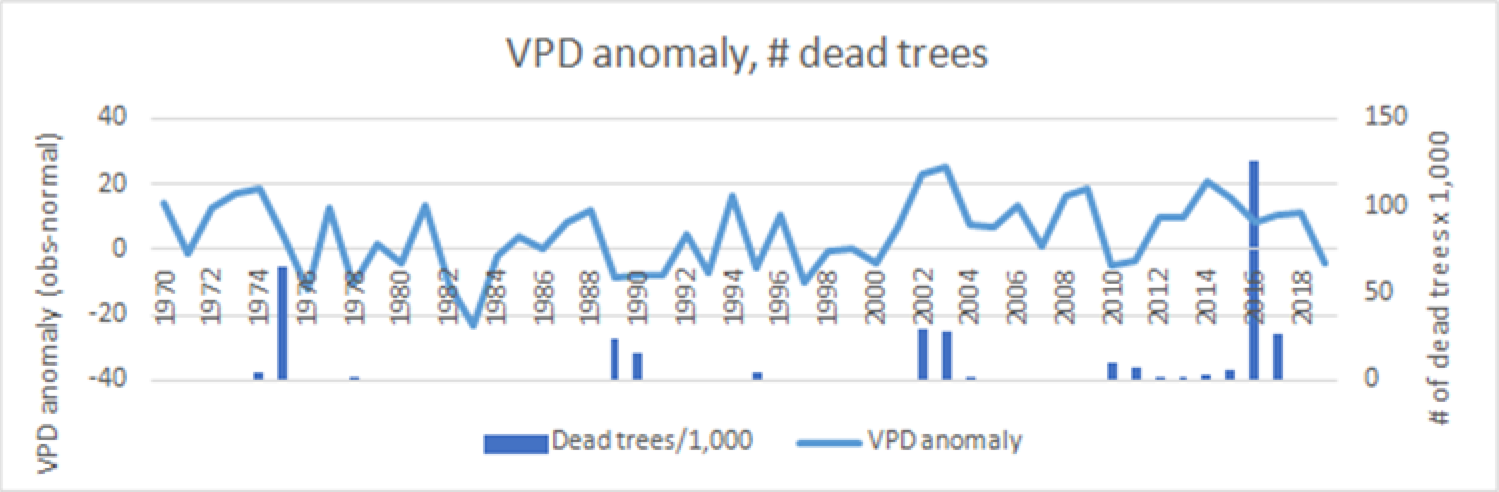
"Douglas-fir mortality related to key variables combining to produce cumulative stress"

Key Variables

- Flatheaded fir borer (Phaenops drummondi) is often the final of the cumulative stressors that result in tree mortality
- Stands with high densities on low moisture, low productivity sites incur stand level mortality in high severity outbreaks rather than more frequent, low severity, endemic levels of mortality on more productive sites.
- Not all sites/stands respond in a similar fashion to stand density reduction; microsite variation is important for thinning release to improve leave tree vigor, especially topographic position and elevation.
- Lower Watershed Douglas-fir is less productive, less vigorous and has had more mortality than more productive, less stressed, higher elevation sites (Winburn; upper half of Lower Watershed parcel)
- Increases in mortality appear to be related to drought and possibly incidence of increasing levels high Vapor Pressure Deficit
- Conifers with 40+% crown ratios respond better to thinning than trees with lesser crown ratios
- Ponderosa pine appears to respond better to thinning than Douglas-fir in Lower Watershed
- Some Douglas-fir stands did not respond immediately to thinning.

Vapor Pressure Deficit and "Hot Drought"

Graph 4



Source: Bennett (2020)

As Vapor Pressure Deficit goes up, the atmospheric "pull" on trees to supply water from their roots increases. If the pull increases beyond a critical level, portions of the water columns within the root-tree transport network may fill with air bubbles (cavitation), resulting in a loss of water transport capability in that location and death of plant tissue supplied by the water column. Alternatively, the tree may close stomata, reducing water loss but also reducing photosynthesis (carbon starvation).

Key Point: With warmer temperatures, tree stress from VPD will continue to increase, and at a faster rate than temperature!

Vegetation: Density/Vigor

Adaptation Options for Management

1. Stand density reduction and continued adjustment towards more open forests in many situations. Apply as soon as possible in forests/stands that can reasonably be expected to respond (i.e. build vigor by distributing site resources, including water, onto fewer numbers of preferred stems). Thin ahead of expected drought or other cumulative stressors **(Persist).**

2. Carefully assess on-the-ground individual tree characteristics for vigor (crown ratio, crown density/color, radial growth, basal area in vicinity, etc.): watch for new developments in individual tree vigor assessment. Rely on regularly assessed , locally generated effectiveness monitoring, both qualitative and quantitative, to guide adaptive management as opposed to more generalized conceptual information designed for more regional applications. Continue to use density indices to identify potential problems and/or determine effectiveness of density reductions **(Persist)**

3. Understand and respond to density/vigor/insect relationships and implement accordingly (e.g. green slash management with pine bark beetles). Do very careful management to avoid encouraging insect population increases; understand each insect and its host relationships. **(Persist, Change)**

4. Pay very close attention to microsite variations in aspect, slope, topography, elevation, soil type and depth and other factors that influence site productivity and soil moisture availability (Main and Schmidt 2020). **(Persist).** Use risk rating system. Identify sites/stands with lower likelihood of favorable thinning response/higher likelihood of thinning-related stand decline (Main 2006, Main and Schmidt 2020) **(Change).** Monitor over time: apply adaptive management strategies.

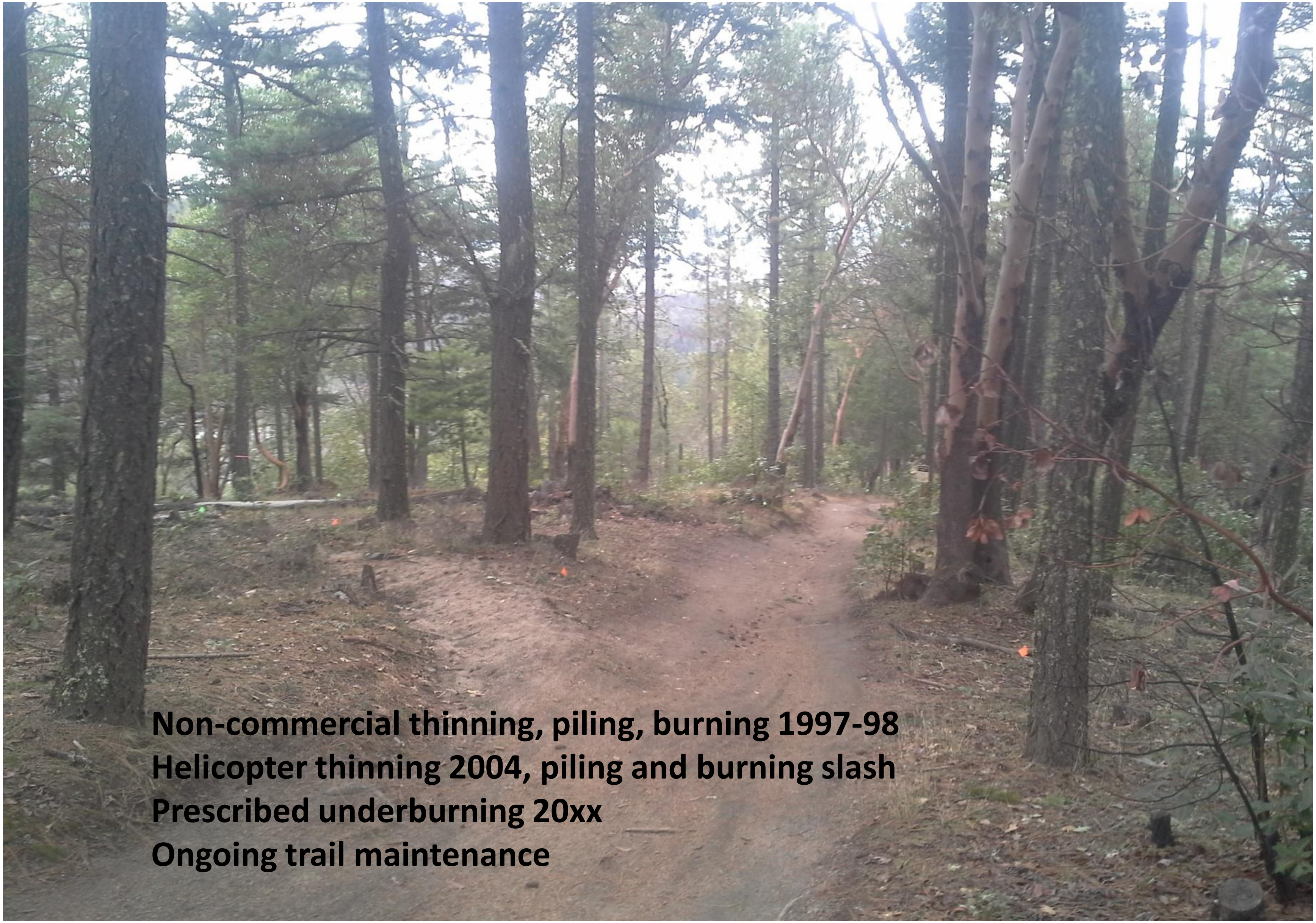
5. Continue to encourage multi species, multi-cohort stands using principles of uneven-aged management and variable density thinning **(Persist, Change)**
   - Maintain multiple options by encouraging vigor in each crown class **(Change),** a classic strategy of uneven-aged management
   - Utilize shading (i.e. temperature controls) to minimize effects of Vapor Pressure Deficit **(Persist, Change).** May make it more difficult for large overstory trees that will most directly experience temperature increases and effects of VPD.

6. Implement density reduction in stages (i.e. more slowly over time and more similar to frequent, low to moderate disturbance regimes), especially around highly desired preferred trees/structures (i.e. particularly older legacy trees often under high stress currently) to allow staged adaptation to new conditions after 100+ years of high density. DO NOT initiate high severity disturbance in the immediate vicinity of treasured older trees. Slowly shift the operating environment of the tree, both above and below ground, to a more favorable condition. Utilize stand level thinning (Hood et.al. 2017) rather than radial thinning whenever possible to accomplish density reduction objectives. **(Persist)**

City of Ashland "Alice Trail"- 1997

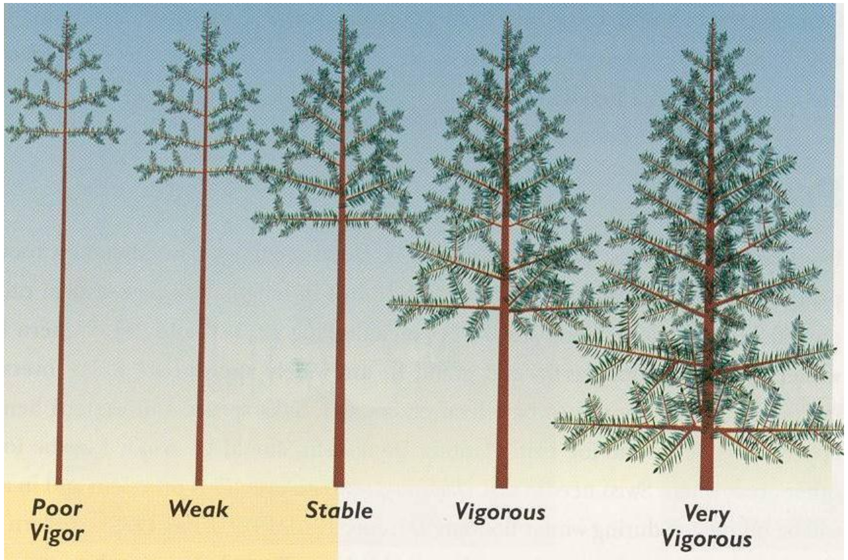
"Alice Trail"- post thinning/slash treatment 1998

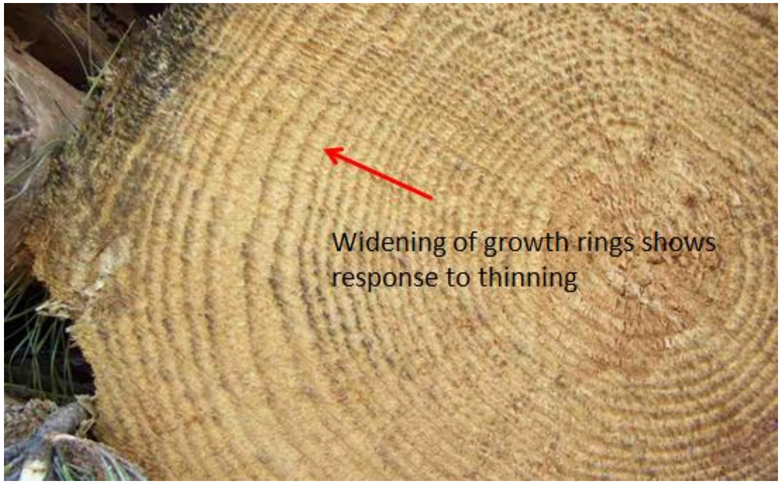
"Alice Trail"- 2015



Tree and Stand Vigor- How it is Determined in the Field

1. Stand Densities
2. Crown ratios
3. Radial Growths
4. Presence/Abundance of Insects, Diseases
5. Other visual characteristics





Conifer Crown Ratio Summary

Lower Watershed

Crown Class	Crown ratio by species						
	DF	PP	SP	IC	PM	BO	BLM
Dominant	39	44	36	48*	-	-	-
Codominant	32	33	65*	30	-	-	-
Intermediate	32	41	-	47	-	-	-
Overtopped	21	14	-	33	-	-	-
Remnant	46	45*	-	-	-	-	-
Open-Grown	49	39	-	25*	-	-	-
Total	34	39	42	40	25	28	18

Winburn

Crown Class	Crown ratio by species							
	DF	WF	PP	SP	IC	PY	PM	GC
Dominant	36	43	32	35*	33*	-	-	-
Codominant	31	38	28	33*	35*	-	-	-
Intermediate	31	36	18	-	50*	-	-	-
Overtopped	24	23	-	-	13	30	-	-
Remnant	41	-	30	39	39	-	-	-
Total**	33	31	31	38	28	30	26	32

* Less than 3 data points

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Radial Growth Summary

(values in tenths of inches)

Lower Watershed (All Crown Classes)

Species	5- and 10-yr Radial Growth By Crown Ratio					
	0-29%		30-39%		40%+	
	10yr	5yr	10yr	5yr	10yr	5yr
PSME	4	2	7	3	7	4
PIPO	4	3	6	3	8	4
PILA	-	-	5	2	7	4
CADE	4	2	7	4	10	4

Lower Watershed (Dominant, Codominant, Remnant, Open-Grown)

Species	5- and 10-yr Radial Growth By Crown Ratio					
	0-29%		30-39%		40%+	
	10yr	5yr	10yr	5yr	10yr	5yr
PSME	6	3	7	3	7	4
PIPO	7	4	6	3	8	4
PILA	-	-	5	2	7	4
CADE	4	2	6	3	12	5

Lower Watershed (Dominant, Codominant, Remnant, Open-Grown)

Species	5- and 10-yr Radial Growth By Crown Ratio									
	0-29%		30%		35%		40%		45%+	
	10yr	5yr	10yr	5yr	10yr	5yr	10yr	5yr	10yr	5yr
PSME	6	3	7	3	7	3	7	3	8	4
PIPO	7	4	7	3	6	3	6	3	8	4

Lower Watershed (All Crown Classes)

Species	5- and 10-yr Radial Growth By Crown Ratio											
	0-20%		25%		30%		35%		40%		45%+	
	10yr	5yr	10yr	5yr	10yr	5yr	10yr	5yr	10yr	5yr	10yr	5yr
PSME	4	2	5	3	7	3	7	3	7	3	7	4
PIPO	3	2	9	5	7	3	5	3	6	3	9	4

Winburn (All Crown Classes)

Species	5- and 10-yr Radial Growth By Crown Ratio											
	0-20%		25%		30%		35%		40%		45%+	
	10yr	5yr	10yr	5yr	10yr	5yr	10yr	5yr	10yr	5yr	10yr	5yr
PSME	3	2	4	2	7	3	8	4	6	3	8	4
PIPO	4	2	3	2	4	2	3	2	5	3	6	3
ABCO	2	1	3	2	4	2	6	3	7	3	10	5

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Crown Ratio and Radial Growth of Pines at Winburn

(values in tenths of inches)

Table 1: Average crown ratio and radial growth of ponderosa pine by diameter class - Winburn

DBH Class (Inches)	# of Trees	Crown Ratio	# of Trees	Radial Growth	
				10-yr	5-yr
0-17.9	7	21	4	5	3
18-29.9	17	32	9	4	2
30+	25	34	20	4	2
Total	49	31	33	4	2

Table 2: Average crown ratio and radial growth of sugar pine by diameter class - Winburn

DBH Class (Inches)	# of Trees	Crown Ratio	# of Trees	Radial Growth	
				10-yr	5-yr
0-17.9	1	35	1	7	4
18-29.9	1	30	1	6	3
30+	9	39	6	5	3
Total	11	38	8	5	3

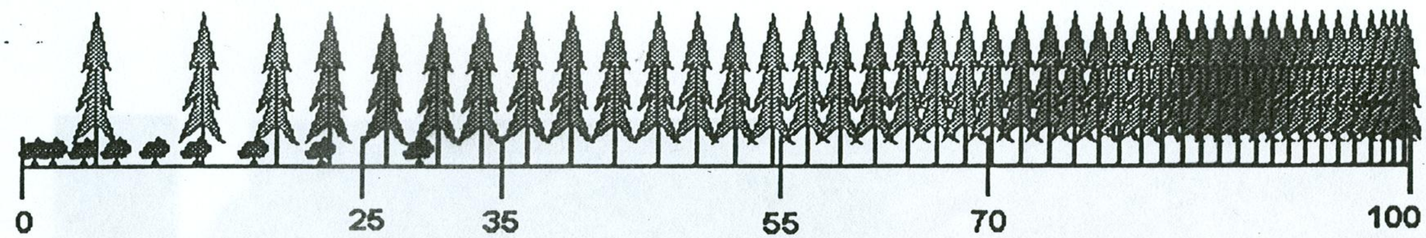
Table 3: Ponderosa and sugar pine crown ratio and radial growth comparison - Winburn

Species	# of Trees	Crown Ratio	# of Trees	Radial Growth	
				10-yr	5-yr
PIPO	49	31	33	4	2
PILA	11	38	8	5	3

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Figure 5

Stand Development and Density



RECRUITMENT — Individual tree growth maximized. Recruitment of new trees & shrubs onto forest floor.

EXCLUSION — New recruitment stops. Trees begin to compete.

Understory is suppressed. Competition increases between trees. Individual tree growth begins to slow.

COMPETITION — Tree competition slows individual tree growth. Stand growth maximized. Trees will be differentiating.

IMMINENT MORTALITY — Trees begin to die from competition. Intermediates become suppressed. Weaker Co-dominates fall to intermediate.

MAXIMUM DENSITY — Maximum stand density. All but dominate and strongest co-dominate have died or are near death. Replacement by more shade tolerant trees as mortality occurs.

Continue to use stand density indices to determine how dense stands actually are, the density desired for any individual stand and if treatment densities are ultimately meeting designed objectives

Table 6
Translation from quantitative whole tree and crown attributes to qualitative ranking.

RANK	WHL	BRDIA2	BRLN1	%MxNL1	CHL4	LF BI	LF A D	DMR
AA	6.7 (0.1)a	5.9 (0.1)b	15 (1)	90 (1)	8 (1)a	2.6 (0.1)a	0.8 (0.0)	0.3 (0.1)a
AVE	6.3 (0.1)b	6.3 (0.1)a	16 (1)	90 (1)	14 (1)b	2.4 (0.1)b	0.8 (0.1)	0.6 (0.1)b
LOW	6.0 (0.2)b	5.8 (0.2)b	15 (1)	89 (1)	19 (3)c	2.5 (0.1)a	1.0 (0.1)	0.8 (0.2)b

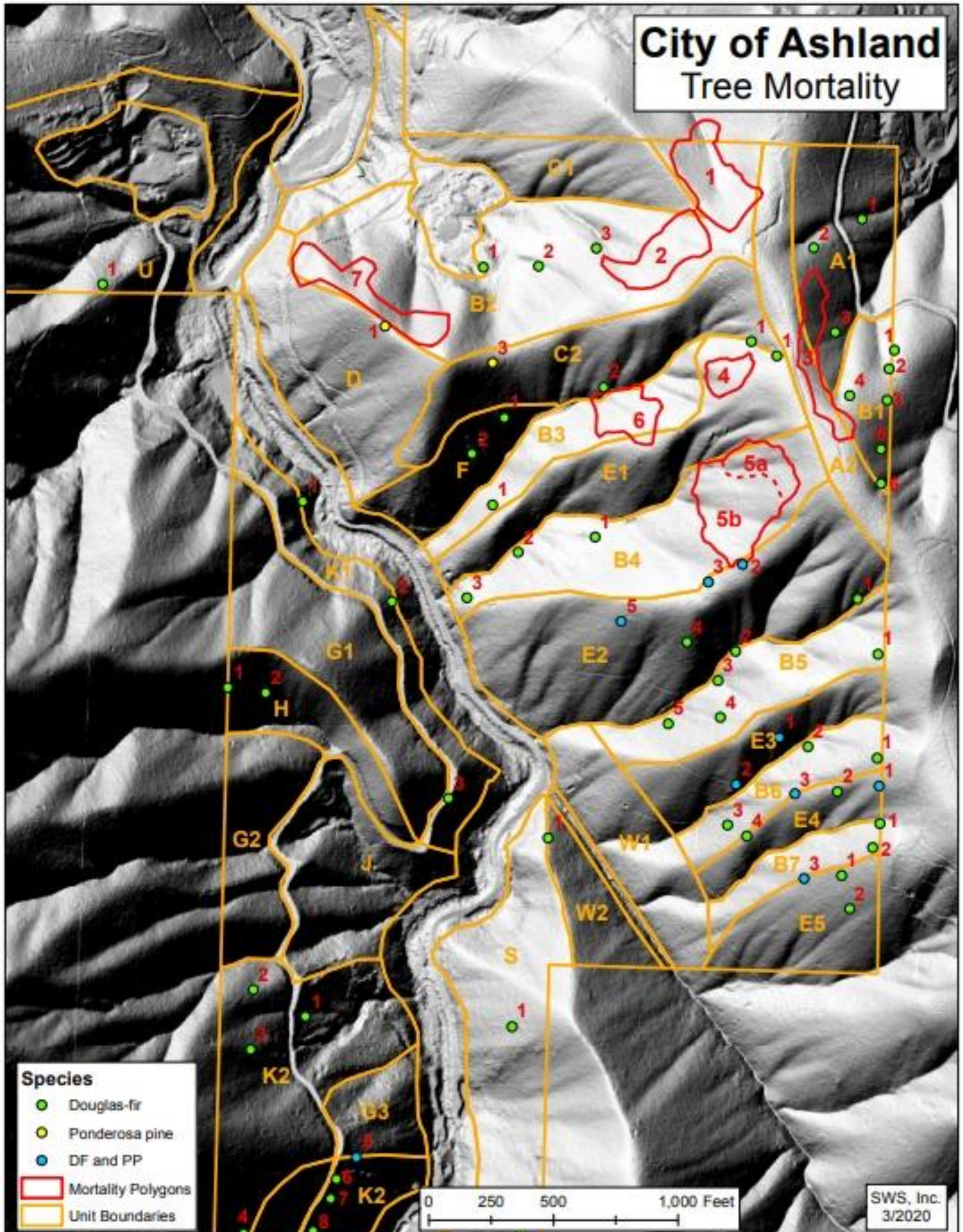
LOW VIGOR	**AVERAGE VIGOR**	**ABOVE-AVERAGE VIGOR**
CHLOROTIC NEEDLES	INTERMEDIATE	BRIGHT GREEN NEEDLES
LOW NEEDLE MASS	INTERMEDIATE	HIGH NEEDLE MASS
THINNER BRANCHLETS	GREATER BRANCHLET LENGTH	LITTLE BRANCH WOOD VISIBLE
EARLY NEEDLE SENESCENCE	INTERMEDIATE LEAF DEFOLIATORS	LOW DMR

Fig. 2. Examples of insect, disease, and abiotic (drought) damage on ponderosa pine needles. A) reduced needle elongation in years of low water availability; (B) needle chlorosis, an oxidative response to high radiation and/or low water availability; (C) early senescence of needles due to drought stress; (D) high frequency of phloem feeder, scale, needle tip dieback, and weevil damage.

Advances in Determining Tree Health and Vigor

"very important on-the-ground moving forward with increasing cumulative stress associated with climate change"

Source: Grulke et.al. 2020. Quantitative and qualitative approaches to assess tree vigor and stand health in dry pine forests



Microsite variations influence site conditions, soil moisture availability and tree/stand vigor.

Source: Main and Schmidt 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis

Table 7: Simple risk rating for Douglas-fir mortality in the lower City of Ashland ownership[1]

(Positive numbers indicate increased likelihood of mortality, lower numbers indicate decreased likelihood of mortality; Scale is from +2 to -2).

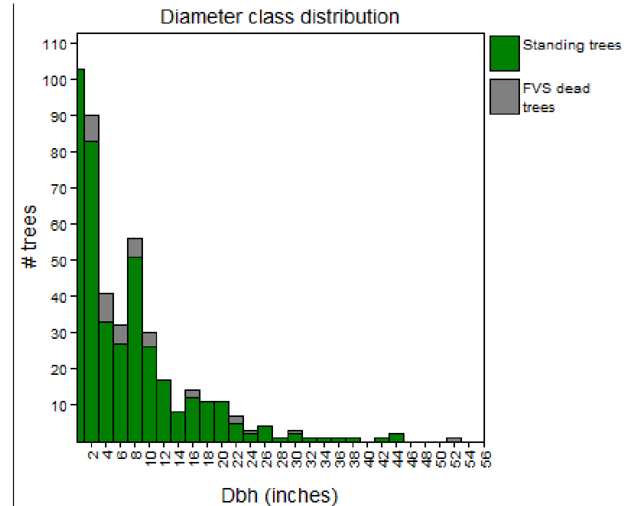
Variable	**Polygons[2]**						**Example Units**				
	1	**2**	**3**	**5[3]**	**6**	**7**	**K1[4]**	**N**	**P**	**Q**	**J[4]**
Elevation	+2	+2	+2	+1	+1	+2	+2	-2	-1	-1	+2
Topographical position	+2	+2	+2	+2	+1	+2	-2	0	0	0	-2
Aspect	-1	+1	-1	+1	+1	0	-2	-1	+1	-1	0
Stand edge/interior habitat	+2	-1	+2	+1	+2	+1	+1	-2	-1	-1	-1
Excessive stand density[5]	+2	+2	+2	+1	+2	+1	+1	+2	0	+1	-1
Total	**+7**	**+6**	**+7**	**+6**	**+7**	**+6**	**0**	**-3**	**-1**	**-2**	**-2**

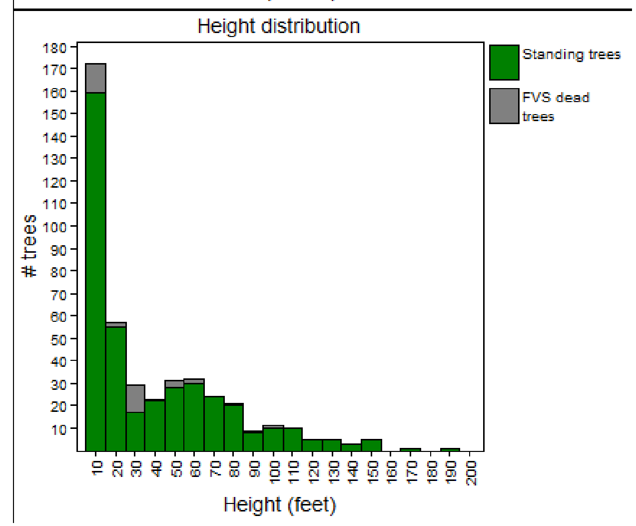
[1]This table is provided as a conceptual framework for assessment to help understand how multiple variables can be assessed to provide a rating for any individual site/stand. The variables should also probably be weighted in importance although a much more elaborate analysis (e.g.. multivariate analysis) would be needed to provide this type of information and is well outside the scope of this paper. The influence of each variable presented varies greatly between sites but all have various levels of relationships with moisture availability.
[2]Polygon 4 was excluded because it was in a portion of the prescribed underburn that had no Douglas-fir mortality.
[3]The 2018 prescribed burn was an additional influence on mortality in Polygon 5.
[4]Close proximity to riparian areas and more favorable microclimate conditions were another influence on the low levels of mortality in Units K1 and J.
[5]Generally in even-aged 80-120 year old stands with much reduced stand differentiation; in these situations, stand level dynamics seem to have greater influence (i.e. they tend to act as a single unit with reduced potential for individual tree release) and adjustments through thinning can be more problematic..

Source: Main and Schmidt 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis

Multi species, Multi-cohort Stand Management

Winburn Unit 1*



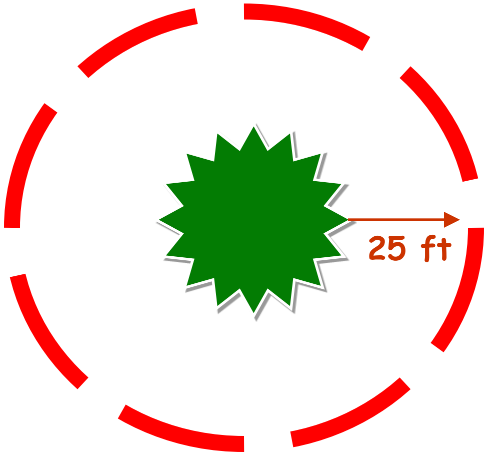


"Increased shading may benefit trees from climate change induced increases in Vapor Pressure Deficit"

* Includes plots where no thinning has occurred (i.e. skips)


Winburn Unit 1

Avoid aggressive radial thinning around stressed older conifers; do reduce densities in their vicinity, ideally in stand level thinning, and especially of smaller trees. Recognize the complex above and belowground functions that have been in place for 100+ years and adjust those conditions in stages. Complex below-ground systems appear to have both cooperative and competitive relationships.




Managing for an individual tree with a spacing guideline
rather than as a complex older forest system

Vegetation: Species Composition

Climate Change Key Vulnerabilities

Main Point- Individual species are responding to increases in temperature and longer summer season (more moisture stress). Vegetation communities will continue to shift over time, although it's not clear how fast they will shift. This may result in new opportunities for invasive plants and/or new species combinations and associations (e.g. ponderosa pine and/or Douglas-fir with a mixed component of Pacific madrone, etc).

1. **Vulnerability strongly dependent on type, frequency and severity of disturbance.**
2. **General loss of conifers.**
3. **Vegetation community shifts, alterations and reorganizations and potential losses of forestlands to other alternate states and community types.**
4. **Individual species effects**

Species Composition Changes Currently Evident

Overstory Douglas-fir; understory Pacific madrone

Overstory ponderosa pine; understory Douglas-fir

Species Composition Affected by Change in Disturbance Regime

Township 39 South, Range 1 East
(% basal area by species)

Date	PP	SP	DF	Oak,Madrone
1899	60	15	20	5
2003*		7	64	29
2003**		4	20	76

*plots in areas with one major wildfire, 1901/1910
**plots in areas with 2 major wildfires, 1901/10 + 1959

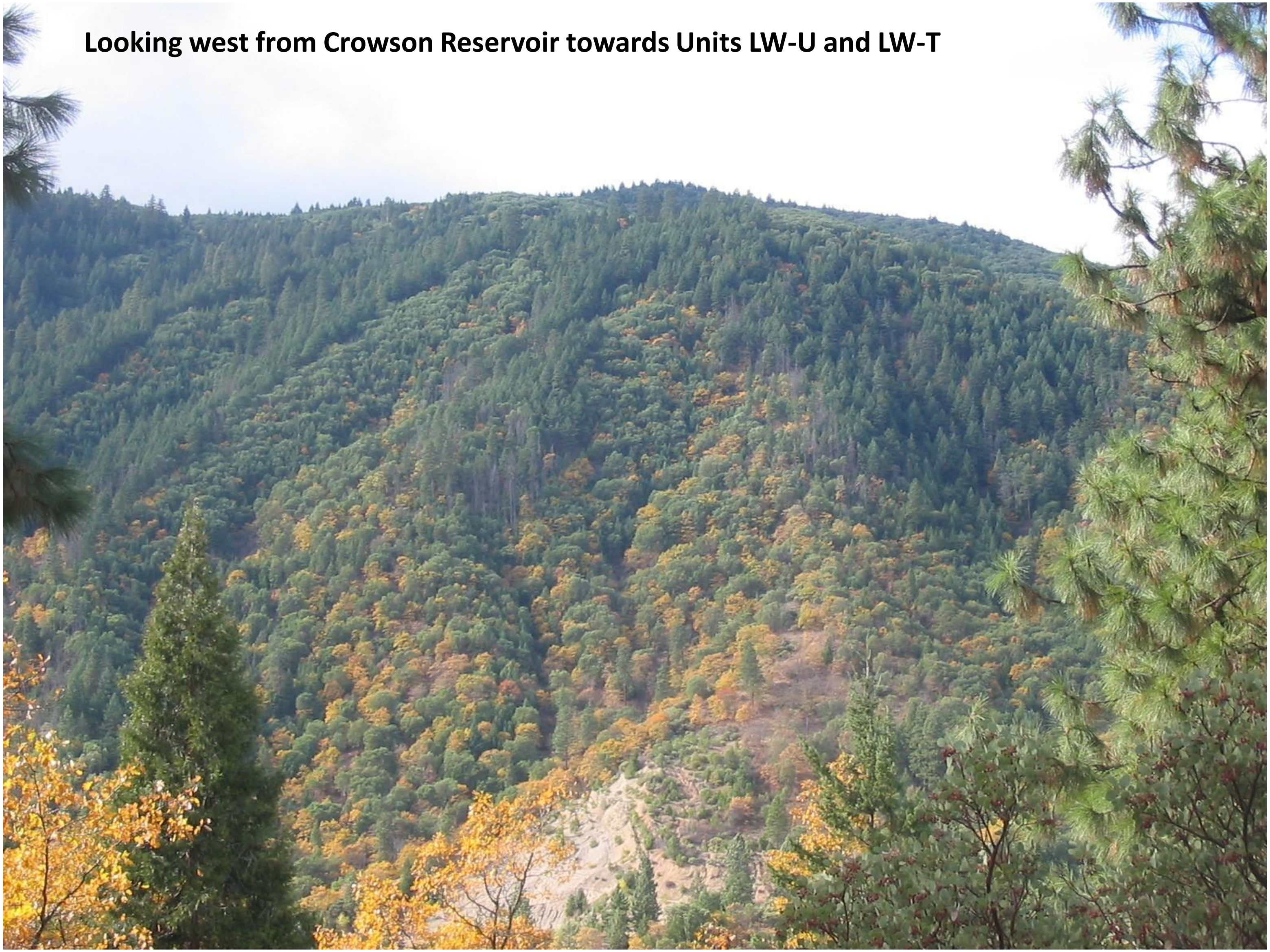
Plant Responses to Disturbance

(Rowe, 1981)

TYPE	DESCRIPTION	EXAMPLE	PREFERRED FIRE TYPE
Invaders	Highly dispersive, short-lived, pioneering	Fireweed, thistles, many grasses	High intensity
Evaders	Long-lived propagules stored in soil or canopy	Serotinous cones (canopy); whiteleaf manzanita, wedge-leaf ceanothus (soil)	High intensity
Avoiders	Shade tolerant, late successional species that slowly invade and have limited adaptation to fire	Hemlocks, western juniper, most true firs	Fire suppression
Resisters	Survive low intensity fires relatively unscathed	Douglas-fir, ponderosa pine	Low intensity
Endurers	Ability to resprout from root crown, lateral roots, or aerial crown	Oaks, Pacific madrone, various shrubs	High intensity

Major Point

Unless there is a successful shift away from high severity disturbance regimes, resisters will continue to decline while others, to a greater or lesser extent, will expand.


Looking west from Crowson Reservoir towards Units LW-U and LW-T

Loss of Conifers

LANDIS-II projected a 15 percent reduction in forest area (table 2), particularly in hotter, drier scenarios, with shifts occurring in the drier, interior portions of the assessment area (primarily in the southeastern portion), where fire return intervals are projected to decrease. Another LANDIS-II-based analysis concluded that a third of the 1899 Klamath region (northern California and southwest Oregon) could transition from conifer forest to shrub-hardwood-chaparral because of increased fire activity coupled with lower post-fire conifer establishment (Serra-Diaz et al. 2018). Drought stress inhibited forest regeneration on the driest sites in the region after fires over the last several decades, and the area potentially inhospitable to seedling establishment is likely to expand in the future (Tepley et al. 2017). Large, high-severity fire patches may further inhibit forest development and result in long-term shrub or hardwood dominance (Airey Lavaux et al. 2016, Donato et al. 2009a).

Source: Halofsky et.al 202x. Climate Change Vulnerability and Adaptation in Southwest Oregon

Increasing Shift from Conifers to Hardwoods

2017 COA Regeneration Survey

Conifer stocking (trees <4.5' tall)

Parcel	Trees per acre by species						
	DF	WF	PP	SP	IC	PY	Total
Lower Watershed	34	0	9	1	20	3	67
Winburn	160	277	11	8	147	55	658

Hardwood stocking (trees <4.5 tall)

Parcel	Trees per acre by species						
	PM		BO		GC		Total[3]
	Seedlings	Clumps	Seedlings	Clumps	Seedlings	Clumps	
Lower Watershed	235	96	7[1]	2[1]	0	0	340
Winburn	303	49	0	0	0	5[2]	357

1: BO was only found in 6 units - A1, E, F, G, K, and R.
2: GC was only found on one plot.
3: Totals are the sum of all seedlings and clumps.

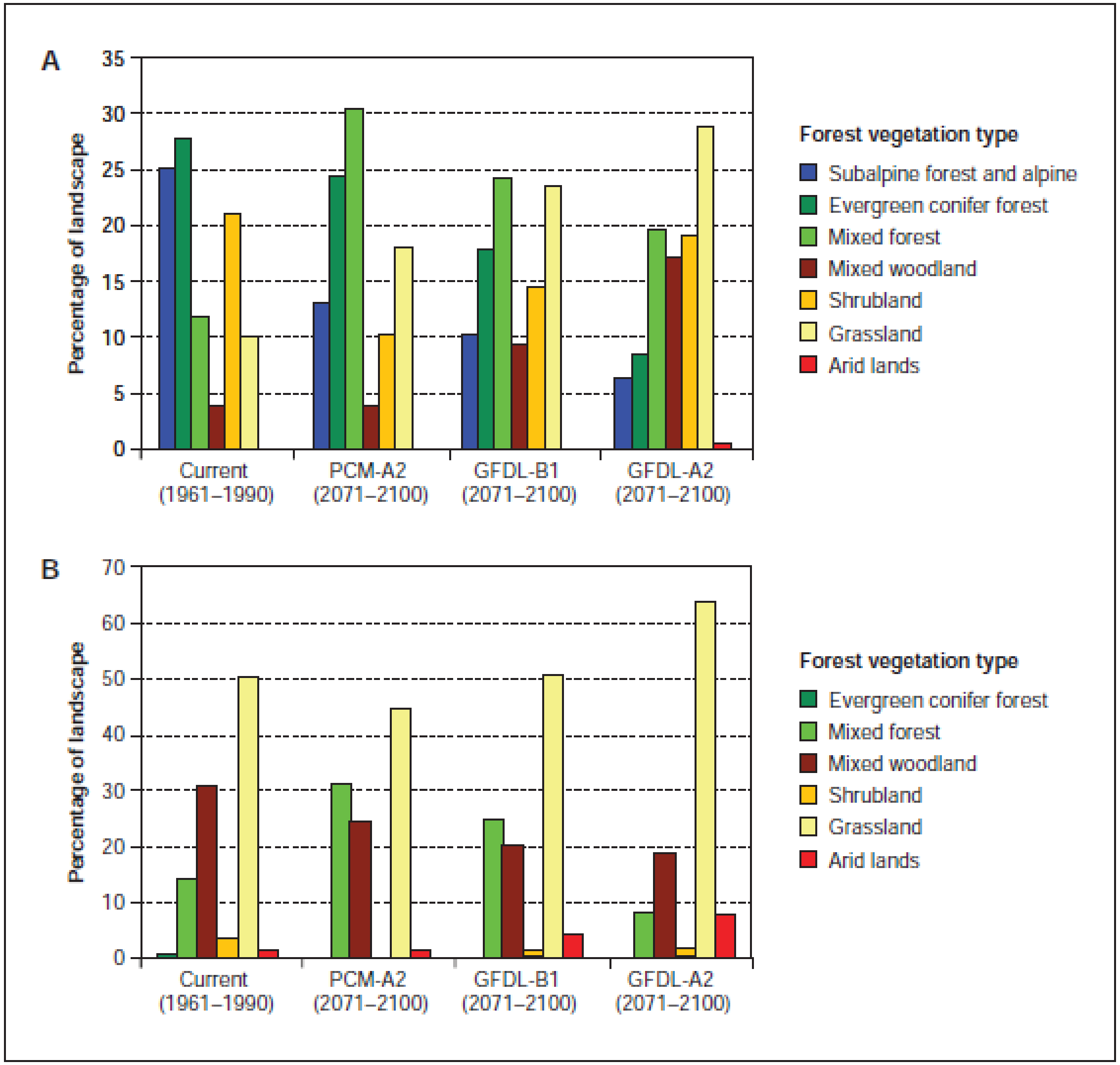
Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Shift to more xeric plant communities

- Mixed conifer/hardwood to oak woodland
- Montane forest to dry Douglas-fir
- Risk of regeneration failure after fire (mixed conifer to brush)
- Increase in chaparral
- Biggest changes at the ecotones between communities

Slide credit: Max Bennett

Model outputs for vegetation change in the Sierra Nevada (A) and Sierra Nevada Foothills (B)



Major Results

1. **Lower cover of shrublands due to increasing fire under most scenarios**
2. **Large increases in hardwood component of forests**
3. **Large increase in cover of grasslands**
4. **Drier scenarios project moderate expansion of arid lands**
5. **Conifer decreases in cover in all scenarios**
6. **Significant losses of alpine and subalpine vegetation**

Source: North ed. 2012. Managing Sierra Nevada forests

Expected trends for vegetation groups and dominant species within vegetation groups for southwest Oregon.[1]

Vegetation group	Current dominant species	LANDIS-II trends	Paleoecological literature	General trends expected
Dry forest	Douglas-fir	▲	▲	Dry forest may shift to woodlands or shrublands in the driest portions of the current range because of drought and increased fire frequency. Tree growth will likely be reduced. Tree mortality may also increase in some locations because of the interacting effects of drought, disturbance, and insects.
	Ponderosa pine	▲	▲	
	Incense cedar	▼	▲	
	Sugar pine	▲ ▼	▲	
	Oregon white oak	▲	▲	
	California black oak	▲	▲	
Woodlands	Oregon white oak	▲	▲	Expansion of woodland types is likely with hotter and drier conditions and increased fire frequency. However, effects of fire suppression and invasive species may limit the capacity of oak woodlands to adapt to changing climate and disturbance regimes.
	Douglas-fir	▲	▼	
	Ponderosa pine	▲	▲	
	Pacific madrone	▲	–	
	Incense cedar	▼	▲	
Shrublands		▲	▲	Shrublands will likely expand with increased fire and summer water deficit. Shrub species establish well in forests burned at high severity, and repeated fire could perpetuate shrublands because short intervals between severe fires and drought conditions do not allow for forest establishment.

[1] Upward (orange) arrows indicate expected increases in abundance, and downward (red) arrows indicate expected decreases in abundance. Trends were derived from LANDIS-II model output and paleoecological studies (pollen and charcoal records from lake sediments) for the Pacific Northwest and northern California. General trends are partly derived from MC2 output. (Halofsky 20xx (in press)

Source: Halofsky et.al 202x. Climate Change Vulnerability and Adaptation in Southwest Oregon

Species Comparison of Ecophysiological Traits

Species	Growth Rate	Nat. regen. potential	Heat Tolerance	Drought Tolerance	Shade Tolerance	Fire Tolerance	Expansion? Contract?
Douglas-fir	Fast	High	Mod-High	Moderate	Moderate	High	shift upward
Ponderosa Pine	Mod	Low-mod	High	High	Low	High	expand
Sugar Pine	Mod-Fast	Low	High	Mod-High	Moderate	Mod	unknown
Incense Cedar	Slow-Mod	High	Mod-High	Mod-High	High	High	expand
White Fir	Mod-Fast	High	Low-Mod	Low	High	Low	shift upward
Pacific madrone	Slow (seed); Fast (sprt)	Mod (seed) High(sprt)	High	High	Low-Mod	Low, but sprouts	expand
California black oak	Slow (seed); Mod (sprt)	Low (seed) High (sprt)	High	High	Low	Mod-High	expand
Oregon white oak	Slow (seed); Mod (sprt)	Low (seed) High (sprt)	High	Very High	Low	Mod-High	expand
Golden Chinquapin	Slow (seed); Mod (sprt)	Low (seed) Mod (sprt)	Low-Mod	Mod	Mod-High	Mod	Shift upward

Compiled from: Minore 1977, Niinemets and Valladeres 2006, Bennett 2121

Species Composition Adjustments with Climate Change- General Consensus

Lower Watershed

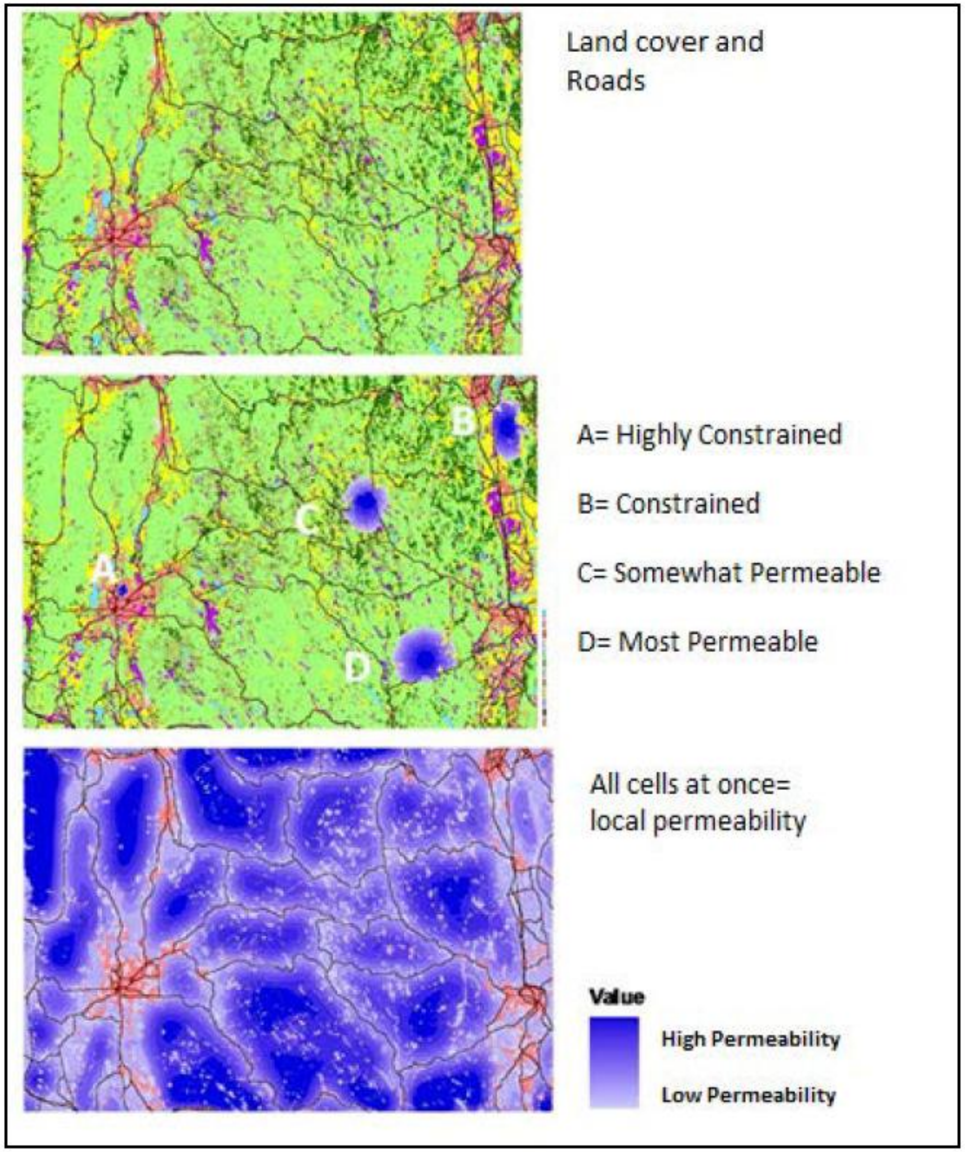
- Ponderosa pine increases
- Pacific madrone increases dramatically
- Oak woodlands, shrubs expand upward in elevation
- Douglas-fir decreases

Winburn

- White fir, golden chinquapin reduced considerably
- Pacific madrone increases dramatically
- California black oak, ponderosa pine increase

Other

- Type, frequency and severity of disturbance can strongly influence results
- Incense cedar, sugar pine not clearly determined but may increase in abundance (especially incense cedar)
- Invasive plants increase
- Ongoing monitoring essential



Local Permeability

The degree to which regional landscapes, encompassing a variety of natural, semi-natural and developed land cover types, will sustain ecological processes and are conducive to the movement of many types of organisms

Source: Buttrick et.al. 2015. Conserving Natures Stage: Identifying Resilient Terrestrial Landscapes in the Pacific Northwest


ASHLAND WATERSHED
The steep environmental gradient in this cooler north trending watershed with diverse plant communities results in a more permeable landscape that may facilitate species movements that will be necessary with climate change
Image © 2010 Jackson County GIS
Image USDA Farm Service Agency
Image © 2010 DigitalGlobe
© 2007 Google

Vegetation: Species Composition

Adaptation Options for Management

Main Point- Restore more appropriate species mixes and vegetation communities that are 1) adapted to more frequent, low severity disturbance regimes 2) are relevant given expected climate change.

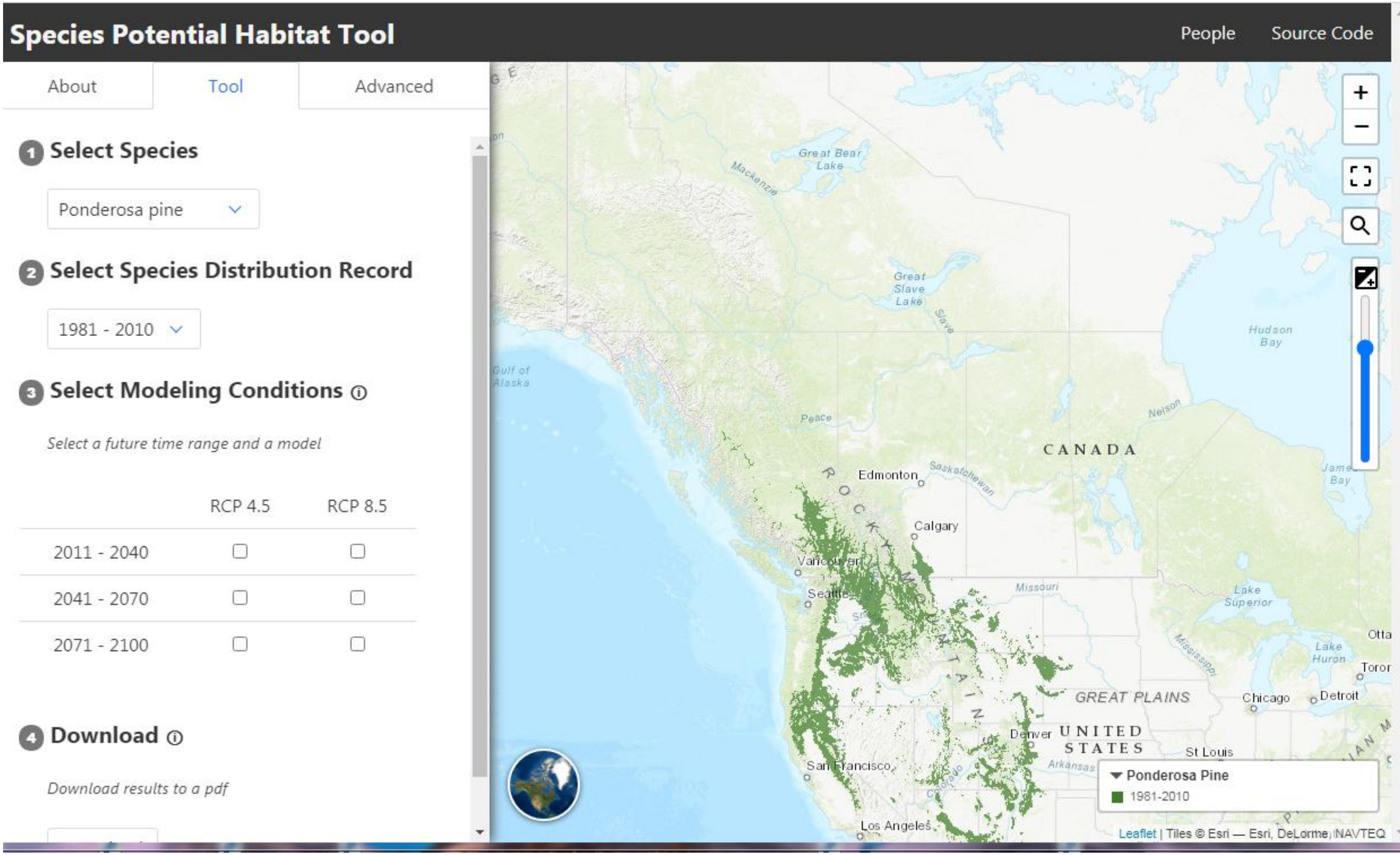
1. Plant communities are likely to move upward in elevation with changes in climate. Continue to plant trees that are more resistant to impacts from temperature increases and decreases in moisture availability (pines, oaks). Consider planting trees from lower elevation seed sources or plant communities up into the next elevation band. Consider planting more drought tolerant species and genotypes from nearby locations. **(Persist, Change)**

2. Encourage more opportunities for shade intolerant species, either natural or planted, through creation of openings, canopy gaps and generally more open forests. If natural regeneration of conifers is desired, there must be an established seed source in close proximity. **(Persist, Change)**

3. Protect and enhance older PP, SP, DF, oaks. **(Persist, as long as possible)**. Accelerate development of older trees of these species **(Persist)**

4. Implement species and stand management strategies based on individual species characteristics and likelihood to be able to adapt to climate changes **(Persist, Change)**

5. Monitor for and manage invasive species of all types, most notably understory vegetation and unusual organisms such as non-native insects and diseases (e.g. the cautionary tale of white pine blister rust). **(Persist, but expand monitoring and management)**


Species Potential Habitat Tool
People
Source Code
About
Tool
Advanced
1 Select Species
Ponderosa pine
2 Select Species Distribution Record
1981 - 2010
3 Select Modeling Conditions
Select a future time range and a model
RCP 4.5
RCP 8.5
2011 - 2040
2041 - 2070
2071 - 2100
4 Download
Download results to a pdf
Great Bear Lake
Mackenzie
Great Slave Lake
Slave
Hudson Bay
Gulf of Alaska
Peace
Nelson
CANADA
James Bay
Edmonton
Saskatchewan
ROCKY MOUNTAINS
Calgary
Vancouver
Seattle
Missouri
Lake Superior
Lake Huron
Mississippi
Toror
Detroit
Chicago
GREAT PLAINS
Denver
UNITED STATES
St Louis
Arkansas
San Francisco
Colorado
Los Angeles
Ponderosa Pine
1981-2010
Leaflet | Tiles © Esri — Esri, DeLorme, NAVTEQ

City of Ashland, Unit LW-D

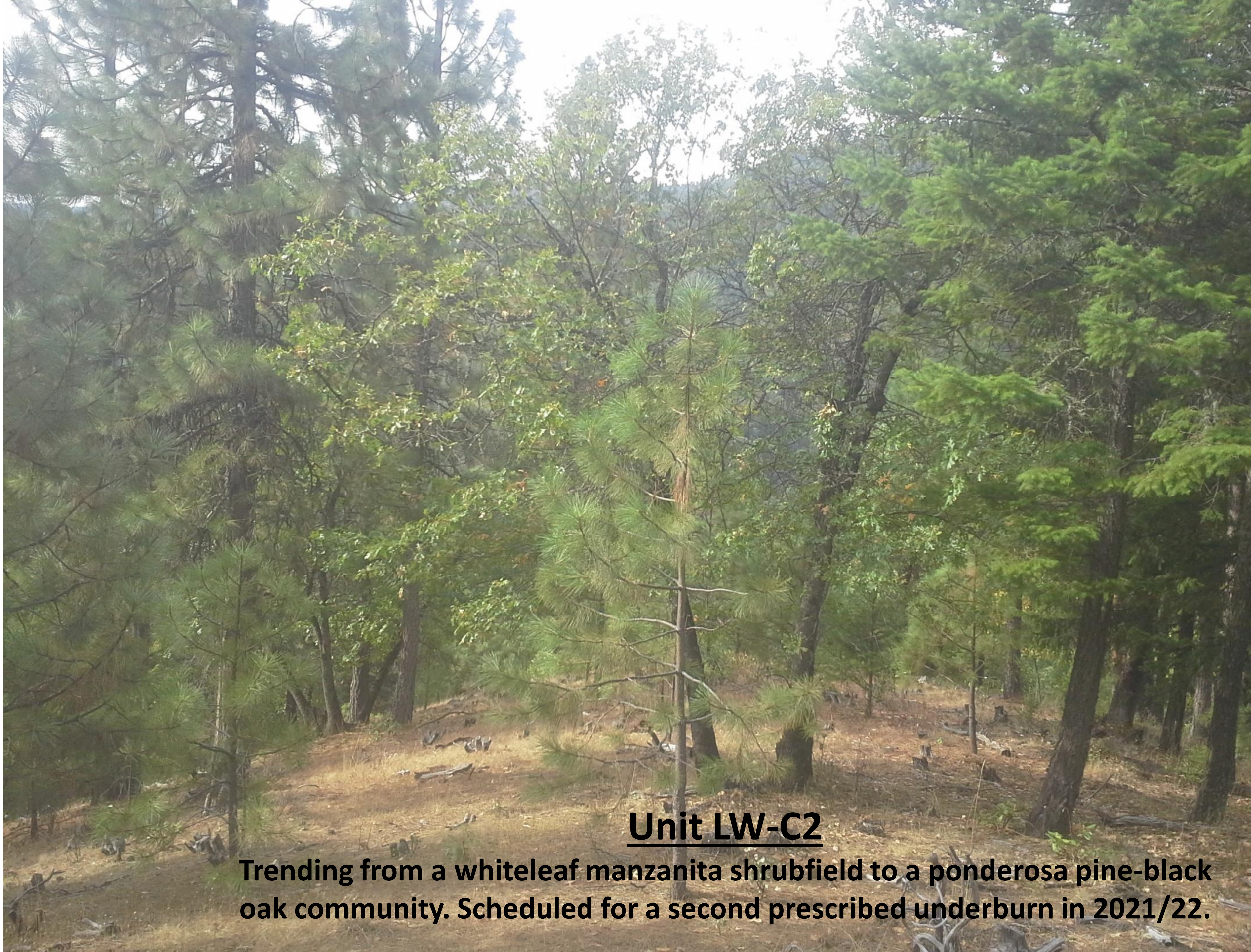
More open forest as a result of extensive Douglas-fir mortality in 1995-96/ 2001-3 and associated ongoing management

Ponderosa Pine

- Ponderosa pine is fire, drought and heat resistant.
- Ponderosa pine is shade intolerant and has declined in abundance in dense forests that have occurred without more frequent disturbance.
- It currently is located primarily on southeasterly to northwesterly aspects, and noticeably on more ridgeline topographic positions.
- It is a key species on lower elevation dry sites, intermixed with oaks, as well as in the Dry Douglas-fir (Lower Watershed) and Mixed conifer (Winburn) vegetation communities.
- Likely to expand its range with climate change.
- Ponderosa pine currently has a skewed age class distribution. Older larger individuals are threatened throughout the ownership while younger age classes are largely missing in the dense forests. The 2017 inventory showed only 9 tpa < 4.5’ tall in the lower Watershed parcel and 11 tpa at Winburn. However, recent walk-through inventories at Winburn indicated considerable recent ponderosa pine seedling establishment in the more open forests of Unit 1 that resulted following the commercial and non-commercial treatments in 2013.
- It appears that opening forest conditions at Winburn may allow natural regeneration of ponderosa pine to develop. On the Lower Watershed parcel, continued planting will likely be necessary to increase abundance of this species; overstory cone-bearing trees are limited in most places and seed crops are not common.
- Ponderosa pine are threatened by aggressive bark beetles of 4 major species, particularly if trees are of poor vigor from cumulative stress factors. Overstory trees can also be stressed by prescribed fire in these long unburned systems; raking bark mounds prior to fire is important to prevent cambial heating. All older pines at Winburn have been raked.

California black oak

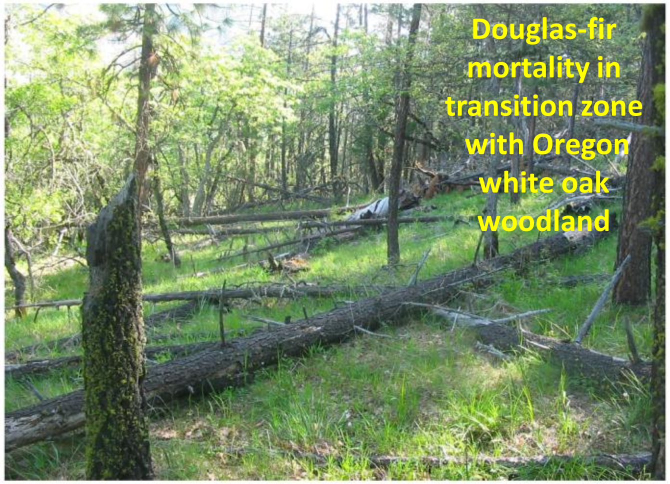
- Black oak is likely to expand its range with climate change, with a good combination of heat, fire and drought tolerance.
- It is currently of rare occurrence on both the lower watershed and Winburn parcels, both within stands and as a seedling or small sapling. It is, however, an important part of tree species composition throughout the City ownership except on the driest sites at lower elevation parcels in the City limits.
- Black oak rarely is found at larger sizes (e.g. 20"+ dbh) in the Ashland watershed. The reasons for this are unknown as it grows more commonly and to much larger sizes elsewhere in southern Oregon
- Stand management to date has consistently tried to promote Black oak through thinning that provides more light and space.
- Black oak tends to be relatively slow growing and easily overtopped by conifers and/or outcompeted by the more ubiquitous Pacific madrone unless continued management favors its development. It is more resistant to damage from low to moderate severity fire and can thrive in more frequent, low severity disturbance regimes.
- It may be appropriate to experiment with planting black oak in more open forest conditions throughout the City ownership.
- Black oak and ponderosa pine often do quite well on the same sites, and a Ponderosa pine/Black oak community should be encouraged whenever possible.
- Black oak is an excellent wildlife tree and is critically important in the life history of the Pacific Fisher, for both resting and nesting/rearing habitat in large cavities, which occur with more regularity in black oak than in any other species.



Unit LW-C2

Trending from a whiteleaf manzanita shrubfield to a ponderosa pine-black oak community. Scheduled for a second prescribed underburn in 2021/22.

Oregon white oak



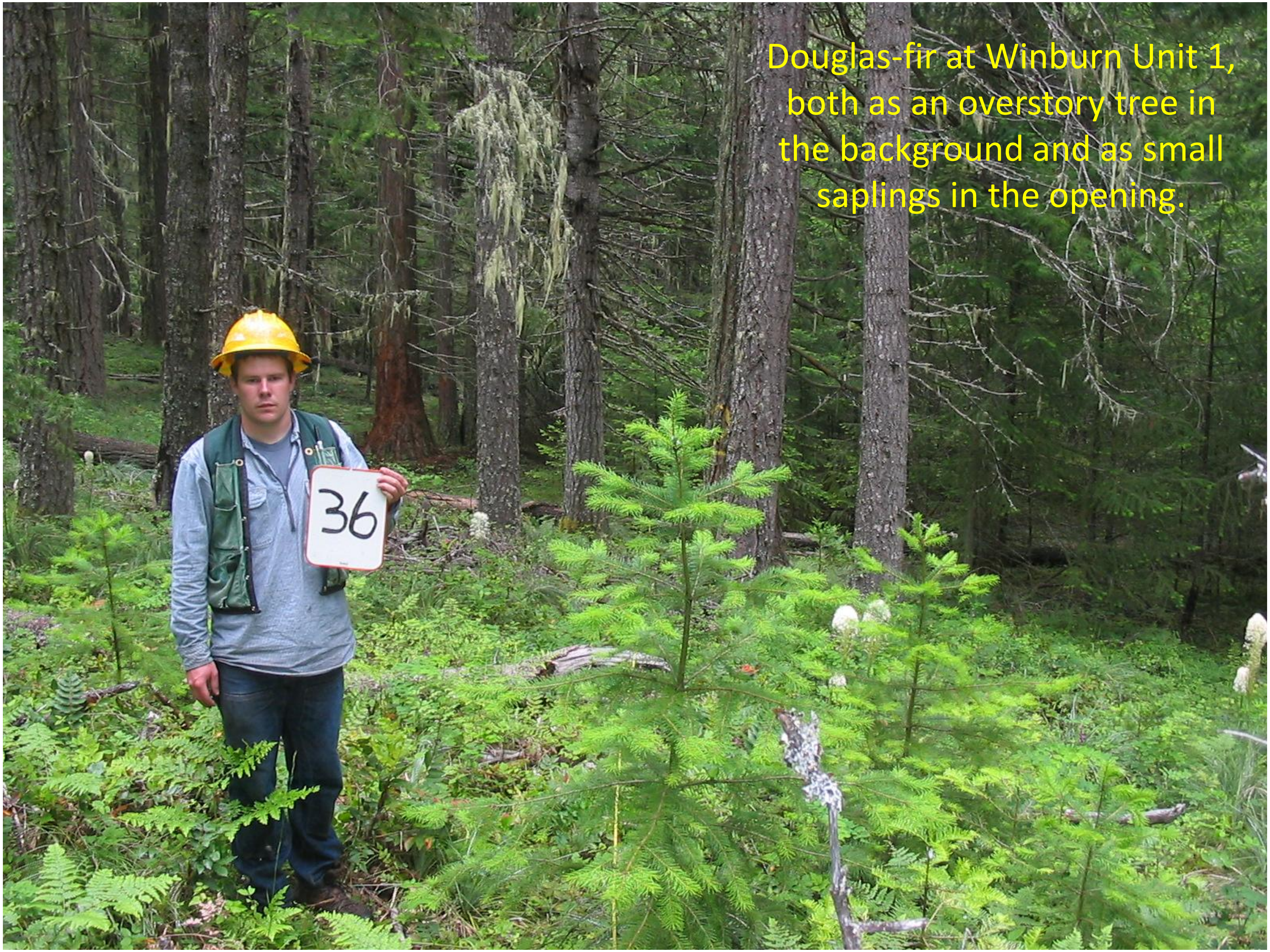
- Not common on the City ownership; only occurs at the lowest elevations in the City limits.
- More commonly associated with very hot dry sites on very moisture-limiting non- granitic soil types with high amounts of clay. In these sites, it can be the only tree species that can survive, often to advanced ages.
- Oregon white oak woodlands are declining in abundance throughout the west.
- Oregon white oak woodlands are excellent wildlife and pollinator habitat.
- Although they generally are of low site productivity and associated amounts of biomass/fuels, fire hazard can be significant in this fuel type with rapid rates-of-spread of fire, particularly with a dry grass/herb understory and occasional shrubs in an oak chaparral community.
- Oregon white oak has the best drought and heat tolerance of any tree species and is expected to expand its range with climate change, although it is unknown how it will interact with decomposed granitic soil types.
- Extensive mortality of Douglas-fir has occurred anywhere in the Ashland interface where Oregon white oak is common.

Sugar Pine

- Sugar pine is rare on the City ownership although it is occasionally found on both the Lower Watershed and Winburn parcels.
- Sugar pine grows to great stature and age in the Ashland watershed.
- Sugar pine has decreased dramatically throughout its range in the western United States due to 1) susceptibility to a non-native disease introduced in the 1920's- white pine blister rust (Cronartium ribicola); 2) preferential harvesting; 3) fire exclusion, high stand densities and associated vigor decline; 4) susceptibility to the mountain pine bark beetle (Dendroctonus ponderosae).
- Sugar Pine is rare as an overstory tree and thus has a limited opportunity to provide for natural regeneration. The City has prioritized planting of rust-resistant sugar pine seedlings throughout its ownership, particularly after prescribed underburning.
- Although quite rare in the mid-canopy layers, any sugar pine regardless of size has been prioritized for retention and promotion during stand management activities on the City ownership.
- Sugar pine is rated from moderate to high in heat, drought, fire and shade tolerance. With this wide amplitude, it may be able to continue its presence with climate change if it is carefully managed and promoted. Planting of rust-resistant seedlings will be essential in the re-establishment of this species in a warmer drier environment.

Douglas-fir

- Douglas-fir has been incorrectly described as a weed by some. On the contrary, the species is uniquely well-selected for a wide variety of sites and stand conditions in southern Oregon that has allowed it to expand onto sites, and in stand conditions, in which it was not suited for longevity- and hence significant stand decline and mortality in spotsd including on City lands and in the Ashland interface.
- Douglas-fir is a good species for adaptation with climate change, given its wide amplitude and favorable ecophysiological traits (see Table "Species Comparison of Ecophysiological Traits") in which only Douglas-fir is rated moderate or better in all categories).
- Management response should definitely be site specific and gradational in character for Douglas-fir moving forward with climate change. Microsite-level changes are extremely important in its viability (Main and Schmidt 2020), especially on the Lower Watershed parcel.
- Larger Douglas-fir are particularly unaffected by prescribed and/or low severity fire and benefit from the post-fire increased availability of site resources, including water. Frequent, low severity disturbance is important for long-term viability of this species on the City ownership.
- Douglas-fir is well suited to perhaps even expand its abundance on the Winburn parcel, particularly if less dense forests can be encouraged through active management, replacing white fir as the most common understory and shade tolerant species in a warmer, drier future climate. It is expected that the range of Douglas-fir will continue to shrink on the lower Watershed parcel, especially in the lower half and elsewhere on City parcels in the Interface. Even on dry sites, however, Douglas-fir can grow to large and mature conditions, although not in the dense stands that have occurred in the absence of disturbance.
- Percentage mortality of large Douglas-fir are greater than any other species in the Ashland watershed, in large part due to high densities and the frequency and severity of infection from the pathogen Douglas-fir dwarfmistletoe (Arcuethobium douglasii), which has likely increased in abundance with fire exclusion. Spatially explicit management of Douglas-fir dwarfmistletoe at Winburn is critically important to continue to provide for its important habitat value for northern spotted owls. Accelerated development of larger Douglas-fir to replace those already lost, and that will continue with future warming and drying, is critically important for protection and promotion of spotted owls.
- Douglas-fir naturally regenerates well and likely will rarely need to be planted; in many places in the lower Watershed, continued removal of younger Douglas-fir should be ongoing, through thinning and/or prescribed fire, in order to improve the long-term survival and growth of species more well-adapted to warmer and drier climates on these sites, such as the pines and oaks.
- Employ stand management practices that reduce the abundance of Douglas-fir on lower elevation dry sites in the Lower Watershed parcel prior to major insect-related mortality in outbreak conditions. The accumulation of fuels that result in these situations are outside historical norms for these sites, can be an extreme fire hazard and are very expensive to treat.


Douglas-fir at Winburn Unit 1,
both as an overstory tree in
the background and as small
saplings in the opening.
36

White Fir

- **Only occurs on the Winburn parcel on the City ownership**
- **Was a small part of the historic species composition, with only white fir currently comprising only 4.5% of the trees greater than 20” dbh. However, it currently comprises 42% of the trees up to 4.5’tall (2017 inventory data). It is clear that white fir has become more abundant on the Winburn parcel with a change in fire regimes. It is shade tolerant and thrives in denser forests. It is not well selected for long-term survival with climate change at this elevation, however, similar to Douglas-fir in the lowest elevations of the City ownership.**
- **Recent increased decline and mortality of white fir has occurred in the last several years across most size classes. The fir engraver, *Scolytus ventralis,* increases as a mortality agent particularly in droughty times and damage and decline is likely to become even more prevalent with climate change.**
- **Management given projected changes in climate change suggests reducing the abundance of white fir and encouraging growth of other species more well-selected for survival and growth with warmer and drier climates. Appropriate removals of this species should improve fuel discontinuity and potentials for reduced fire severity.**

Three older white fir, including one on the right in the background that has recently died

Incense Cedar

• Incense cedar is not common on the City ownership and has mostly become established after the change in disturbance regime with the significant reduction in frequent low to moderate severity fire and the resulting denser forests. It's shade tolerance has allowed its expansion and increased abundance.

• Incense cedar is an extremely adaptable conifer, rated moderate/high to high in all ecophysiological traits except growth rate (see table "Species Comparison of Ecophysiological Traits"). It is well–adapted to survive in both high moisture and low moisture conditions and high light and low light conditions; is insect, disease and heat resistant; and is well adapted to survive fire. This tendency for high adaptability suggests it is well suited to be able to thrive in a wide range of potential and changing conditions that will likely occur with climate change in the future.

•Incense cedar naturally regenerates well and seedlings can survive in dense shade, giving it a competitive edge in the dense forests that have developed over the past 100+ years. Incense cedar over 100+ years of age are rare throughout the City ownership.

Pacific madrone

- Pacific madrone has greatly increased in abundance throughout its range with the change in disturbance regimes towards more infrequent high severity types.
- Pacific madrone aggressively uses site water and can significantly compete with all other tree species. It rapidly responds to thinning and opening of forests, and can easily outcompete other species intended for establishment/release.
- It supports a rich a diverse mycorrhizal community, can also improve soil properties and can be an important element of resilience in new and developing vegetation communities.
- Pacific madrone grows slowly from seed and had (has) a difficult time gaining establishment in frequent low to moderate severity fire regimes. However, once established, its prolific sprouting from the root crown below soil surface allows it to quickly dominate sites after disturbance. It is the most abundant tree <4.5' tall on the Lower watershed parcel by far, comprising over 80% of this size class by species.
- Pacific madrone historically has been rare at elevations above 3500-4000', although it appears to already be expanding upward with climate change- a process that is likely to continue on the Winburn parcel.
- Pacific madone is particularly valuable for soil holding potential in steep landslide-prone terrain, as its roots remain in place fully functioning even after severe disturbance.
- Pacific madrone is expected to continue its dramatic expansion with climate change, likely becoming the most common tree species in the dry Douglas-fir forests on the City ownership, replacing conifers and impacting and adjusting associated ecosystem services *unless active management provides other opportunities*.
- The above-ground tree portion of Pacific madrone is more vulnerable to the effects of low severity fire than perhaps any tree species on the Lower Watershed parcel, although it quickly re-sprouts.
- Pacific madrone is a good wildlife tree , particularly the berries which serve as an important food source. It is also believed that wildlife have been a particularly important vector in the spread of Pacific madrone.
- Forests with a high percentage of Pacific madrone are thought to be "no-analog" stands, having been rare if not non-existent in the past. Understanding how these stands, and this species, may develop in the future is uncertain, except that it is highly likely that it will become much more prominent , affecting stand development, stand structures, species compositions and functional processes in the future, with or without climate change.
- Alternative management strategies for Pacific madrone have been in place on City lands for the past 20 years, and should continue and be closely monitoredin an adaptive management framework.


Old growth conifers being
outcompeted from below
by Pacific madrone

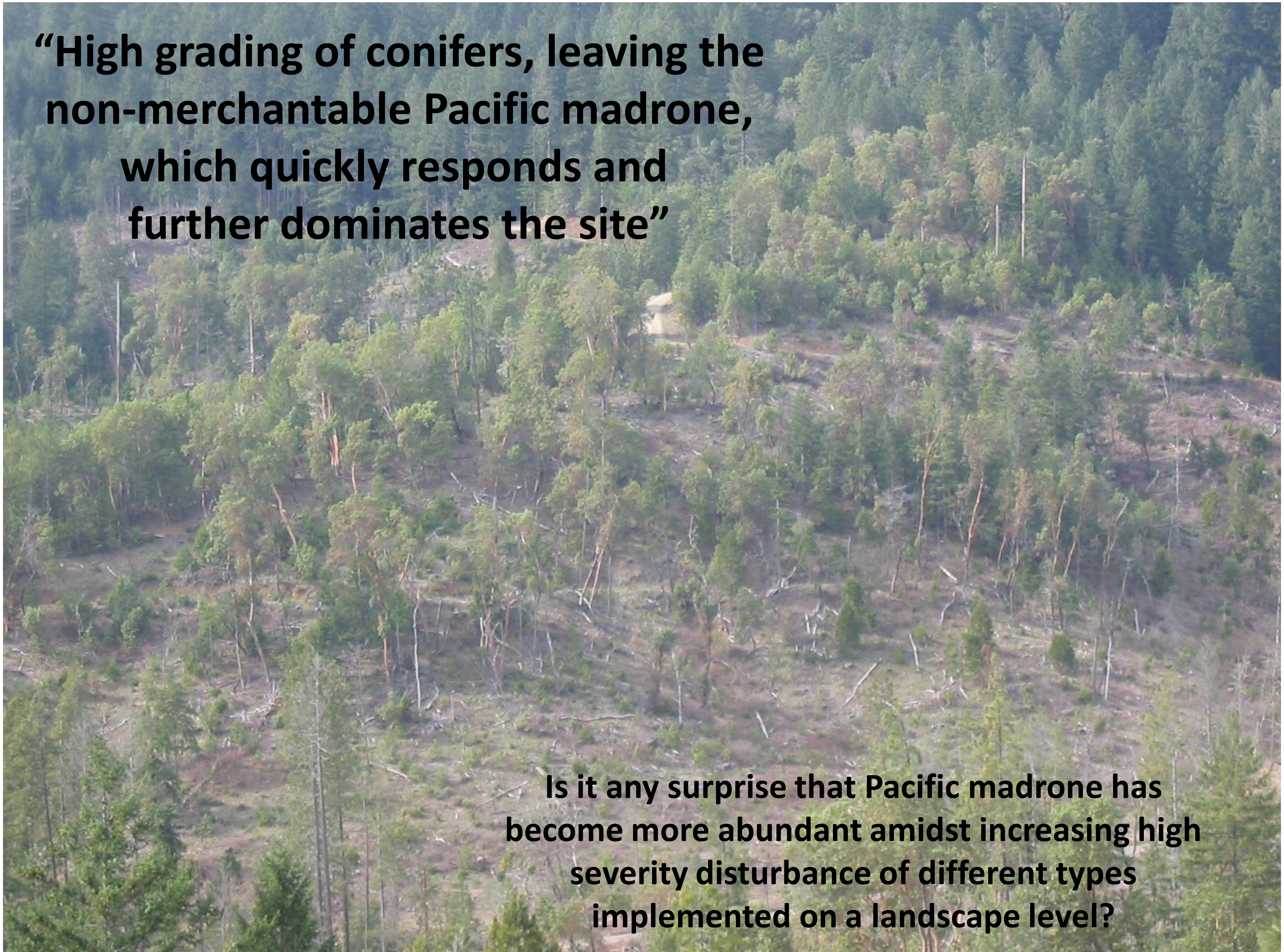

"High grading of conifers, leaving the
non-merchantable Pacific madrone,
which quickly responds and
further dominates the site"
Is it any surprise that Pacific madrone has
become more abundant amidst increasing high
severity disturbance of different types
implemented on a landscape level?

Table 5: Unit E2- Post-fire Tree Mortality

Species	DBH	Trees	Tree Mortality (1/2014)	Tree Mortality (%, 2014)	Addl. Mortality (7/2015)	Total Tree Mortality (%, 4/13- 7/15)
DF	0-10"	12	3	25.0	0	25.0
	10"+	14	0	0	1	7.1
	Total	26	3	11.5	1	15.3
PP	0-10"	17	0	0	0	0
	10"+	11	0	0	0	0
	Total	28	0	0	0	0
SP	0-10"	1	1	100.0	0	100.0
	10"+	5	0	0	0	0
	Total	6	1	16.7	0	16.7
PM	0-10"	5	2	40.0	0	40.0
	10"+	9	3	33.3	2	55.6
	Total	14	5	35.7	2	50.0
BO	0-10"	11	1	9.1	2	27.3
	10"+	5	0	0	0	0
	Total	16	1	6.2	2	18.7
All	0-10"	46	7	15.2	2	19.6
	10"+	44	3	6.8	3	13.6
	Total	90	10	11.1	5	16.7
All conifers	0-10"	30	4	13.3	0	13.3
	10"+	30	0	0	1	3.3
	Total	60	4	6.7	1	8.3

City of Ashland Management of Pacific Madrone as a Climate Adaptation Strategy

1. **Conversion of madrone dominated stands (initiated after 1959 wildfire) to mixed hardwood/conifer through small openings creation and planting conifers. Initiated 2000+/-; non-commercial thinning, piling, burning in last 5 years (Units LW-G2, U).**

2. **Similar to 1. and implemented in the same era, but in refugia location in lower third topographic location close to Ashland Creek. Thinned to co-manage existing larger Pacific madrone and Douglas-fir initiated after 1959 wildfire (Unit LW-G3).**

3. **Gradational site and stand conditions from ridge at top down to close to Ashland Creek with dramatically different site productivities and associated levels of mortality. Multiple thinning strategies over time to reflect different site/stand conditions; extensive Douglas-fir mortality in upper half with significant fuel accumulation and associated repeat planting of pines. Recent slashing of Pacific madrone sprouts, piling of fuels in this area close to homes (Unit LW-B2).**

4. **Coppice treatment for long term management of Pacific madrone; with or without prescribed underburning, which, based on monitoring data, is the tree species most affected by low severity fire (although it does resprout vigorously).**

5. **Pacific madrone management in dense stands (1959 initiated) using various thin/no thin strategies on oversteepened sites prone to failure.**

6. **Others?**

Note: Silvicultural strategies 1, 2 and 3 have been implemented with a history of up to 20+ years; Strategies 4 and 5 (and 6?) being considered for implementation in the near future in an adaptive management framework.

Epstein Property, 2021

31 year old planted ponderosa pine co-managed with Pacific madrone


Thinning, piling and burning of
pure stands of Pacific madrone
by Lomakatsi

Eco-Stimpy Hardwood Thinning, Frank Betlejewski, 1993-98

Monitoring Results

52% increase in average diameter in 80 thinned madrone sprouts versus average diameter in 129 unthinned madrone sprouts.

46% increase in average diameter in 25 thinned black oak sprouts compared to average diameter in 45 unthinned black oak sprouts.

Shrubs

- In most of the City forestlands, shrubs are not well-established in the dense forests that have developed in the absence of disturbance. Small to moderate amounts of more shade tolerant shrubs have been inventoried and monitored throughout the ownership on permanent plots. Although changes have undoubtedly occurred over time and with changes in management and climate, these analyses of the data have not yet been done.
- Main (2006) found a strong post-treatment response of understory vegetation following thinning treatments in the Lower Watershed parcel while associated leave conifers failed to respond or even declined in growth. On sites of lower productivity in the lower half of the Lower Watershed, it was theorized that low vigor Douglas-fir in dense stands may not release as well post-treatment as associated understory shrubs, grasses and herbaceous vegetation.
- Increased openings in canopies, such as suggested in future stand management throughout the City ownership, can create light and site conditions that can encourage development of native shrubs.
- Native shrubs have important values for pollinator and wildlife species and add to overall vegetational diversity.
- Shrubs can also significantly increase fire behavior, especially the more flammable species such as whiteleaf manazanita and wedgeleaf ceanothus that have the highest spotting potential of any vegetational community. Unfortunately, these tend to be located at the lowest elevations close to the city where fire danger is an extreme concern. Although these shrubfields may be natural occurrences on the historic landscape and may have been alternative native vegetational states maintained by frequent fire (Odion et.al 2010), they can also be significant hazards and a threat to the urban and semi-urban landscape in a fire event.
- The City should implement spatially explicit management of shrubs and retain a diversity of species and vegetation communities in places that are less strategically important from a fire management perspective. In the interim (i.e. until a mire fire resilient landscape can be developed), continued retention of small patches within the highly fire-prone environment can be retained in a minimal amount.
- Drought and heat tolerant shrubs in general, and schlerophyllous shrubs in particular, are well-suited to expand their range and abundance with increasing drought and temperature from climate change in the future.


Crowson Reservoir Unit, 1998
Manzanita cut, piled and burned,
skips of manzanita retained;
native grasses planted
“a closer approximation of the historic Ponderosa pine/native grassland community that was once more common in southern Oregon, and is a vast improvement from a fire management perspective”

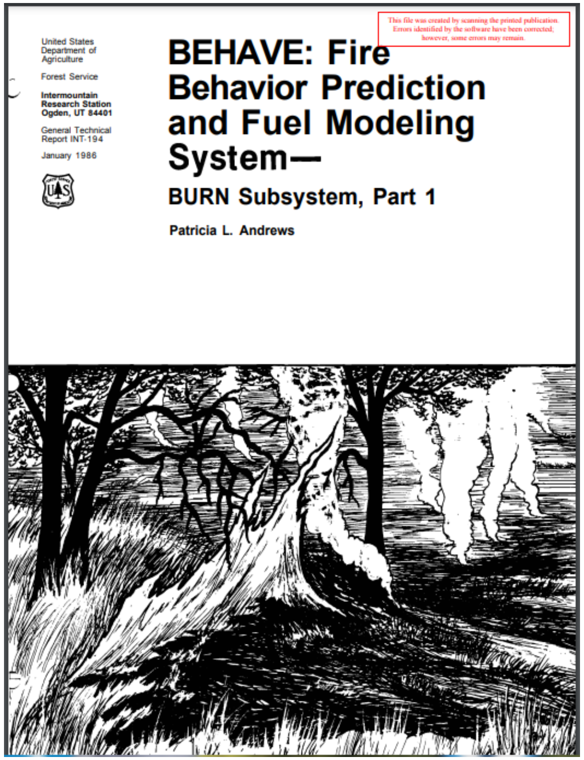
Epstein Property

Burned in high severity fires 1901,1973: shrubfield of whiteleaf manzanita partially treated in 1989 to create fire management opportunities; ponderosa pine planted 1989; pine plantation thinned, piled and burned 2020

"Trying to, over time:
1) reduce the potential and/or size of another high severity fire;
2) restore pines;
3) create more structural and species diversity;
4) maintain a reduced likelihood of erosion/landslides."

Predicting Fire Behavior using:

1) Fuel Models
2) Predictive Fire Behavior Models



United States Department of Agriculture
Forest Service
Intermountain Research Station
Ogden, UT 84401
General Technical Report INT-194
January 1986

BEHAVE: Fire Behavior Prediction and Fuel Modeling System—
BURN Subsystem, Part 1

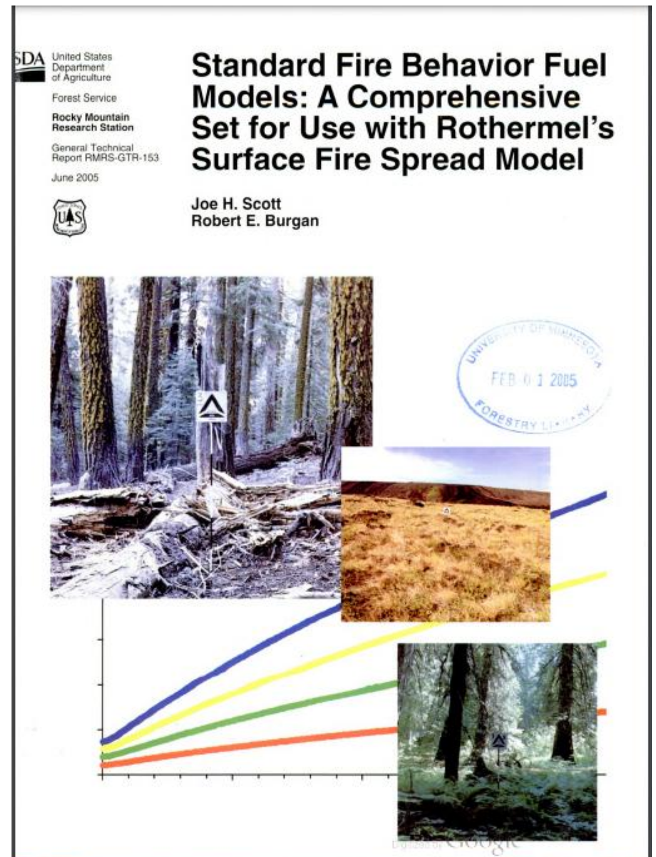
Patricia L. Andrews

SH7 (147)

Very High Load, Dry Climate Shrub

Description: The primary carrier of fire in SH7 is woody shrubs and shrub litter. Very heavy shrub load, depth 4 to 6 feet. Spread rate lower than SH7, but flame length similar. Spread rate is high; flame length very high.

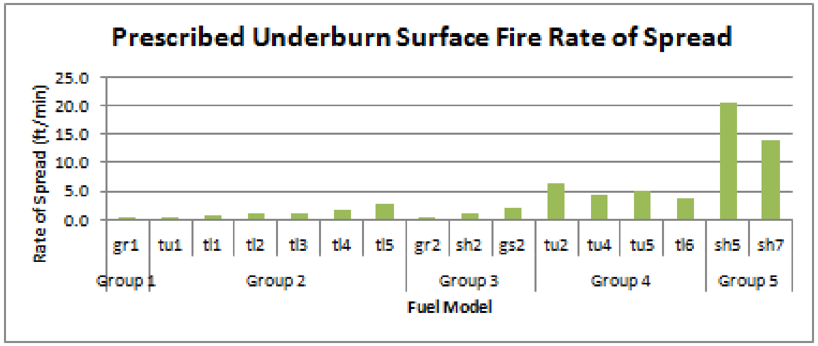
Fine fuel load (t/ac) 6.9

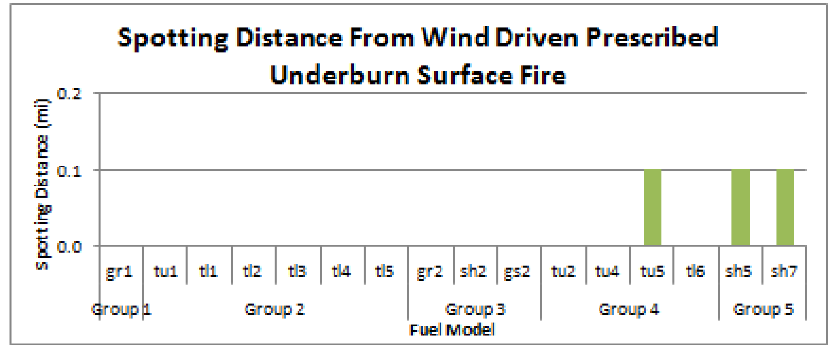

USDA United States Department of Agriculture
Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-153
June 2005

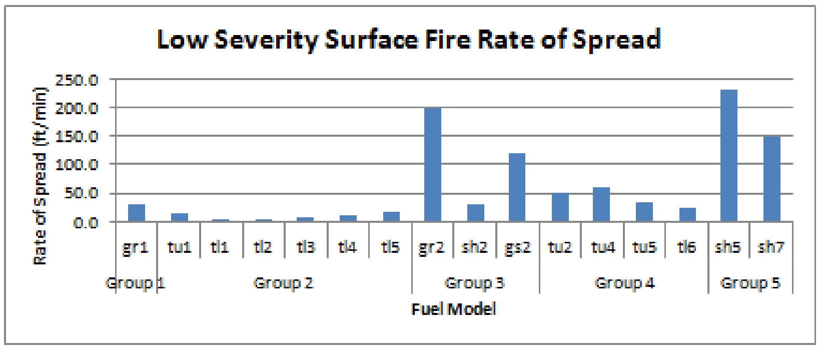
Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model

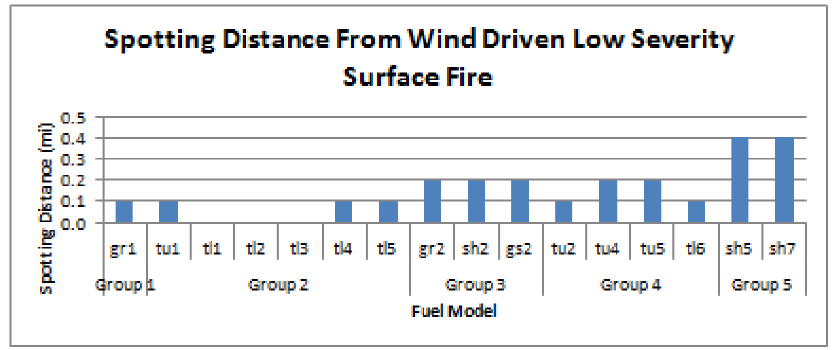
Joe H. Scott
Robert E. Burgan

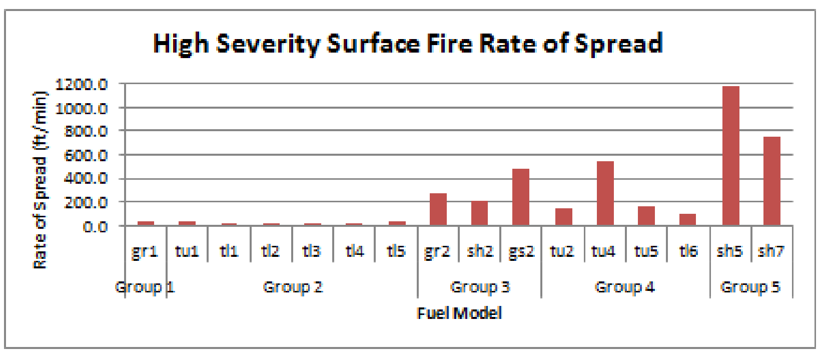
Predicted Fire Behavior for Various Fuel Types, City of Ashland

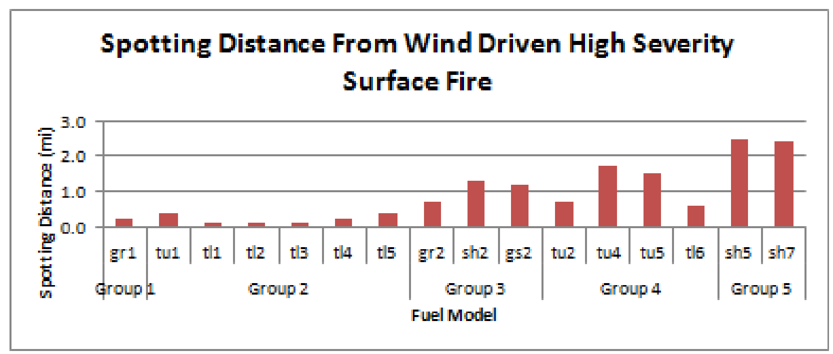













28
E

Grasses, herbacous vegetation and invasive species

- **Invasives are highly diverse, with unique life histories, virulence and potential management strategies.**
- **The City has been actively monitoring understory vegetation and undesirable non-native invasive species throughout its ownership continually in the past 25+ years, both in permanent plots and in the course of ongoing management.**
- **Management direction has included not only eradication of existing populations, but also prioritizing trying to limit spread of invasives any further into the Ashland watershed and/or onto City of Ashland forestlands.**
- **The greatest likelihood for invasive establishment exists in the lowest part of the City ownership that is intermixed in the urban and semi-urban environment where there is high human (and pet) use. Invasives can be easily spread by those vectors, especially in areas that get high amount of public use.**
- **With potential increases in disturbance of all types with climate change, a significant opportunity exists for rapid expansion of non-native invasive species of all types- in this case, various plant species.**

Layer 1 Groundcover Vegetation- 2018 Inventory

Lower Watershed

Unit	# of Plots	% Cover
A1	3	86
B	14	81
C	5	74
D	2	97
E	9	63
F	2	104
G	15	67
H	4	75
J	6	106
K	13	98
L	6	48
M1	4	53
M2	3	59
N	8	68
P	11	28
Q	6	48
R	5	68
S	6	89
W1	3	88
W2	4	107
Total[1]	129	72
S/SW Aspects[1]	35	59

1: Weighted by unit acreages

Winburn

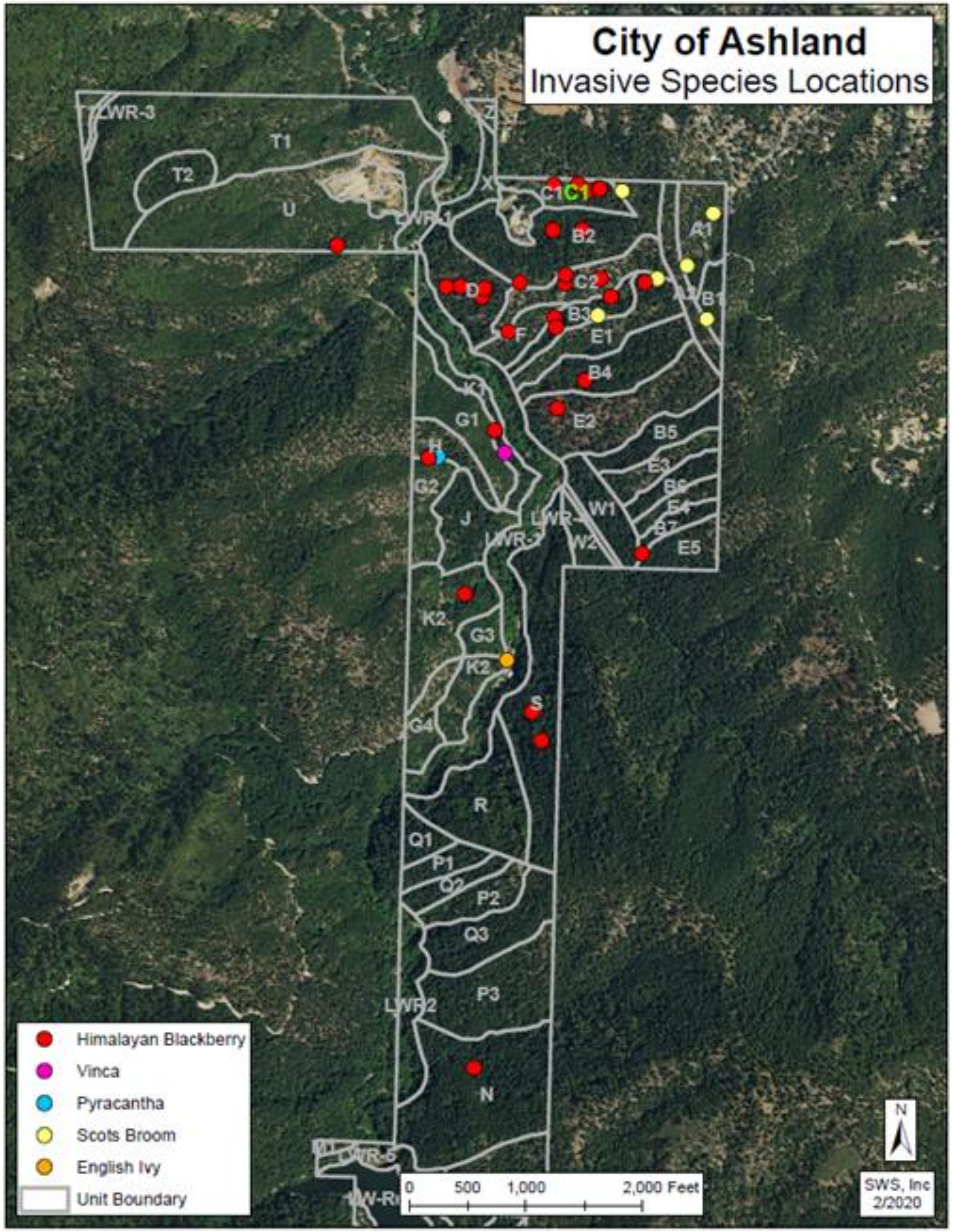
Unit	# of Plots	% Cover
1	33	45
2	9	93
3	8	141
4	3	96
5	10	66
6	6	126
Total[1]	69	75

Important Points

1. Lower Watershed and Winburn have similar % cover in the layer 1 vegetation.
2. Southerly/southwesterly aspects tend to have less layer 1 vegetation.
3. Species composition varies with the different sites and can be good indicators of site potential
4. Layer 1 understory vegetation has been increasing- 26% on the Lower Watershed and 11% at Winburn during the last 10 year inventory period. This is in part due to stand density reduction and availability of site resources post-treatment. The better site productivity at Winburn allows most trees to assimilate resources faster than in most of the Lower Watershed and higher levels of understory vegetation can be retained without deleterious affects on trees. This difference in effect is most noticeable during drought events.

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Map 3



City of Ashland Invasive Species Management

1. **Clustered in lower portion of City ownership with an ongoing strategy of preventing expansion upward into the Ashland Watershed.**
2. **Each invasive species requires a specialized management plan; most often manual removal.**
3. **Invasives are most often unknowingly spread by people, pets, cars, bikes and wildlife primarily on roads, trails, disturbed areas and stream corridors.**
4. **Regular monitoring occurs both in permanent plots and in the course of ongoing management.**
5. **Climate change will likely (perhaps dramatically) increase the potential for invasive establishment, including new association of species that migrate from elsewhere.**

Slide Source: Main and Schmidt 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis


We have vastly changed the type, frequency, severity and scale of disturbance!
Invasive Grasses
1) Recognize and communicate that invasive grasses can be high impact species in forest ecosystems and take early action to mitigate and monitor such invasions.
2) Develop treatment options based on individual species biology, ecology and invasion drivers
3) Map and monitor invasive grass populations.
4) Identify potential tradeoffs of management actions and integrate overstory, woody fuel, fire, and weed management approaches.
(Kerns et.al 2020. Invasive grasses: A new perfect storm for forested ecosystems?)

Vegetation: Stand Structures and Structural States

Climate Change Key Vulnerabilities

Main Point: Vegetation structures tend to be homogenous on both a stand and landscape level thereby increasing potential for high severity fire and decreasing the inherent variability that characterizes our region.

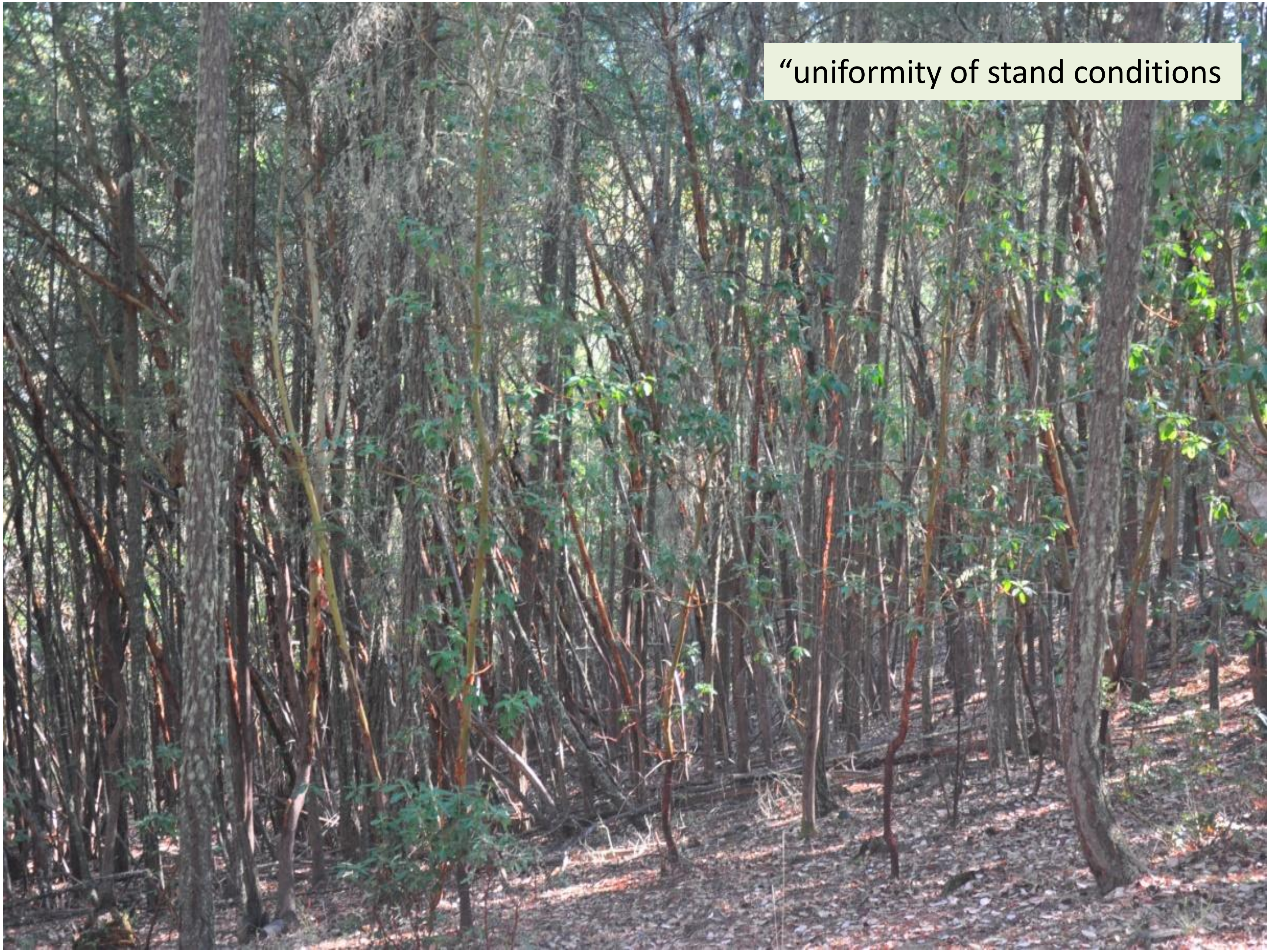
1.Structural homogeneity on both a stand and landscape level creates the following vulnerabilities:

- Fire- Fuel continuity and increased likelihood of large scale, high severity fire and further simplification of structural variability
- High stand densities elevate the potential for additional fire, insect and/or disease related mortality
- Species composition- Consistent stand structures and canopies reduce the potential for shade intolerant species;
- Wildlife- Important habitat values reduced
- Water- Potentially less water yield and changes in seasonality
- Biodiversity- Homogenous stand structures have reduced inherent biodiversity values

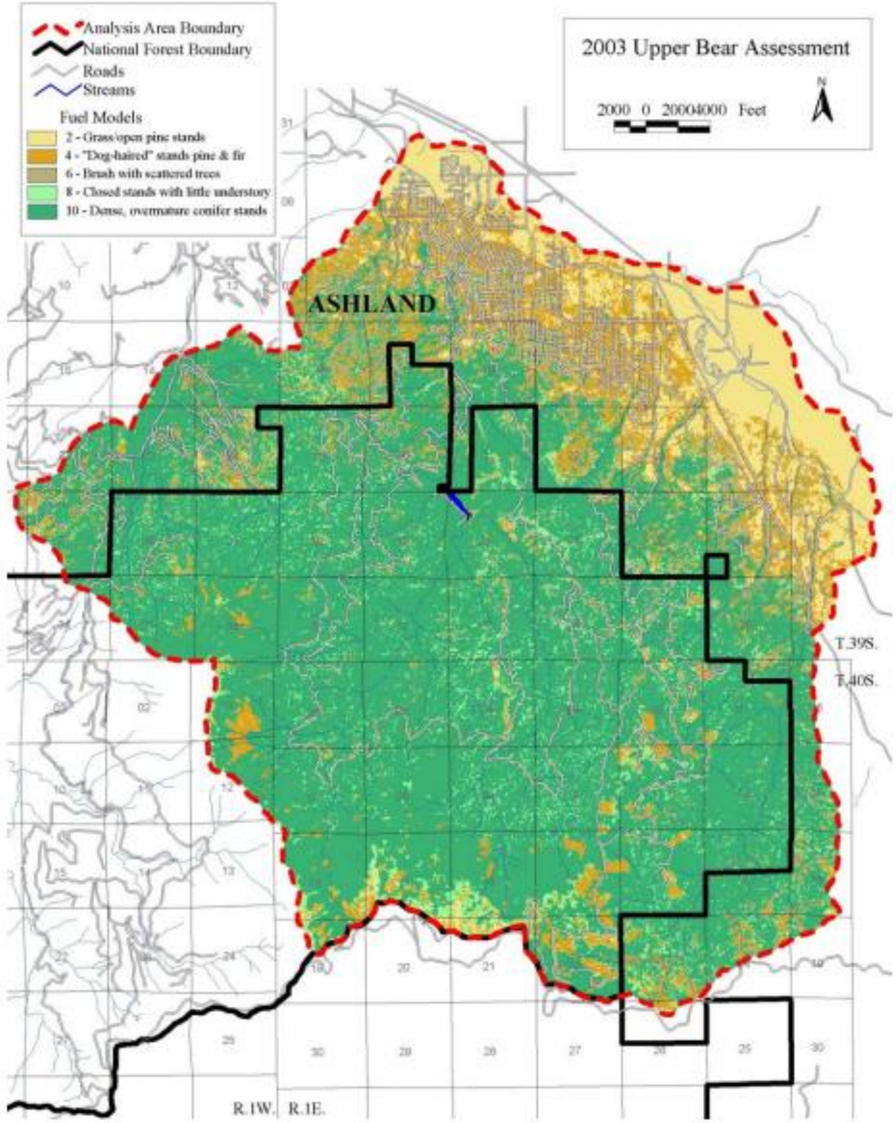
2. Unbalanced representation of structural states, with several underrepresented- 1) early successional 2) more open, mid seral 3) more open, late seral,

3. Older forests structures are threatened, primarily at Winburn.

A greater percentage of more open forests with less fuel continuity is desired for the Ashland watershed


“uniformity of stand conditions

MAP 3-5. Fuel Model Map



The USDA Forest Service uses the most current and complete data available. Existing resource data and locations are approximate. Geographic Information Systems (GIS) data and product accuracy may vary. Using GIS products for purposes other than those for which they were intended may yield inaccurate or misleading results.

Continuous homogenous vegetation in the Ashland watershed


Ecosystem and Stand Heterogeneity

Unit	Canopy Cover (%)
A1	58
B2	62
B3	69
B4	71
B5	85
B6	66
B7	54
C1	42
C2	43
D	44
E1	63
E2	28
E3	66
E5	76
F	72
G1	90
G2	77
G3	91
H	58
J	81
K1	88
K2	81
L	84
M1	73
M2	87
N	88
P1	75
P2	70
P3	78
Q2	76
Q3	88
R	86
S	84
W1	82
W2	86
Total*	73

City of Ashland Lower Watershed

Canopy Cover (%)

<u>39 total subunits</u>

7 subunits < 60% canopy cover

4 subunits < 50% canopy cover

1 unit < 40% canopy cover

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

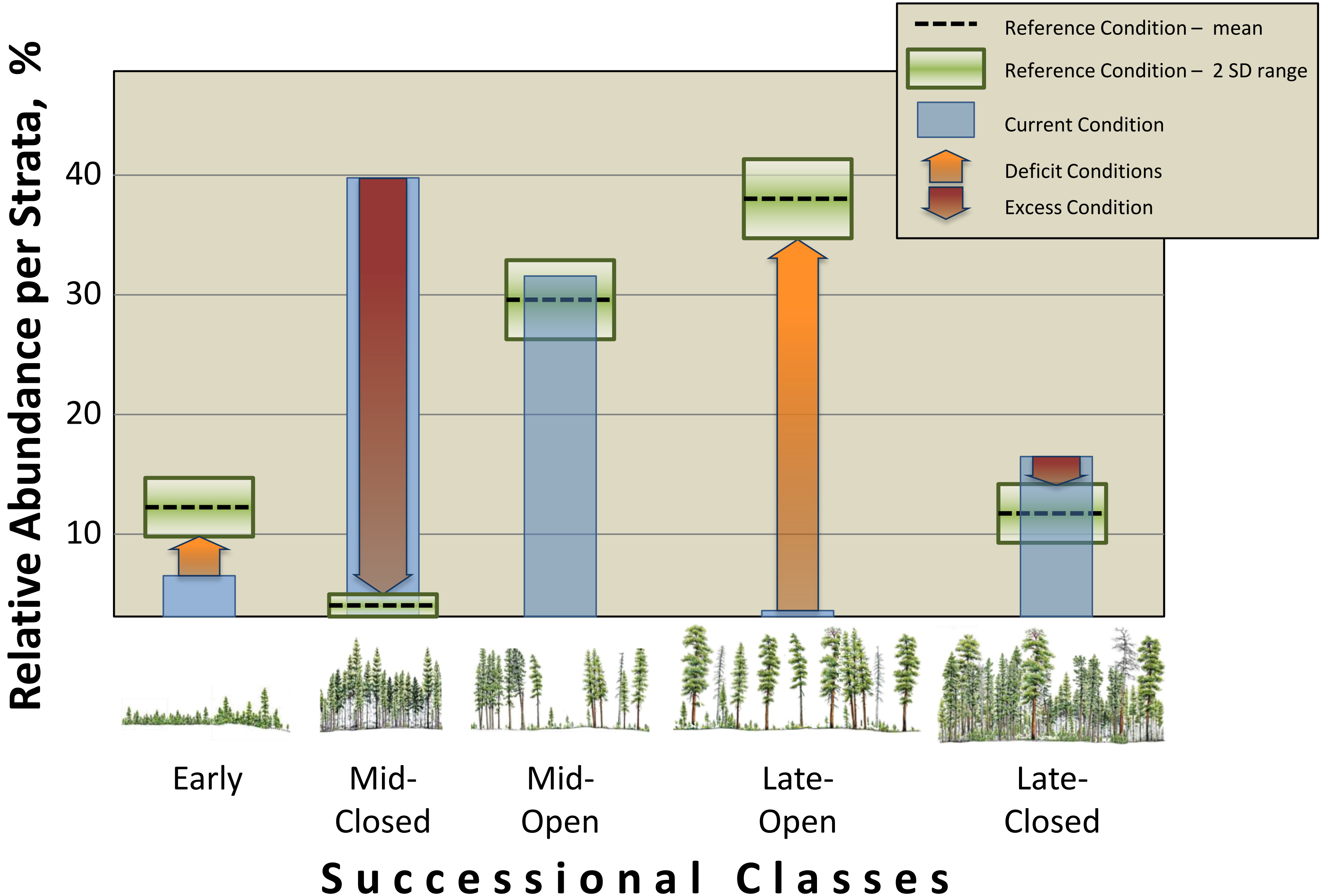
Landscape Assessment of Structural States

(2003 Upper Bear Assessment, USFS)

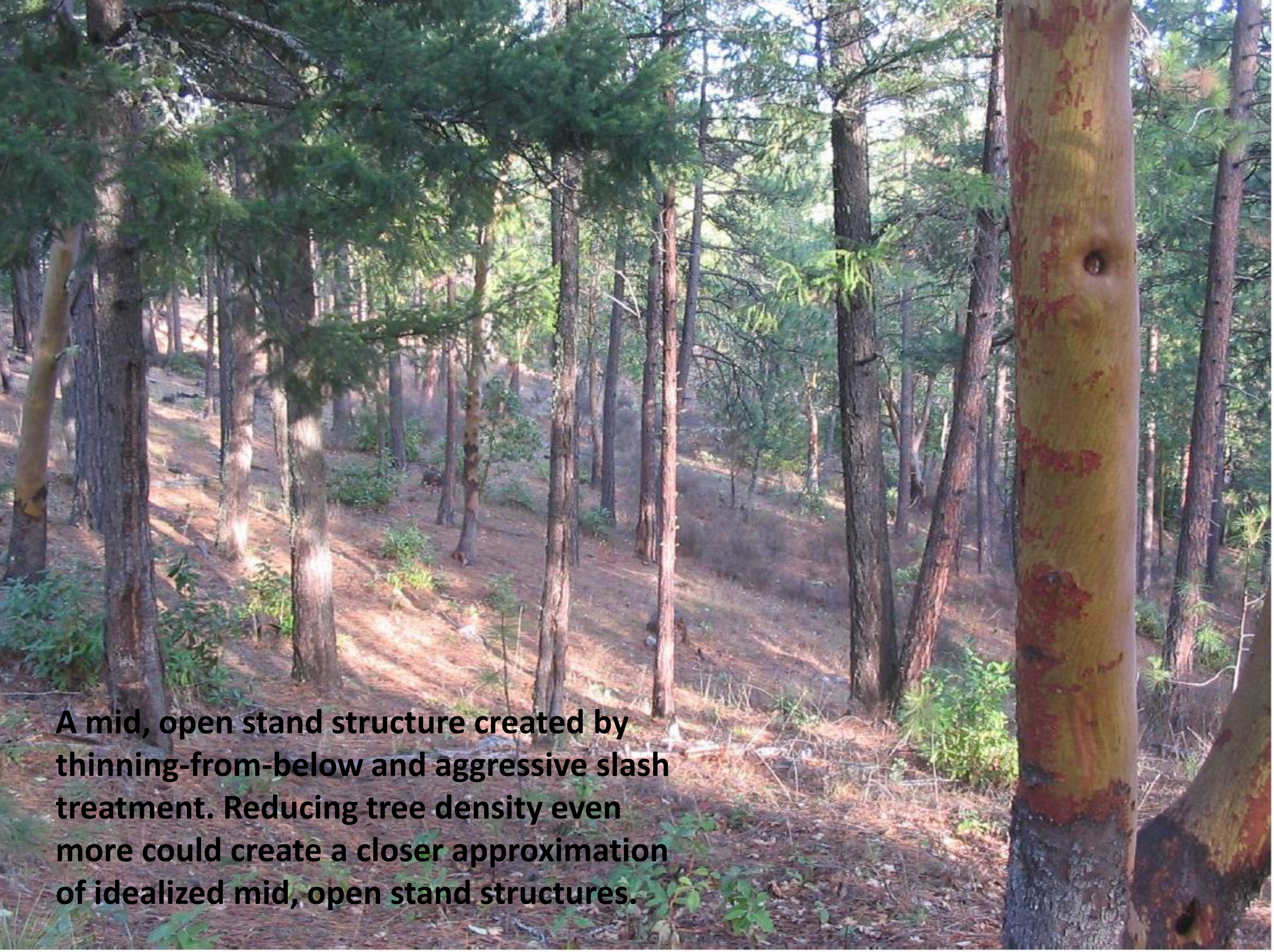
Dry White fir PAG

Seral Stage, Canopy Closure	Past %	Current %	Desired %
Early seral, Open	15	4	10
Mid-seral, Open	35	14	26
Mid-seral, Closed	20	24	8
Late seral, Open	15	0	30
Late seral, Closed	15	58	26

Landscape Resilience and Natural Range of Variation



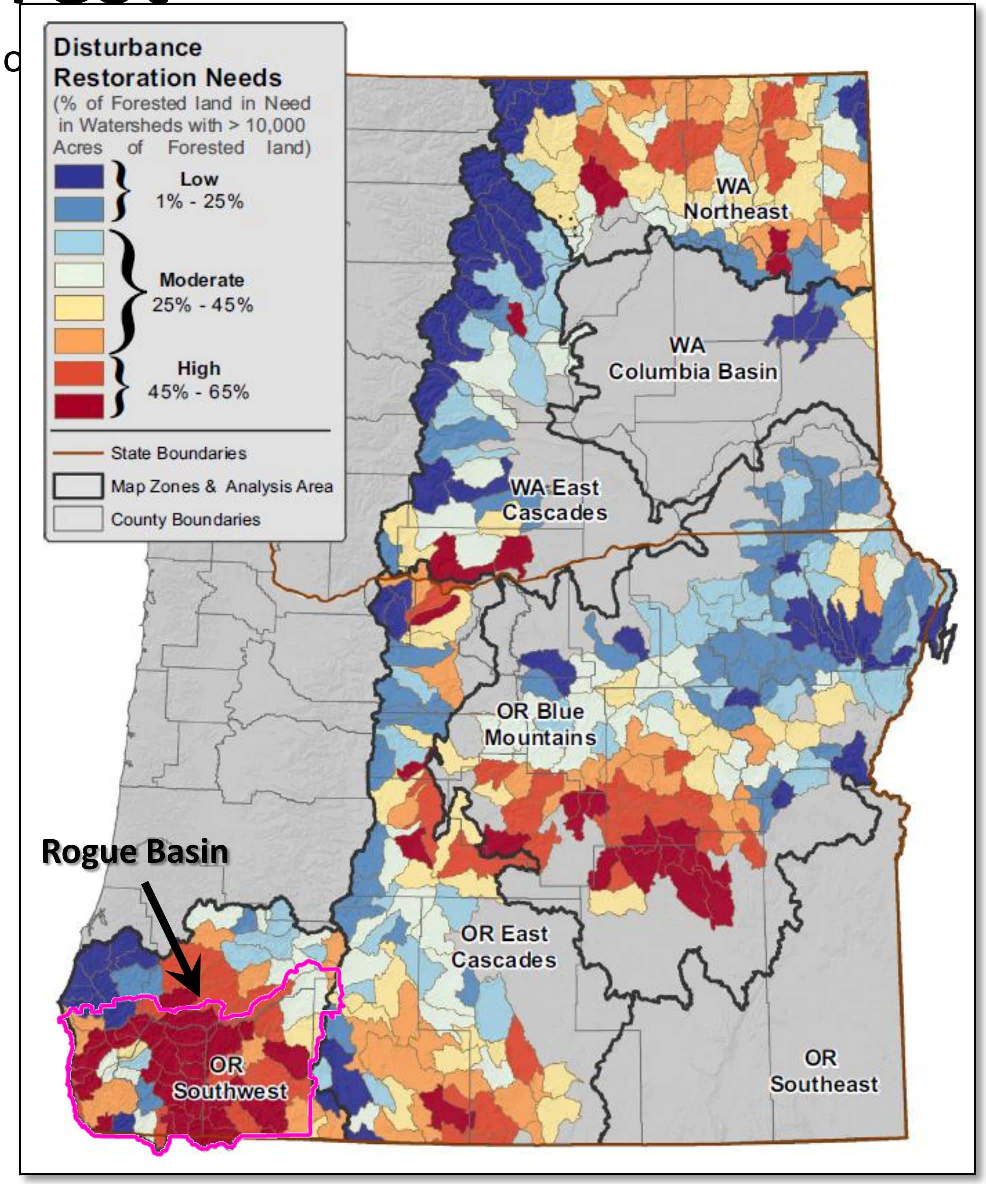
Haugo, R., C. Zanger, T. DeMeo, C. Ringo, K. Blankenship, M. Simpson, K. Mellen-McLean, A. Shlisky, and J. Kertis, Mark Stern. 2015. A new approach to evaluate forest structure restoration needs across Oregon and Washington, USA. **Forest Ecology and Management 335:37-50**.


A mid, open stand structure created by thinning-from-below and aggressive slash treatment. Reducing tree density even more could create a closer approximation of idealized mid, open stand structures.

Restoration Needs in Frequent Fire Forest

A collaboration o

- **Rogue Basin Forests and Woodlands**
  - 4.2 million acres
  - **2.1 million acres are overly dense (50%)**
- *~ 105,000 ac/year (over 20 yrs.)*



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

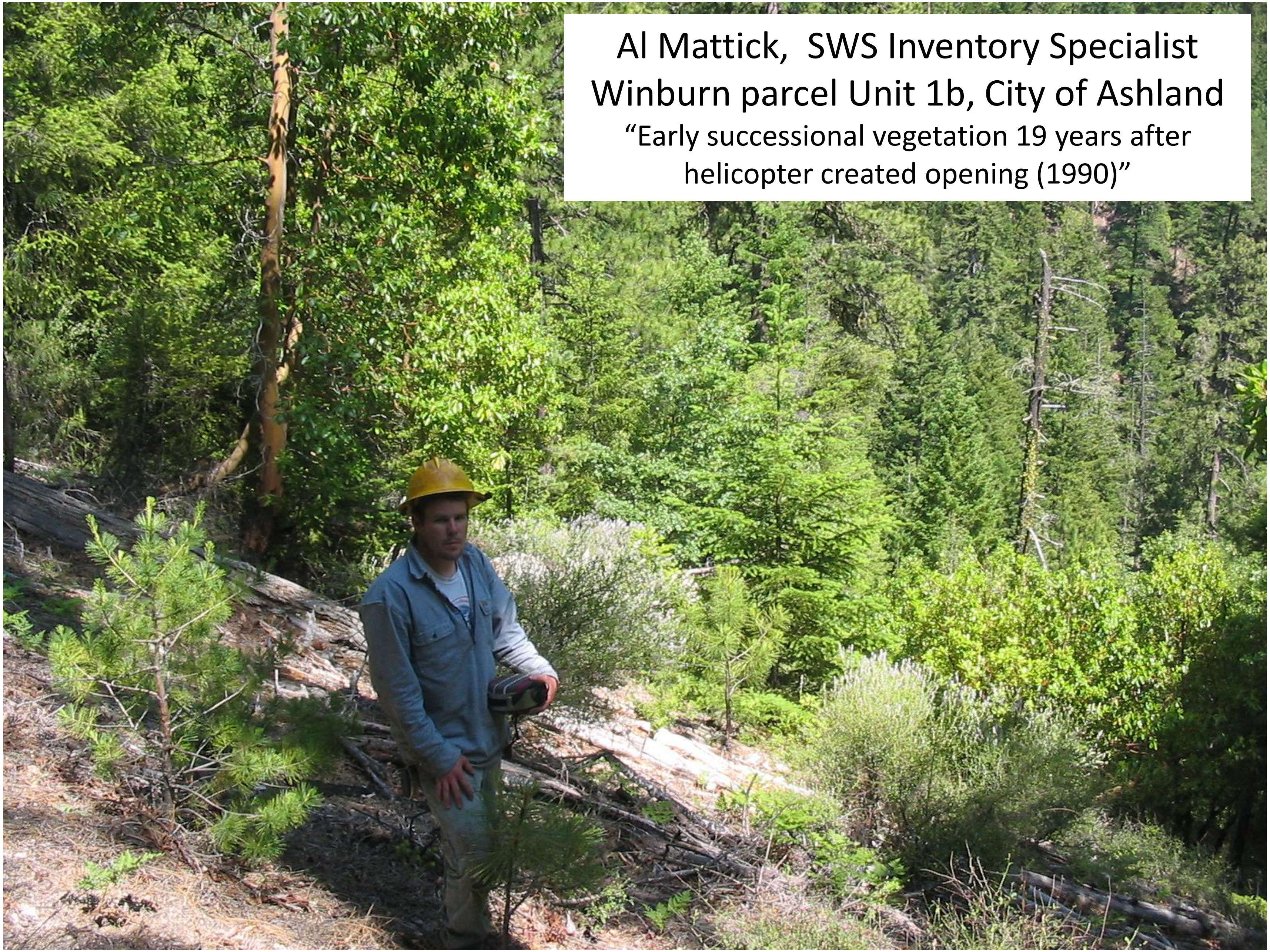
Important Ecological Functions of Gaps/Openings

- **Fire-** Horizontal discontinuity of fuels
- **Species composition-** Necessary for establishment of shade intolerant species
- **Wildlife**- Important habitat values; structural class less well-represented on COA and in watershed
- **Water**- Potentially more water yield of longer duration: less interception, evapotranspiration
- **Biodiversity**-High species diversity; largest level of plant diversity
- **Biological Legacies-** Often abundant in openings
- **Others**

Early-successional forest ecosystems that develop after stand-replacing or partial disturbances are diverse in species, processes, and structure. Post-disturbance ecosystems are also often rich in biological legacies, including surviving organisms and organically derived structures, such as woody debris. These legacies and post-disturbance plant communities provide resources that attract and sustain high species diversity, including numerous early-successional obligates.

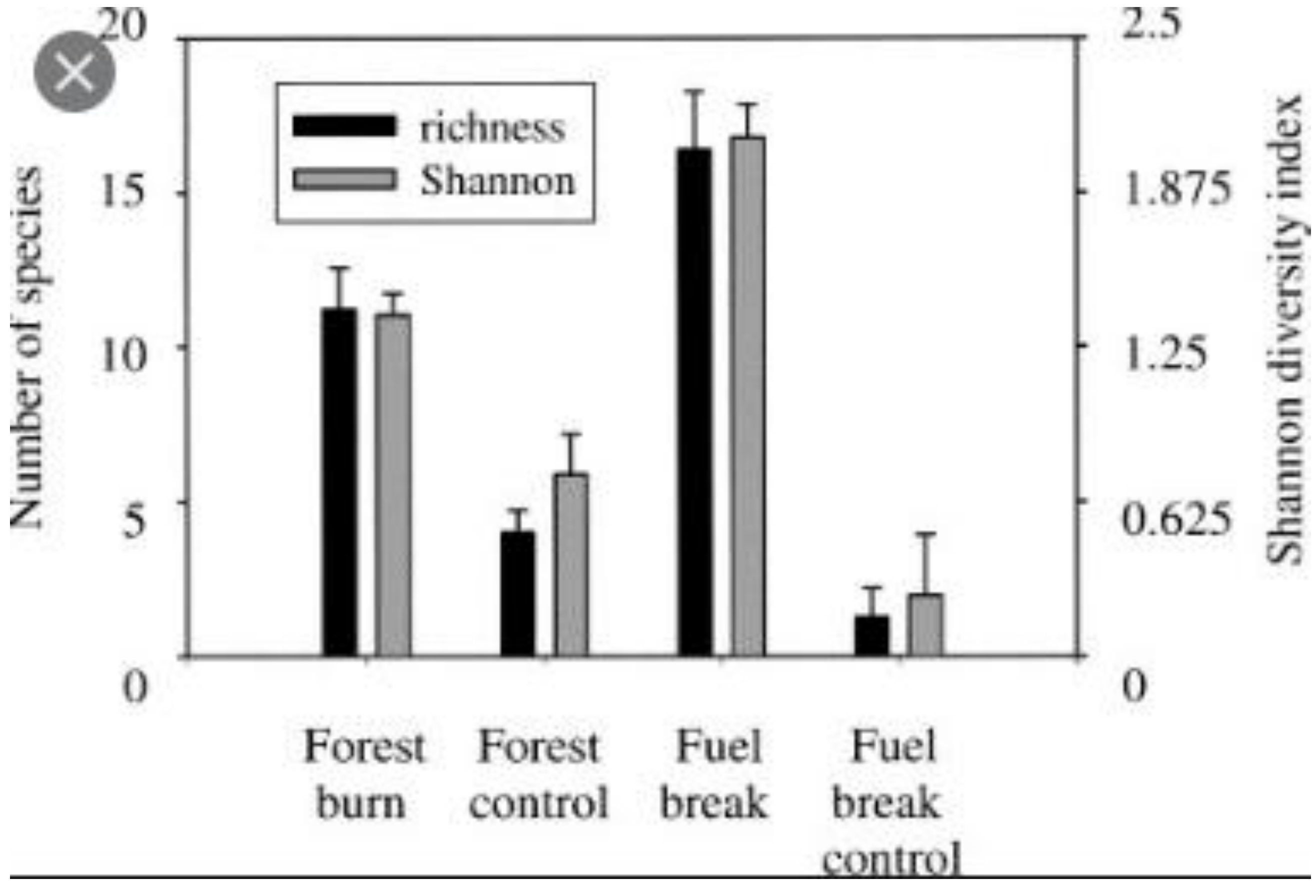
The forgotten stage of forest succession: early-successional ecosystems on forest sites. 2010.
Mark E Swanson Jerry F Franklin Robert L Beschta Charles M Crisafulli Dominick A DellaSala Richard L Hutto David B Lindenmayer Frederick J Swanson

Early successional vegetation- a structure type with good plant diversity and many important values but not desired from a fire management perspective. Strategically locate this structural to maintain its many important values.



Al Mattick, SWS Inventory Specialist
Winburn parcel Unit 1b, City of Ashland
“Early successional vegetation 19 years after helicopter created opening (1990)”

Effects of fire management practices on butterfly diversity in the forested western United States
MikaelaHuntzinger 2003



“Both area and density of gaps in the forest canopy were found to explain large amounts of the variation in butterfly richness (R^2=0.64 and R^2=0.80, respectively). This study demonstrates that using non-traditional taxa (e.g., butterflies instead of trees) to study ecosystem processes may help to provide valuable insights into alternative management strategies.”

Horkelia tridentata

“Three-toothed horkelia”

A small, non-descript perennial forb in the rose family, this species, more common in California, was originally only found in rare openings in our area (e.g. the powerline easement on City forestlands; implemented shaded fuelbreaks on USFS lands in the watershed). This species appears to be expanding it’s occurrence and range with more openings, such as this individual in a small population that was found after fuel reduction work on City lands in 1997. This particular population is regularly monitored and appears to be slowly expanding.

City of Ashland

Unit LW-B

Small opening enhanced during helicopter thinning in 2004

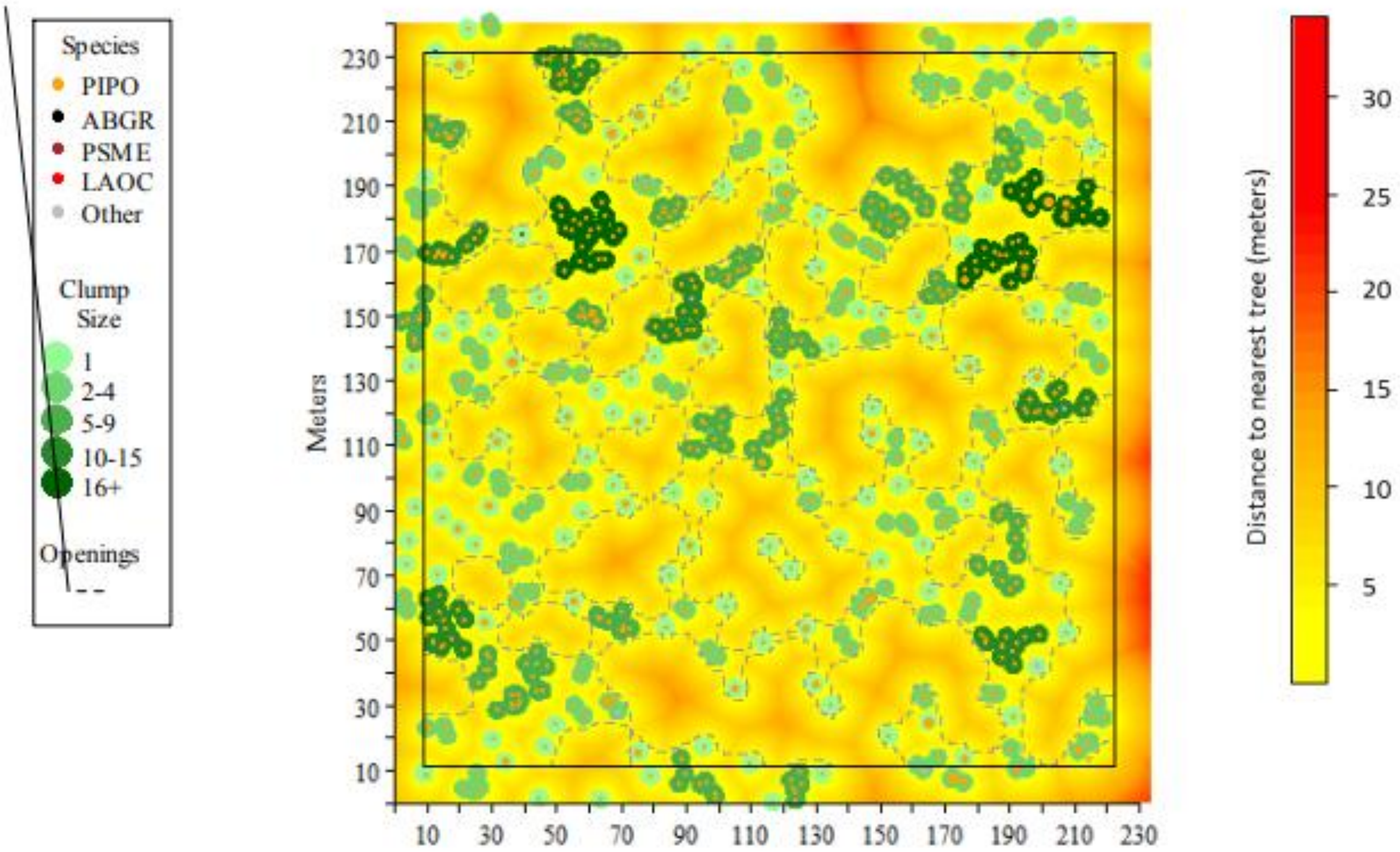


Figure 11: Stem map of historical conditions from an 11-acre plot on the Malheur National Forest.

Source: Churchill et.al. 2016 The ICO Approach to Quantifying and Restoring Forest Spatial Pattern: Implementation Guide.

Values of Older Forests

- Greater resistance to wildfire (Zald and Dunn 2017)
- Microclimatic buffering, cooling (i.e. refugia effect) (Frey et. al 2016)
- Large trees store high amounts of carbon (Mildrexler 2020, Lutz 2018)
- Higher seasonal water supply in summer (Perry and Jones 2017)
- Importance as wildlife habitat (e.g. northern spotted owl)
- Regional importance, especially in low to mid elevation dry forests
- Federally designated Late Successional Reserve in the Ashland Watershed
- Only exist on the Winburn parcel on City of Ashland forestlands

Lower Watershed Fuels

Unit	# of Plots	Tons per acre by size class (inches)							
		0-0.25	0.26-1	1.1-3	3-4	5-9	10-19	20+	Total
A1	3	0.45	2.44	3.47	3.80	26.70	22.67	0	59.53
B	14	0.27	1.38	3.19	1.95	16.32	12.02	0	35.13
C	5	0.08	0.42	3.26	0.76	1.49	0	0	6.01
D	2	0.07	0.86	4.36	0	15.48	5.89	0	26.66
E	9	0.48	0.95	2.92	0.61	5.98	17.94	0	28.88
F	2	0.28	2.30	0.77	3.74	15.88	0	0	22.97
G	15	0.31	1.81	5.29	2.87	8.26	5.22	0	23.76
H	4	0.47	2.02	4.60	0	13.02	12.44	0	32.55
J	5	0.34	1.04	1.39	0.45	4.87	0	0	8.09
K	14	0.52	2.35	4.70	0.95	5.22	8.83	0	22.57
L	6	0.68	1.94	5.04	2.68	3.64	8.06	0	22.04
M1	4	0.29	0.83	2.61	0.49	7.23	0	0	11.45
M2	3	0.60	1.44	2.32	1.27	1.37	0	0	7.00
N	8	0.81	2.35	4.18	4.40	5.94	6.18	9.49	33.35
P	11	0.56	2.31	2.33	1.69	3.99	0	0	10.88
Q	6	0.82	3.11	5.71	2.42	13.68	12.36	0	38.10
R	5	0.61	2.11	5.68	2.68	8.17	19.64	0	38.89
S	6	0.62	1.37	3.97	1.61	12.63	0	0	20.20
U	6	0.31	0.89	1.61	1.29	0.52	0	0	4.62
W1	3	0.22	0.94	1.13	1.91	5.05	16.42	0	25.67
W2	4	0.46	1.38	3.31	0.48	17.31	7.42	0	30.36
Total*	135	0.45	1.62	3.52	1.82	8.43	7.94	0.86	24.64

*Weighted by unit acreages

Winburn Fuels

Unit	# of Plots	Tons per acre by size class (inches)							
		0-0.25	0.26-1	1.1-3	3-4	5-9	10-19	20+	Total
1	33	1.03	2.96	5.06	1.81	8.54	18.84	47.76	86.00
2	9	0.82	3.14	3.82	0.46	8.06	15.07	42.08	73.45
3	8	0.89	2.36	5.17	2.07	6.79	4.65	50.38	72.31
4	3	0.69	2.45	6.77	2.47	16.04	9.30	83.23	120.95
5	10	1.22	2.58	4.94	2.77	6.84	15.64	19.45	53.44
6	6	1.62	2.45	2.47	1.26	4.91	37.27	46.58	96.56
Total*	69	1.02	2.83	4.72	1.65	8.28	17.16	46.10	81.76

*Weighted by unit acreages

Large woody debris data seem to indicate that most of the Lower Watershed parcel was not historically older forests. Individual conifers > 150 years of age are rare in this parcel and in the Ashland interface area.

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Characteristics of Older Forests of Increasing Age

Large tree size.

Large trees are often the first thing that comes to mind when discussing older forests. These trees are generally the anchors of a forest, as they are the primary means of energy input into the system through photosynthesis.

Large snags and fallen logs.

As trees die from disturbances such as fire, disease, or insects, snags become more abundant and start the decomposition process while the tree is still standing. As they fall to the ground, the large logs continue to decay and the nutrients are cycled back through the soil and into the living vegetation.

Vertical complexity.

As trees mature into large, old trees, they develop deep, spreading crowns with large branches. The next layer of trees (generally hardwoods and smaller conifers) begin to grow in the open spaces in the dominant canopy to form a multi-layered, continuous canopy layer. Below that, shrubs and small trees fill in the understory to continue the canopy layer down near the ground. All of these trees contribute to an multi-aged, multi- species stand that is also structurally diverse.

Horizontal patchiness.

Clumps of trees are common in older forests and they are generally spaced in a heterogeneous fashion with openings scattered between them. The openings allow for patches of tree regeneration or shrub fields to grow and create a more diverse landscape.

Plant, animal, and fungal diversity.

This takes many forms in an older forests. Vegetation and wildlife species diversity is generally very high, while diverse networks of fungi are also present in these forests. While these systems are diverse, they are also interconnected and each play a role in maintaining healthy ecosystem functions.

Old-Growth Forest Structure

J.F. Franklin et al. / Forest Ecology and Management 155 (2002) 399–423 417

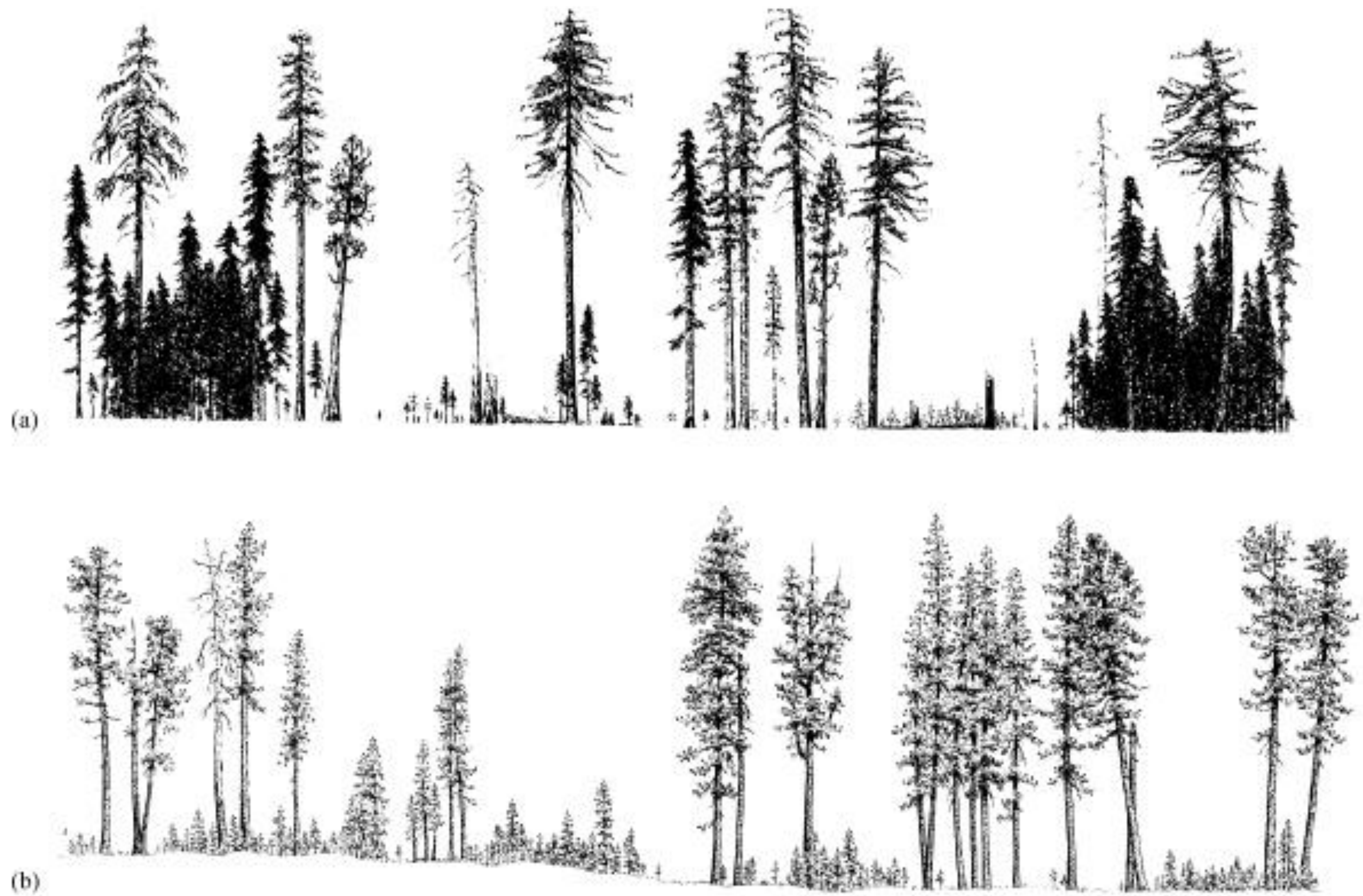
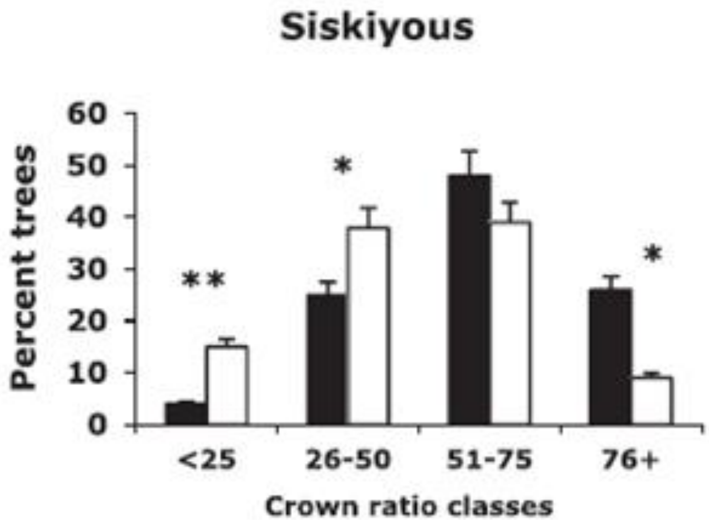
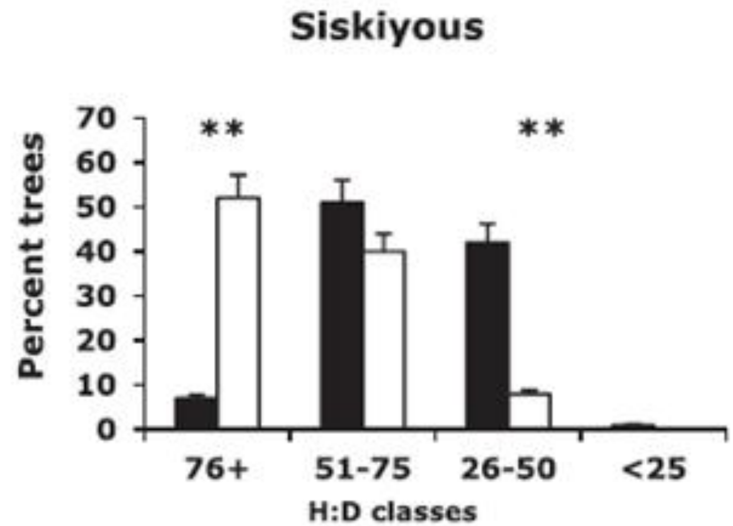
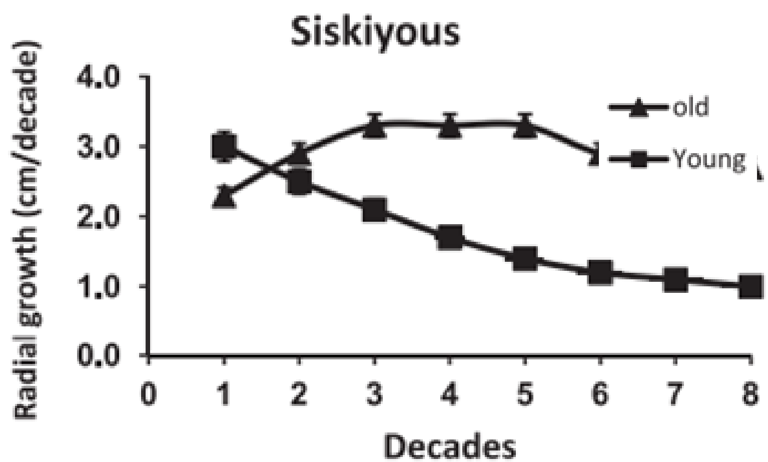


Fig. 8. Old-growth forest structure in two forest regions characterized by low- to moderate-intensity disturbances showing the mosaic of structural patches that collectively form the functional old-growth stand: (a) 200 m × 20 m profile of old-growth stand characteristic of the Sierra mixed-conifer type (Aspen Valley, Yosemite National Park, California); (b) 15 m × 150 m transect of old-growth pure ponderosa pine stand (Bluejay Springs Research Natural Area, Winema National Forest, Oregon) (drawings by R. Van Pelt).

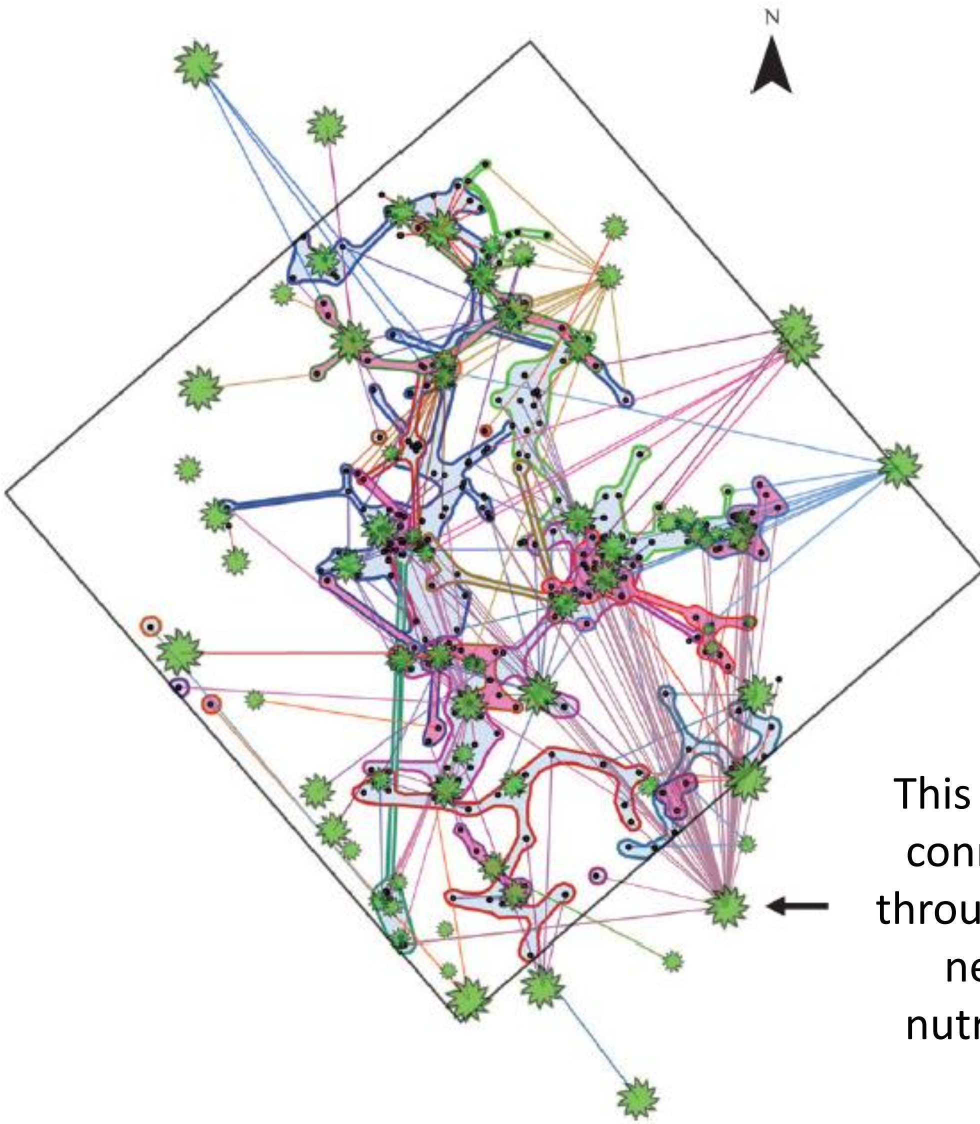
Characteristics of Older versus Younger Stands







Sensenig et.al. 2013. Stand development, fire and growth of old-growth and young forests in southwestern Oregon, USA



Older forests and younger forests are functionally different- and our planned interactions with them should respond accordingly!

This one tree was found to be connected to 47 other trees through complex below-ground networks, sharing water, nutrients, carbon and others

Source: Beiler et al. "Architecture of the wood-wide web: Rhizopogon spp. genets link multiple Douglas-fir cohorts." New Phytologist 2009

Table1. Percentage of large trees dead in 40 randomly located stand examination plots in the Ashland Research Natural Area arrayed by species and diameter class.

Tree Species	*% of all trees dead*		
	>17” dbh	*> 24” dbh*	*> 30” dbh*
Ponderosa pine	*23.6*	*26.7*	*32.0*
Sugar pine	*50.0*	*50.0*	*50.0*
Douglas-fir	*19.5*	*43.9*	*53.1*
White fir	*30.0*	*46.6*	*20.9*
Incense-cedar	*0*	*0*	*0*
All Conifers	*25.2*	*40.0*	*30.8*

Table 2. DF Dwarf mistletoe Infection by DBH and Stage of Infection Ashland Watershed Research Natural Area (40 plot sample)

Dwarfmistletoe Infection Rating	*>20”dbh (n=55)*	*20-30”dbh (n=42)*	*30”+dbh (n=13)*
0	*62%*	*69%*	*38%*
1,2,3	*13%*	*12%*	*15%*
4,5,6	*25%*	*19%*	*46%*

Dwarf mistletoe Infection Rating as per Hawksworth: 0= no infection, 1=very lightly infected in lower one-third of crown, 6=heavily infected throughout crown

Source: Main, 2009 “Large Tree Mortality in the Ashland Research Natural Area”
(from data collected by Southwest Oregon Forest Insect and Disease Service Center)


Mature stand in Ashland
Watershed without disturbance

Ashland Research Natural Area, ~2010

Radial growth of highly-stressed legacy pines (>18” DBH) on the Winburn parcel

# of Trees Sampled	# of Trees with Radial Growth 50+ rings/inch	% of Trees with Radial Growth 50+ rings/inch
36	11	30.5

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Large tall trees and older forests are threatened by a warming climate

"The more pronounced drought sensitivity of larger trees could be underpinned by greater inherent vulnerability to hydraulic stress, the higher radiation and evaporative demand experienced by exposed crowns, and the tendency for bark beetles to preferentially attack larger trees. We suggest that future droughts will have a more detrimental impact on the growth and mortality of larger trees, potentially exacerbating feedbacks to climate change."

Source: Bennett et.al. 2015 Larger trees suffer most during drought in forests worldwide.

"In conclusion, the hydraulic corollary to Darcy's law (equation (1)) predicts that as rising temperatures drive increasing vapour pressure deficits, the resultant greater water stresses will force major shifts in the dominant plants. Shrubby, low-statured plants are most likely to survive, whereas tall old-growth forests are particularly vulnerable to warming climate."

Source: McDowell and Allen, 2015. Darcy's law predicts widespread forest mortality under climate warming.

Vegetation: Stand Structures and Structural States

Adaptation Options for Management

Main Point- Encourage more heterogenous stand structures and structural states on both a stand and landscape level while emphasizing protection and development of under-represented structural types.

1. **Match appropriate stand management to the structure type. Implement multi-cohort, multi-species stand management where appropriate utilizing variable density thinning, thinning-from-below and other ecologically appropriate stand improvement silvicultural strategies (Persist).**

2. **Strive for a diversity of structural states and stand conditions. Promote a high contrast landscape at multiple scales of reference. Convert to a more balanced representation of structural states by managing to create more mid open and late open stand structures. Create more heterogenous stand structures with more openings, early successional habitat and open forests with improved fuel discontinuity (Persist, Change).**

3. **Continue active planned disturbance to protect and promote existing older forests (Persist)**
   - **improve vigor of larger older forest structures**
   - **rake around older pines as needed**
   - **manage snags and LWD- middle elevations most vulnerable to high severity, long duration, mass fire**

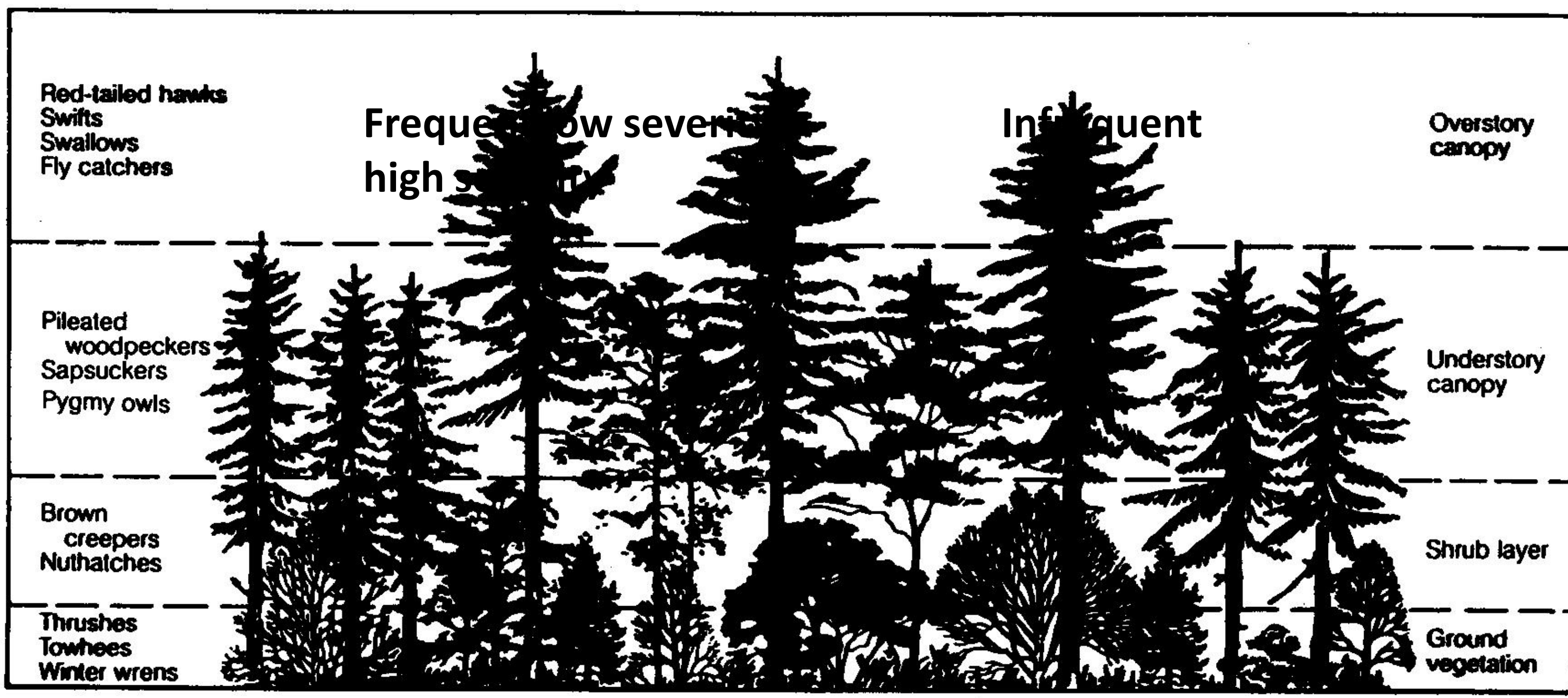
4. **Accelerate development of older forests through aggressive management of mid-seral forests (Persist, Change)**

5. **Identify refugia and prioritize for retention (Persist)**

-

Forest Structure

Structure = "Habitat"



—Four layers of a mature forest, with the birds that typically inhabit each.

The Importance of Structural Heterogeneity

Spatial variability in forest structure is a key element in these resilient forests and heterogeneity should be included in US forest management efforts (Stephens and Ful´e 2005). However, spatial variability is uncommon in most US forest restoration practices (North *et al 2009). The most common* forest fuel reduction treatment in western US forests is a thin-from-below to separate overstory tree crowns and maintain a desired basal area within a limited range (Graham *et al 2004).* These practices produce relatively uniform forest conditions over broad areas and are in strong contrast to what is found in the resilient Sierra San Pedro Martir (SSPM) forests.

Stephens et.al 2010. Operational approaches to managing forests of the future in Mediterranean regions within a context of changing climates.

The potential for climate change to cause 'novel' or 'no analogue' environmental conditions in some ecosystems presents new challenges for management, policy and planning. An obvious goal is to have ongoing fire regimes that minimize the risk of biodiversity loss. Yet, what adaptation responses are appropriate if we do not know how future climates and related biophysical processes will differ from the recent past? These uncertainties have resulted in somewhat similar recommendations about fire and ecosystem resilience. Heterogeneity in vegetation types, stand structures and successional age classes at all spatial scales and environmental settings is emerging as a strategy for enhancing ecosystem resilience to climate change. This essentially facilitates diverse initial conditions for multiple future ecological trajectories, the most likely and successful of which will not be known for decades. The role of diverse topography in creating microclimate refugia, or 'holdouts', as well as in influencing fire sizes and severity characteristics within large fires, comprises the physical template for resilience in more mountainous regions.

Moritz et.al. 2014. Learning to Co-exist with Wildfire.

Multi-species, multi-cohort stand management silvicultural systems using variable density thinning or other stand improvement treatments

Advantages

-Lower risk of high severity disturbance from insects/pathogens; host specificity
-Potential for continuous stocking, root stability and reduced likelihood of landslides
-Relies on a desirable more frequent, low to moderate disturbance regime and reflects that historical template of disturbance
-More options for intermediate treatments with subsequent more regular monitoring
-Increased potential for response to partial mortality
-More shading and potential reduced impacts from increased temperatures and Vapor Pressure Deficit
-Variable response to drought
-Generally higher habitat value
-Includes prioritization of retention of older larger trees
-Can be implemented to create either more open or more closed stand structures

Disadvantages

-Requires more intimate and comprehensive approaches to stand management
-Potentially more operating costs on the stand level
-Potentials for increased risk from fire; essential to create fuel discontinuity throughout the fuel profile in order to reduce that risk
- Can be disadvantageous for spread of some forest diseases (e.g. dwarfmistletoe)

Winburn Unit 1, 2015

Multi-cohort, multi-species stand structure

Stand Management of Mixed Conifer/Hardwood Forests in Southern Oregon

"Stand management in southwest Oregon forests is extremely complex for several reasons:

■ There is a greater diversity of tree species than in most other areas of Oregon. Mixed-conifer forests in this region include various numbers of Douglas-fir, ponderosa pine, sugar pine, incense cedar, white fir, black oak, white oak, Pacific madrone, and other species, each with distinct silvical requirements.

■ The environment is extremely variable and heterogeneous. Climate, soils, and topography often vary greatly over small distances and result in major changes in vegetation and site productivity. Most obvious are the typically dramatic contrasts in the composition of vegetation with slight changes in aspect. Highly variable soils and strong elevational moisture gradients also contribute to vegetative diversity.

■ Disturbance history includes a complex mix of mostly low- to moderate-severity fires, with increasing numbers of higher severity fires in the past century; various types of timber harvesting methods used in the past; and decades of fire exclusion. As a result, the current conditions and future potential of any given site are highly variable, and there is no "standard" prescription for mixed species, multi-aged management."

Source: Bennett et.al. 2013. Mixed Conifer and Hardwood Forest Management in Southwest Oregon.

“In fire-prone environments like southern Oregon, there can be a tension between developing an uneven-aged forest structure in the long term, and the short-term need to reduce fire hazard by removing dense, early to mid-seral vegetation (i.e., ladder fuels). Development of an uneven-aged structure may require a multi-phase process, beginning with thinning from below in dense stands (to enhance vertical fuel discontinuity) followed by establishing or enhancing (or both) tree cohorts over time in spatially separated patches, both horizontally and vertically.”

Source: Bennett et.al. 2013. Mixed Conifer and Hardwood Forest Management in Southwest Oregon.

Stand Structures on the City of Ashland Ownership

(already pretty diverse)

SS#1- Even-aged, Douglas-fir dominated stands with high height-to-crown base.

-Important fire management opportunity; high height-to-crown base and good vertical fuel discontinuity
-Difficult to retain due to low tree and stand vigor in low productivity sites in the Lower Watershed; multiple light thinnings recommended
-Flatheaded fir borer well-established in Lower Watershed and contributing to ongoing tree decline and mortality

SS#2a- Complex, multi-cohort stands of mixed species; more open, less dense stands on more southerly aspects

-Open stands with fuel discontinuity in both horizontal and vertical directions
-Potential for landscape level high severity fire management benefits
-Management for shade intolerant species and desirable species composition shifts

SS#2b- Complex, multi-cohort stands of mixed species; dense stands usually on more productive northerly aspects

-Most productive sites; grows larger trees fastest allowing acceleration of older forest structures
-Important wildlife habitat values
-Can be more prone to high severity fire
-Slope stability issues on steeper slopes

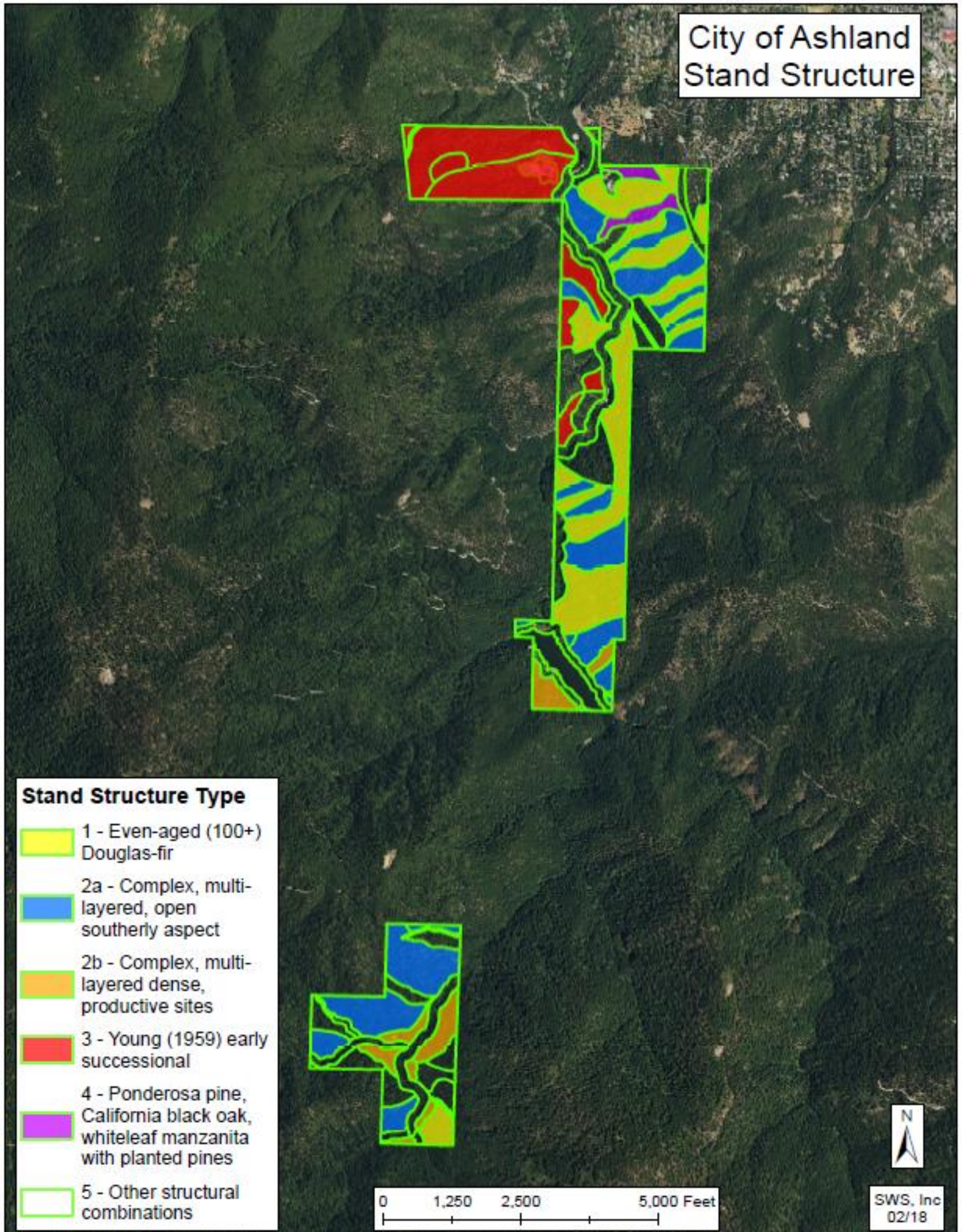
SS#3- Early successional stands initiated after the 1959 wildfire.

-Dense early successional vegetation transitioning to mis-seral; highly fire prone
- Already undergone significant species comp shifts after 2 high severity fire events; currently heavy to madrone
-Difficult to quickly manage for fire management objectives

SS#4- Ponderosa pine, California black oak, whiteleaf manzanita with planted pines

-Intensively managed for wildfire management objectives by reducing prevalence of whiteleaf manzanita and encouraging more open forests dominated by ponderosa pine and California black oak
-Continue management for more open less fire-prone forests of drought tolerant mixed species

SS#5- Other structural types contribute additional structural diversity



The City of Ashland forestlands have good inherent structural heterogeneity that we have tried to maintain, if not encourage, in the past 26 years of active management. This includes intentional retention of areas with no management footprint to date.

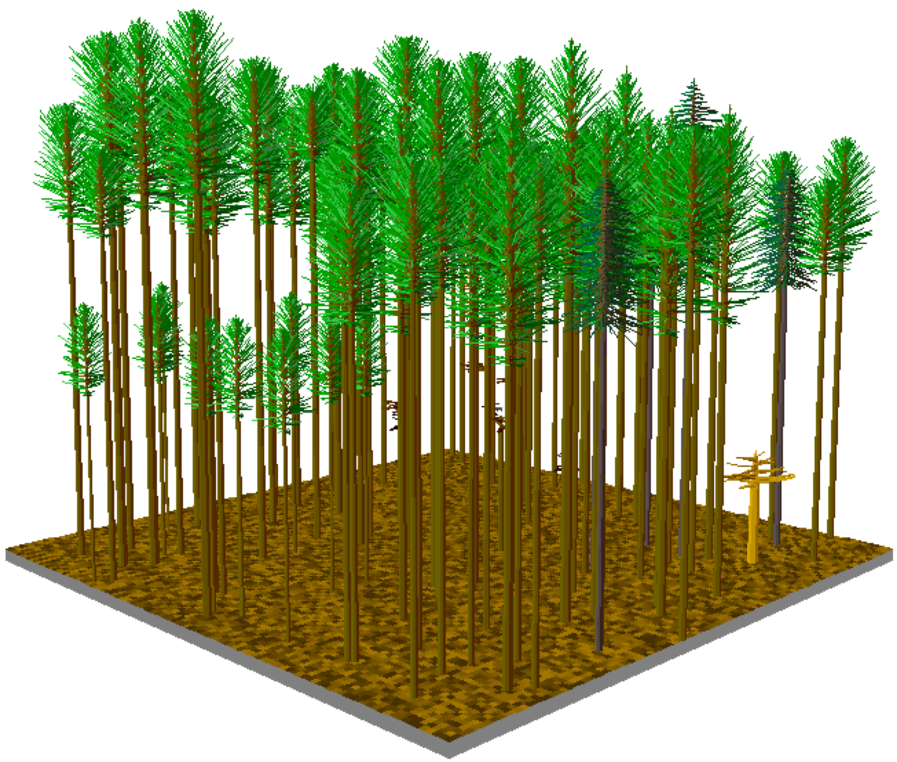
Stand Structure Type 1

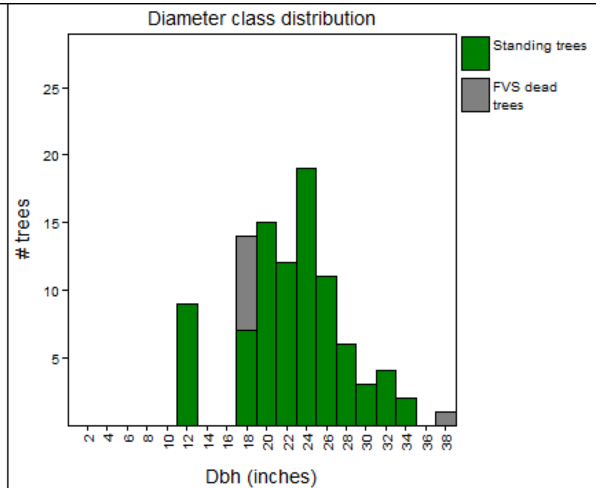
Even-aged, Douglas-fir dominated stands with high height-to-crown base

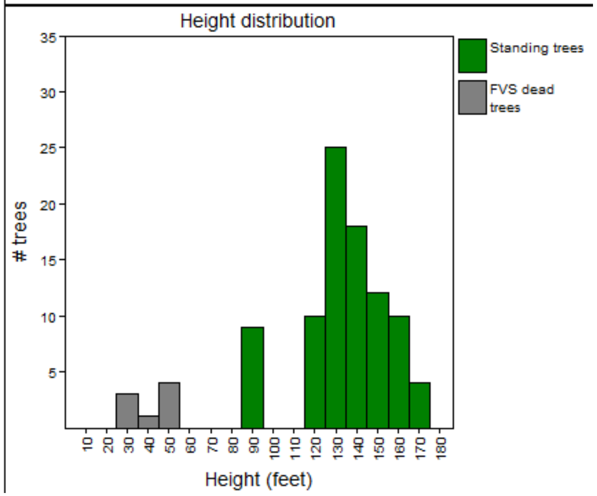
Lower Watershed Units- B,J,N,Q,S

Winburn Unit- 4

Winburn Unit 4








Unit LW-B4
City of Ashland

Climate Change Adaptation

Stand Structure Type 1

- Important fire management opportunity currently; high height-to-crown base and good vertical fuel discontinuity (**Persist** where possible)

- Difficult to retain in Lower Watershed due to low tree and stand vigor, height to diameter ratio, windthrow potential; product of higher severity disturbance; multiple light thinnings usually recommended (**Persist, Change**)

- Flatheaded fir borer well-established and causing pockets of high severity disturbance on lower half of Lower Watershed; likely will expand upward in elevation with climate change and will require constant adaptation depending on severity (**Persist, Change**).

- Management potential for older structures not known; best opportunity would be at Winburn Unit 4.

- Often first treated with thinning-from-below. If the stand stabilizes with reasonably vigorous stand conditions, variable density thinning is later employed and multi-cohort, multi species stands with intentional openings can be developed, although openings should be avoided on steep, landslide prone topography (**Change, although management has been moving towards this potential since inception**).

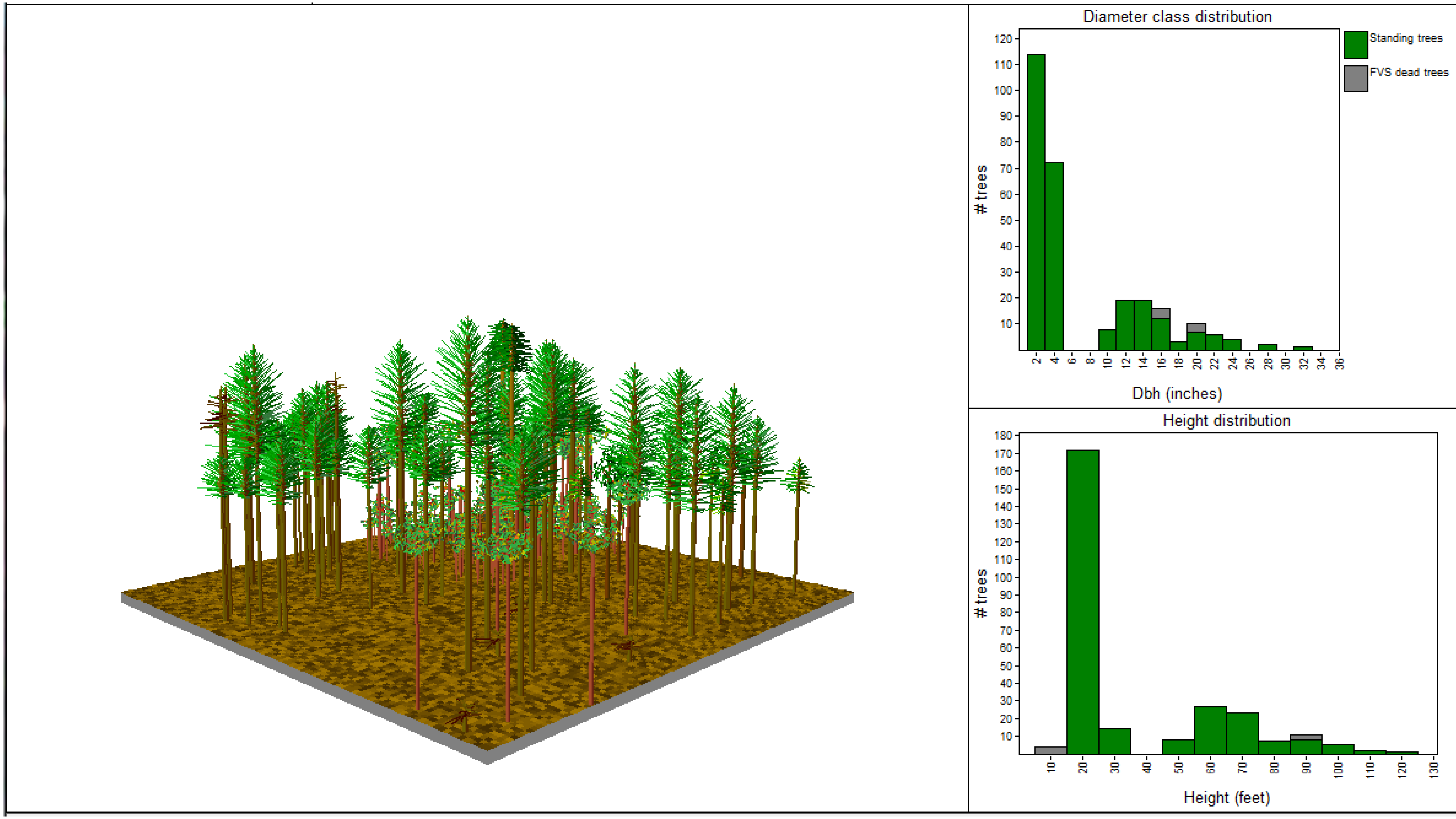
Stand Structure Type 2a

Complex, multi-cohort, less dense stands of mixed species and age classes usually on more southerly aspects

Lower Watershed Units-D,E,F,H

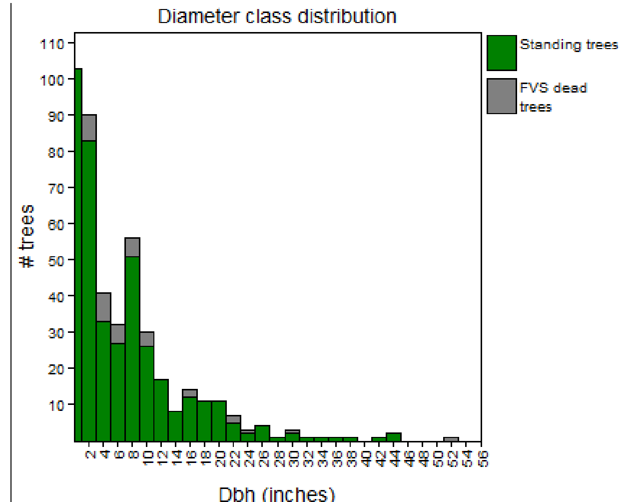
Winburn Unit 1

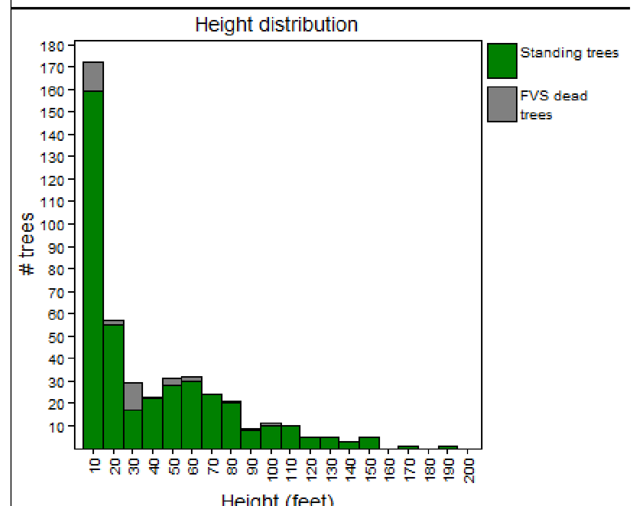
Lower Watershed Unit LW-H




2007 Prescribed underburn,Unit LW-H
Cross-boundary treatment with US Forest Service

Winburn Unit 1





Winburn Unit 1

Management History

2000-02	Non-commercial thin around legacy trees, pile and burn
2003-04	Non-commercial thin unit, leave skips, pile and burn
2013	Helicopter variable density thin
2014-15	Non-commercial thin in portions, pile and burn
2017	Rake around all legacy trees

Through active management, stand conditions are shifting towards a late-seral, more open stand structure dominated by large, od growth conifers and less at risk of a developing high severity wildfire.

Climate Change Adaptation
Stand Structure Type 2a

- Open stands with improving fuel discontinuity in both horizontal and vertical directions **(Persist)**
- Potential for landscape level management benefits associated with reduced potential for high severity fire **(Persist)**
- Management to increase shade intolerant species and desirable species composition shifts **(Persist, Change)**
- Multi-cohort, multi-species older stands currently; maintain through periodic variable density thinning and frequent, low to moderate severity disturbance, including prescribed underburning. **(Persist, Change)**
- Trending towards mid-open (e.g. Unit LW-H) or late open (e.g. Winburn 1) stand structure. **(Persist)**

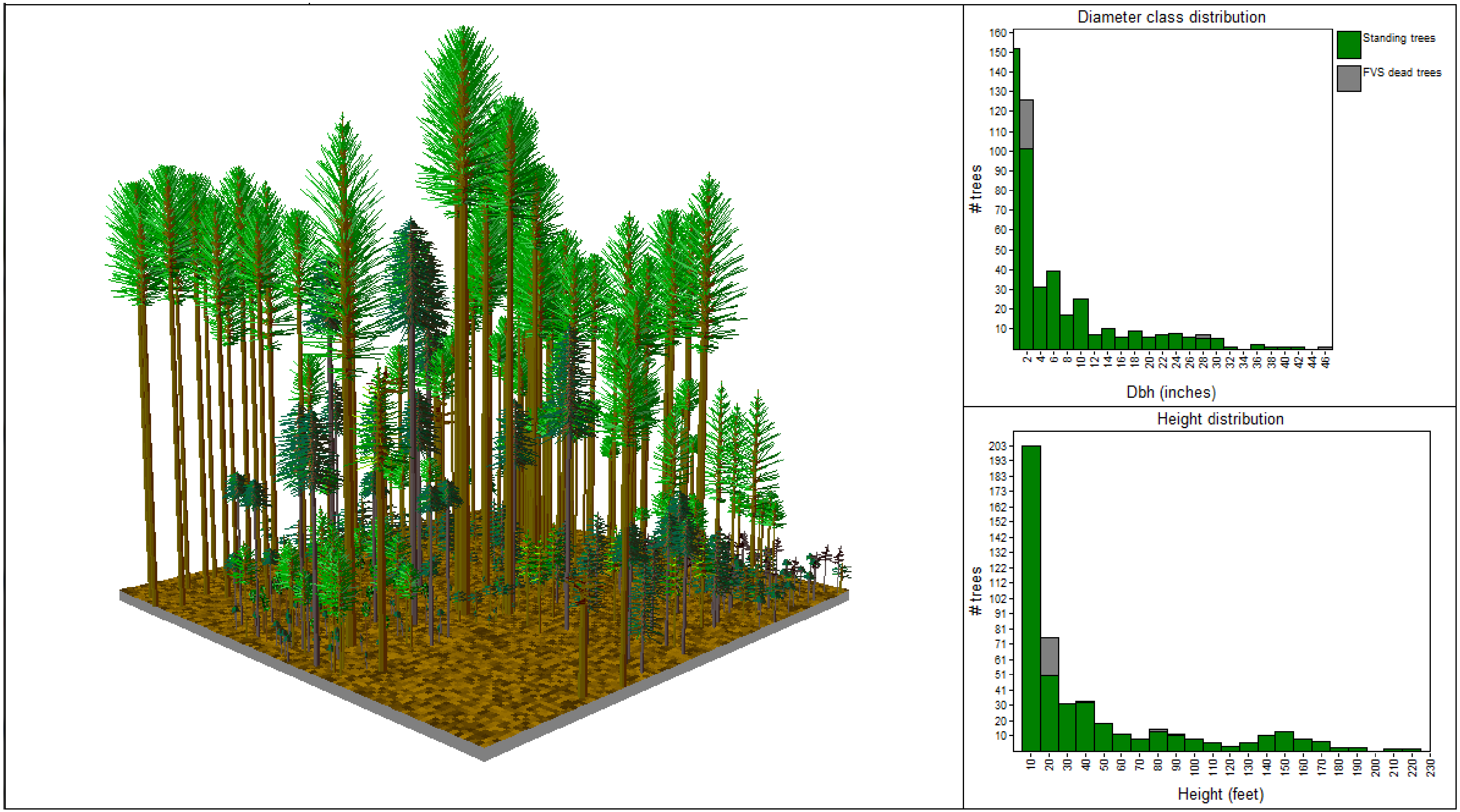
Stand Structure Type 2B

Complex, dense, multi-cohort stands of primarily Douglas-fir dominated stands usually on more productive northerly aspects

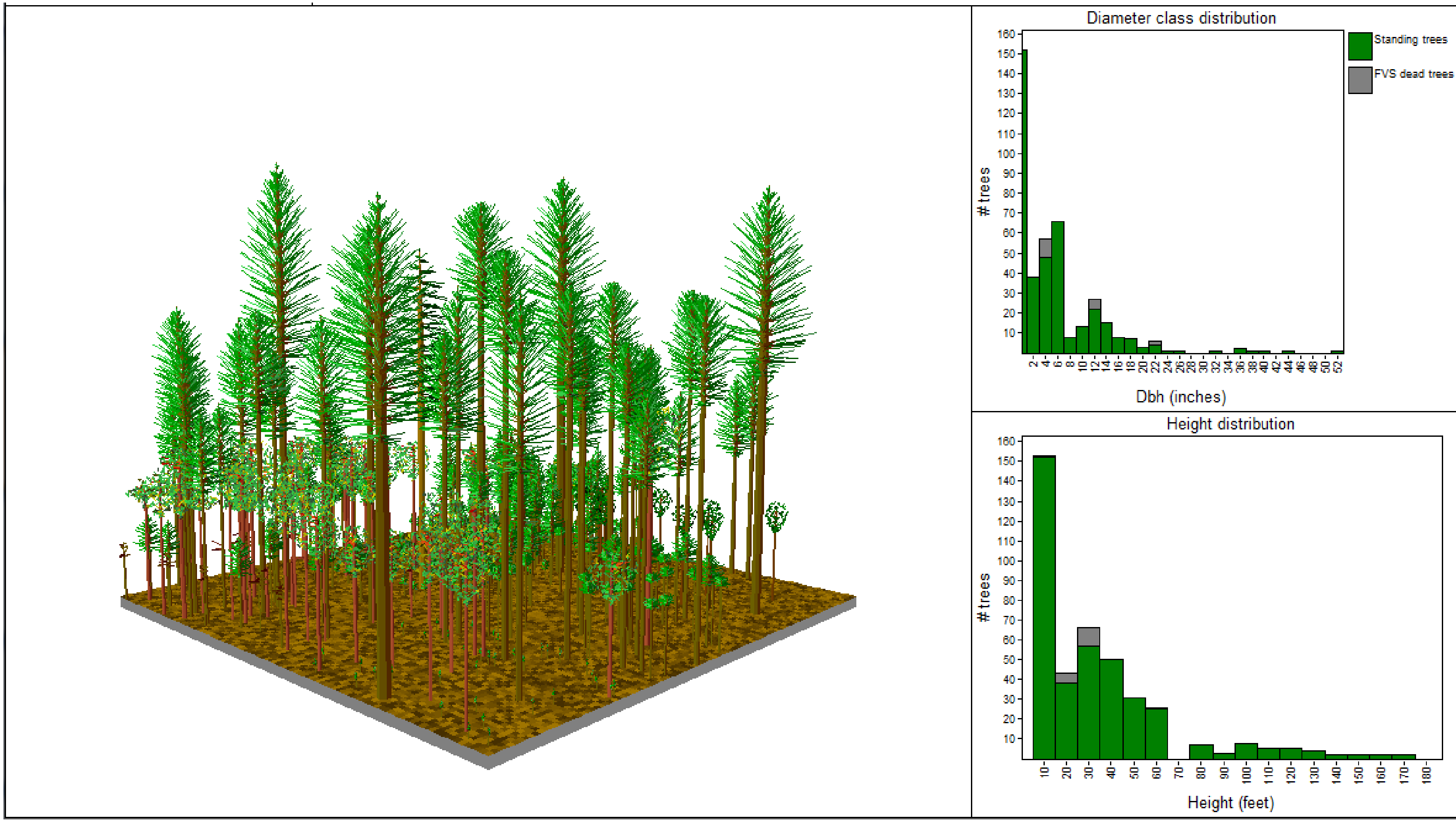
Lower Watershed Units- L, M2

Winburn Units- 3, 6

Winburn Unit 3



Lower Watershed Unit LW-L



Climate Change Adaptation

Stand Structure Type 2b

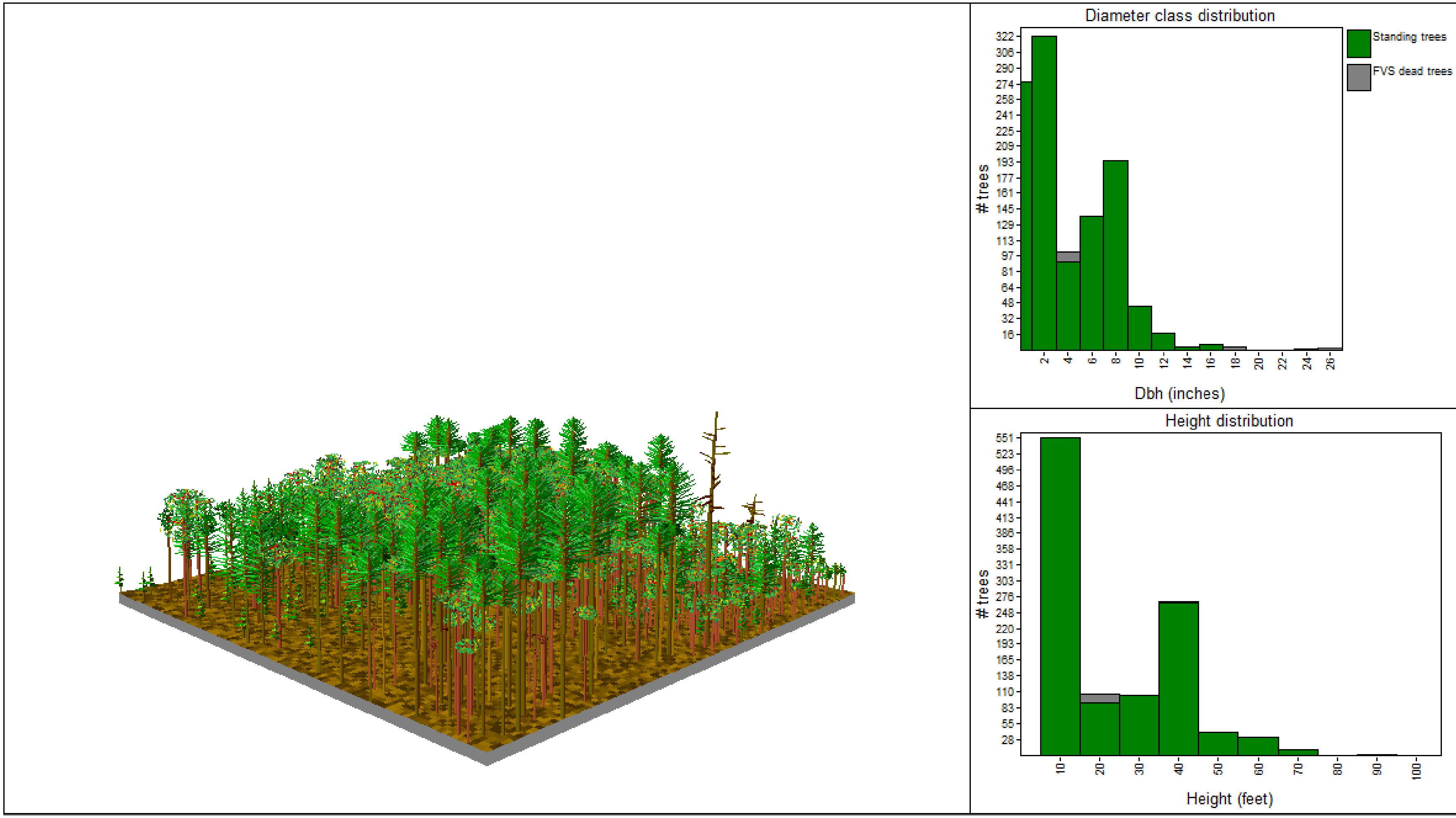
- Most productive sites; grows larger trees fastest; lower canopy layers can still be vigorous
- Good candidate for existing or accelerated development of older closed forest structures using multi-cohort, multi-species management and variable density thinning (**Persist, Change)**
- Slope stability issues; northerly aspects usually steeper **(Persist).**
- Can be more prone to more infrequent and potentially higher severity fire; harder to prescribed underburn and meet objectives.
- Pacific madrone expansion most likely and abundant on northerly and easterly aspects; may compromise conifer retention/development while increasing species diversity and wildlife habitat values.
- Includes important climate refugia values in some places
- Important wildlife habitat values including northern spotted owl habitat at Winburn **(Persist)**
- Has not received as much active management to date, at least in part due to slope stability issues and somewhat better tree and stand vigor than most other types (**Persist?, Change?)**

<u>Stand Structure Type 3</u>

Early successional stands initiated after the 1959 wildfire

Lower Watershed Units G,U,T

Lower Watershed Unit G1



Looking west from Crowson Reservoir at Units LW-U, T

Climate Change Adaptation

Stand Structure Type 3

- Dense early successional vegetation initiated after 1959 high severity wildfire; highly prone to additional high severity reburn (**Change,** if possible- see below).

- Already undergone significant species composition shifts after 2 high severity fire events; conifers much less common; currently dominated with high percentages of Pacific madrone (**Persist?, Change?** See below)

- Difficult to quickly manage to achieve fire management objectives, especially on steeper slopes.

- Adaptive management with multiple prescriptions should continue in these no-analog stands; careful monitoring (**Persist**).

City of Ashland Management of Pacific Madrone as a Climate Adaptation Strategy

1. **Conversion of madrone dominated stands (initiated after 1959 wildfire) to mixed hardwood/conifer through small openings creation and planting conifers. Initiated 2000+/-; non-commercial thinning, piling, burning in last 5 years (Units LW-G2, U).**

2. **Similar to 1. and implemented in the same era, but in refugia location in lower third topographic location close to Ashland Creek. Thinned to co-manage existing larger Pacific madrone and Douglas-fir initiated after 1959 wildfire (Unit LW-G3).**

3. **Gradational site and stand conditions from ridge at top down to close to Ashland Creek with dramatically different site productivities and associated levels of mortality. Multiple thinning strategies over time to reflect different site/stand conditions; extensive Douglas-fir mortality in upper half with significant fuel accumulation and associated repeat planting of pines. Recent slashing of Pacific madrone sprouts, piling of fuels in this area close to homes (Unit LW-B2).**

4. **Coppice treatment for long term management of Pacific madrone; with or without prescribed underburning, which, based on monitoring data, is the tree species most affected by low severity fire (although it does resprout vigorously).**

5. **Pacific madrone management in dense stands (1959 initiated) using various thin/no thin strategies on oversteepened sites prone to failure.**

6. **Others?**

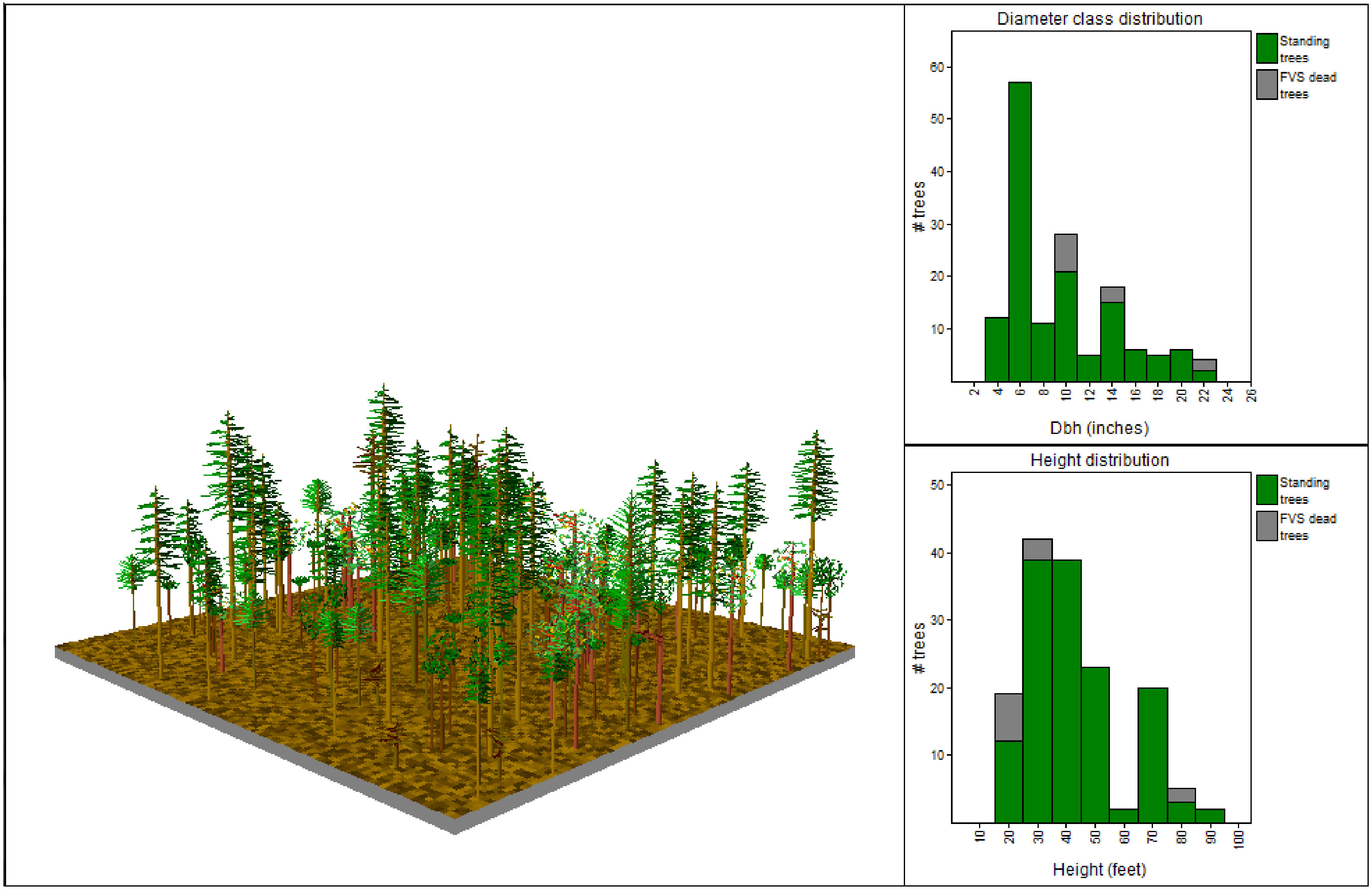
Note: Silvicultural strategies 1, 2 and 3 have been implemented with a history of up to 20+ years; Strategies 4 and 5 (and 6?) being considered for implementation in the near future in an adaptive management framework.

Stand Structure Type 4

Ponderosa pine, California black oak, whiteleaf manzanita with planted pines

Lower Watershed Units C1, C2; some locations in Siskiyou Mountain Park and other properties in City limits

Lower Watershed Units C1 and C2



Climate Change Adaptation

Stand Structure Type 4

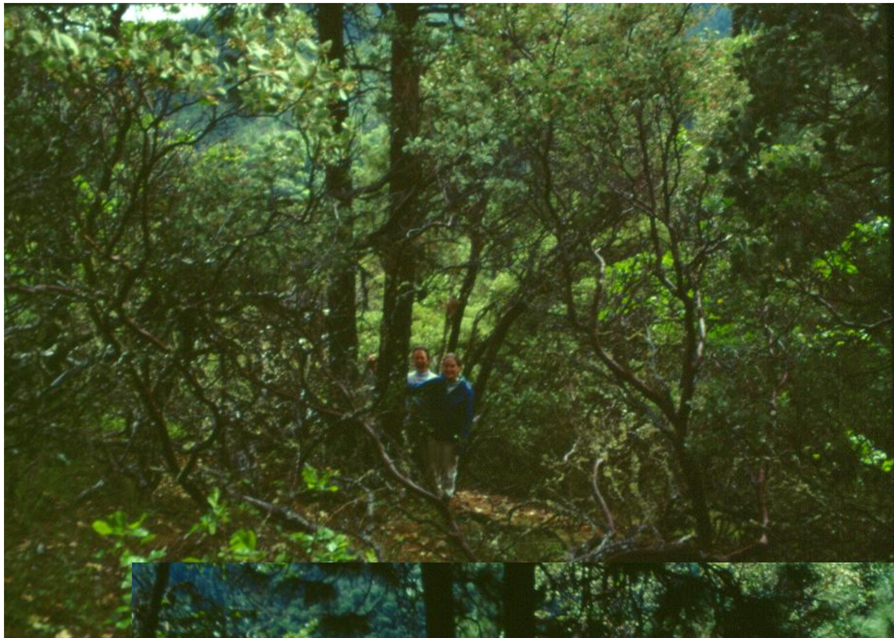
- Intensively managed for fire management objectives by reducing prevalence of whiteleaf manzanita and encouraging more open forests dominated by ponderosa pine and California black oak; maintain patches of important shrub species where possible for wildlife and pollinator habitat **(Persist).**

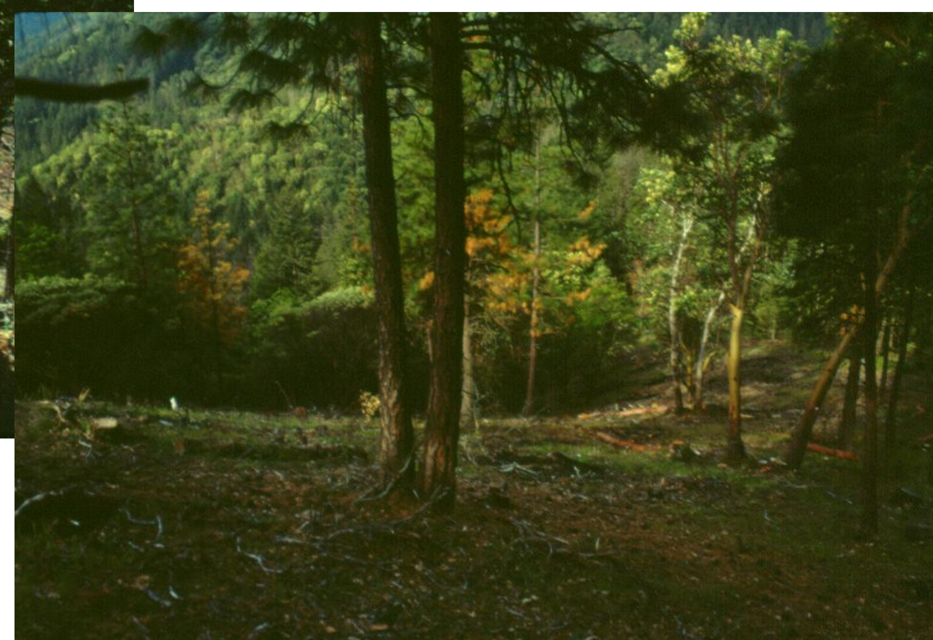
- Initiate and maintain frequent, low severity disturbance regime with continued utilization of prescribed fire when possible to achieve objectives (**Persist**).

- Ongoing monitoring for invasive species, including grasses **(Persist).**

- Important area for recreational values in scattered parcels within or close to City limits (**Persist, Change**)

City of Ashland
Unit LW-C2
1996





Unit C2 Maintenance Treatments

1996-97- Thinning/brushing, piling, burning

1997- Plant conifer seedlings

Winter 2004/05; 2006/07; 2010/11; 2020- Maintenance treatments (brushing/grubbing manzanita seedlings, blackberry, Scotch broom, etc)

Winter 2010/11- Low prune pine saplings

Spring 2012- Prescribed underburn

Spring 2021 or 2022- Prescribed underburn planned

City of Ashland Unit C2- 2015


Unit LW-C2, 2021

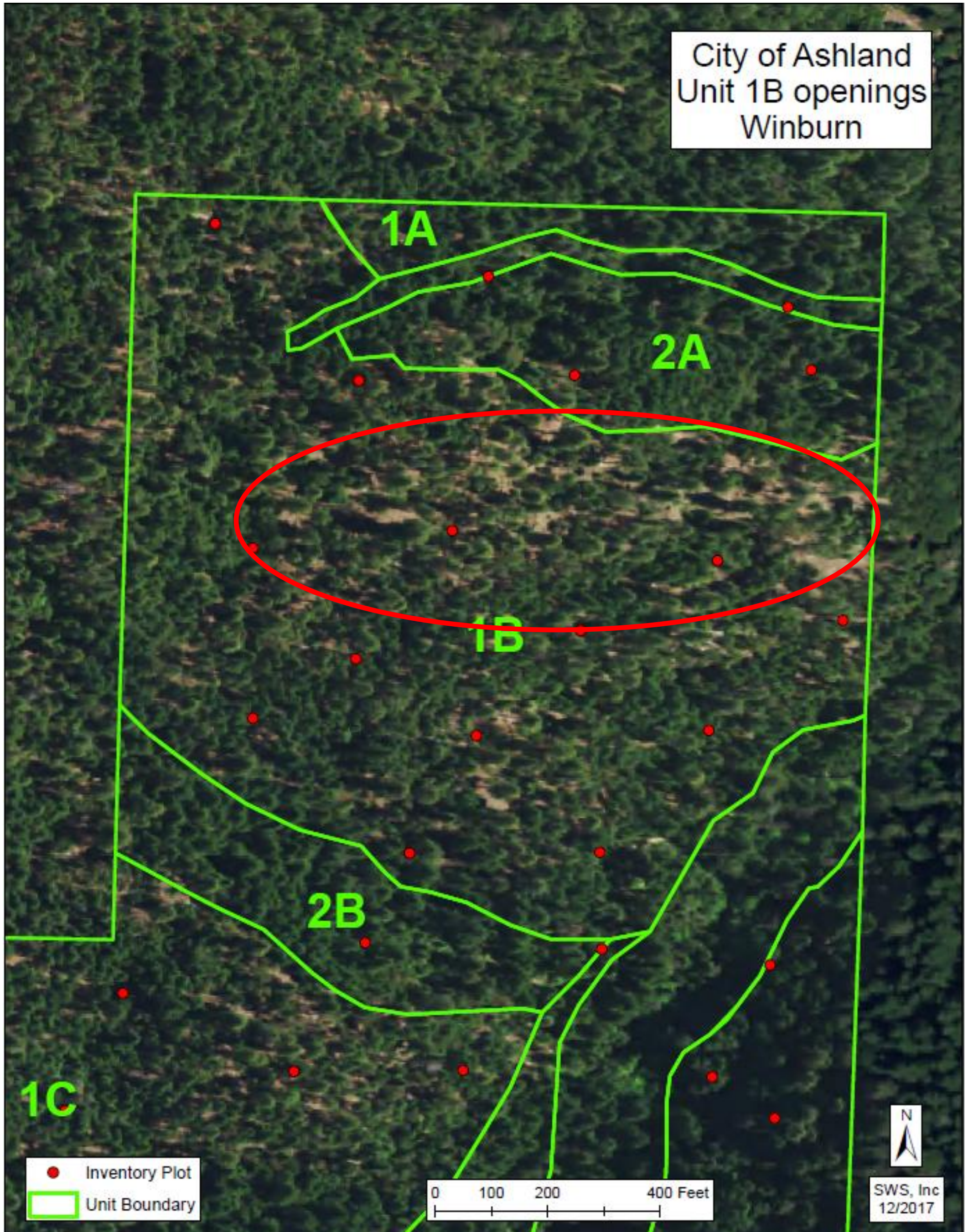
Crowson Reservoir Unit, 1998

manzanita cut, piled and burned, skips retained; native grasses planted

Example of conversion of a fire-prone dense manzanita brushfield to a closer approximation of the historic open Ponderosa pine/grass community with skips of manzanita retained. In area surrounded by homes within Ashland City limits.

Crowson Reservoir Unit, 2020

Protect, Promote and/or Accelerate Development of Older Forests



Restoring Late Open Structural Forest Characteristics in Unit 1 on the Winburn Parcel (especially in the upper third slope position)

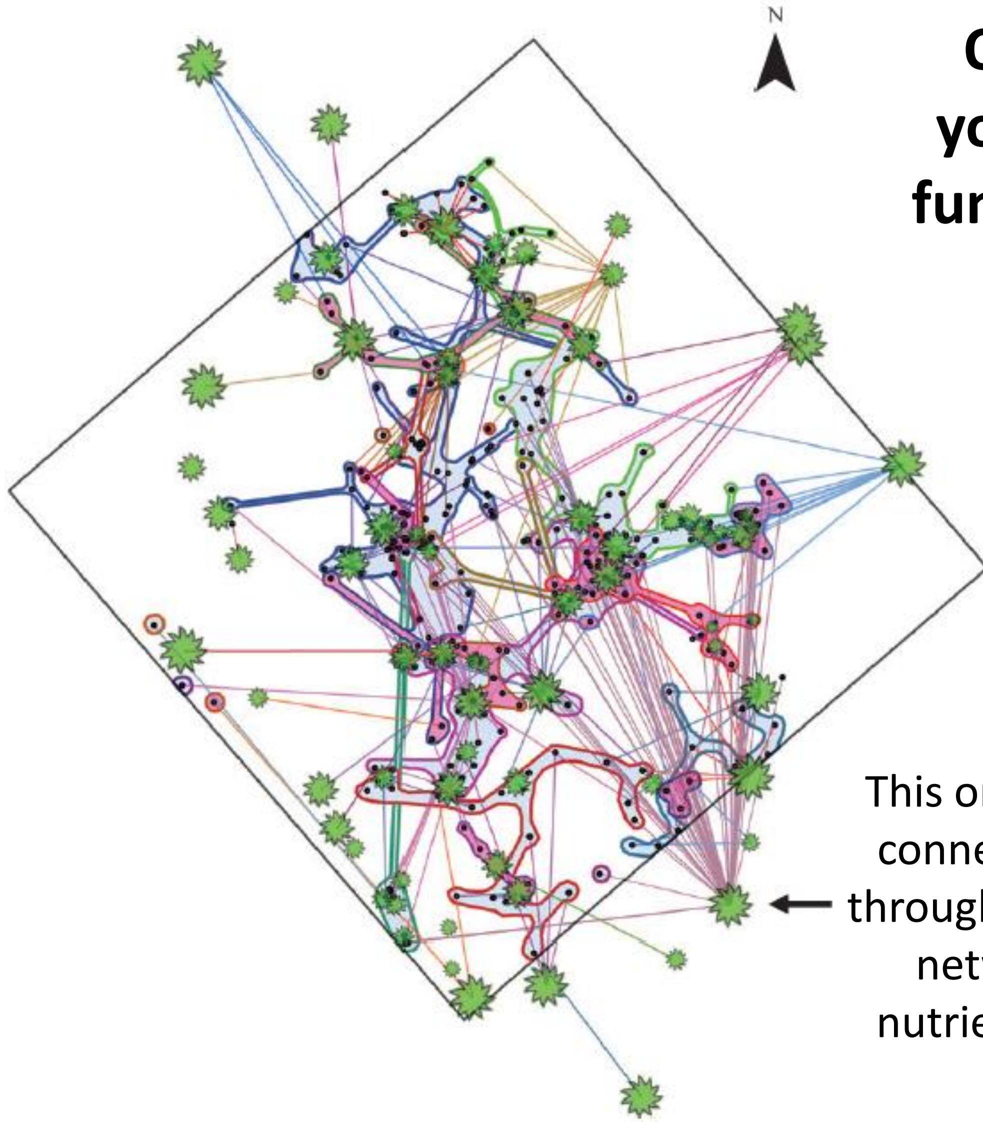
"The first law of intelligent tinkering is to retain all of the pieces."

Aldo Leopold, A Sand County Almanac, 1948

This implies the greatest care possible, especially with those valuable "pieces" that are the most threatened and at-risk.

Unit LW-M1, 1997

Non-commercial pre-treatment around legacy tree minimized potential damage from prescribed underburning that followed in Unit LW-M (1997). First cross boundary treatment in the country performed by the US Forest Service under the Wyden Amendment.



Older forests and younger forests are functionally different

This one tree was found to be connected to 47 other trees through complex below-ground networks, sharing water, nutrients, carbon and others

Source: Beiler et al. “Architecture of the wood-wide web: Rhizopogon spp. genets link multiple Douglas-fir cohorts.” New Phytologist 2009


Post prescribed burn 2016
Main Property, Trail, Oregon
Raking around pine completed pre-burn

City of Ashland Legacy Tree Radial Thinning

Winburn Parcel Units 1 and 5
2000-2013

2000- Non-commercial thinning in 50' radius around 139 legacy trees of 4 different species; basal area reduction from 197 to 171 ft2/acre but only of trees < 7" dbh with high sapwood basal area

2003- Stand level non-commercial thinning, piling and burning

2013- 2 legacy trees have died in 13 years (0.11% annually)

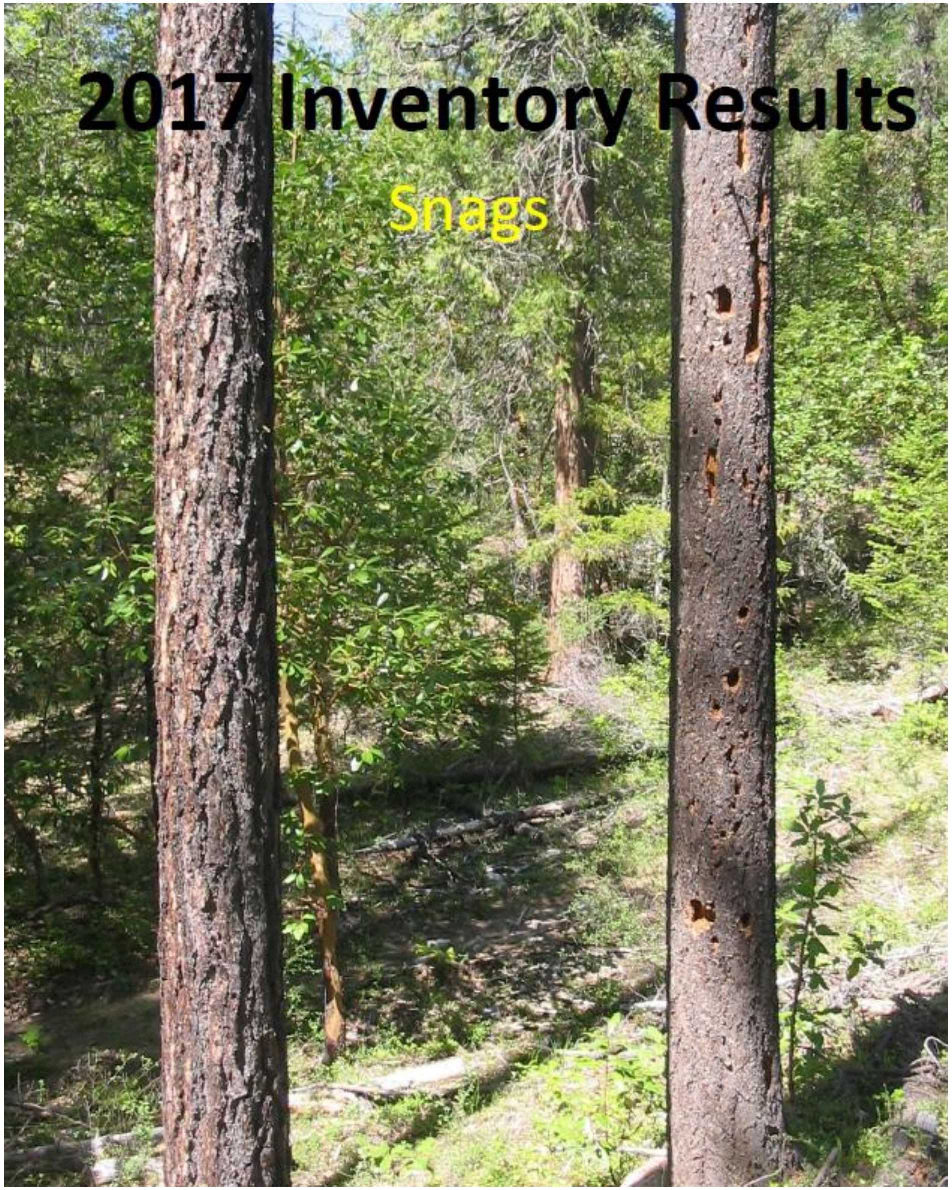
2013- Helicopter thinning; average post-treatment basal area 93 ft2/acre around legacy trees in subunit 1b; piling and burning thinning slash retaining scattered wildlife piles far removed from legacy tree.

2016- Raked around all legacy pines in Units 1,5 to minimize cambial heating during any future fire.

Major Point:

Multiple conservative interventions (staged thinnings) can be used to help large, old , highly stressed trees adjust more gradually to desired stand densities after 100 +/- years of changes in disturbance regimes and stand conditions, above and belowground. Stand level thinning appears to be more successful than radial thinning at improving vigor of older trees.

Source: Main. 2013. Winburn Parcel 2013 Treatment Summary



Changes in Snag Abundance, 2007-2017- Lower Watershed

Unit	# of Plots	Snags per acre by diameter class							
		5-11"		11-19"		19"+		Total	
		2007	2017	2007	2017	2007	2017	2007	2017
A1	3	0	0	0	14	0	0	0	14
B	14	10	19	5	10	0	0	15	29
C	5	13	7	0	3	0	1	13	11
D	2	0	0	8	8	0	0	8	8
E	9	0	0	12	9	2	2	14	11
F	2	0	0	0	0	0	5	0	5
G	15	0	0	1	2	0	1	1	3
H	4	0	0	5	4	3	2	8	6
J	6	0	0	0	0	2	3	2	3
K	13	0	8	6	6	2	6	8	20
L	6	0	0	0	5	3	3	3	8
M1	4	0	0	4	4	0	0	4	4
M2	3	69	126	0	9	2	2	71	137
N	8	21	35	8	8	1	1	30	44
P	11	0	14	0	4	1	1	1	19
Q	6	0	0	6	4	1	1	7	5
R	5	11	17	13	12	4	3	28	32
S	6	10	5	2	2	2	6	14	13
W1	3	0	14	0	0	0	0	0	14
W2	4	40	61	19	10	0	2	59	73
Total*	129	7	12	5	6	1	2	13	20

Changes in Snag Abundance, 2007-2017- Winburn

Unit	# of Plots	Snags per acre by diameter class							
		5-11"		11-19"		19"+		Total	
		2007	2017	2007	2017	2007	2017	2007	2017
1	33	8	14	3	2	3	4	14	20
2	9	30	11	6	14	6	3	42	28
3	8	0	0	0	0	4	2	4	2
4	3	19	0	7	7	1	1	27	8
5	10	6	35	4	6	7	8	17	49
6	6	0	10	0	6	3	4	3	20
Total*	69	12	13	3	5	4	4	19	22

*Totals weighted by unit acreages

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

City of Ashland 2017 Snag Inventory

1. There has been a 62% increase in total snags in the Lower Watershed in the last ten year inventory period- from 13 to 21/acre- mostly in the 5-11” diameter size class.

2. There has been a 16% increase in total snags at Winburn in the last 10 year inventory period.

3. Larger snags >17” dbh are functionally the most important snags.

4. Winburn currently has 5 snags per acre and Lower Watershed has 4 snags per acre in the 17+ dbh size class- amounts which meet standards as described in Restoration 2 (2016 Ashland Forest Plan).

5. Large hardwood snags, though less common, are also important.

6. It is expected that snag amounts will continue to increase in the future, especially during droughty periods and with projected climate change.

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Important Points

1. Winburn has much greater amounts of downed woody debris than the Lower Watershed.
2. It is expected that ongoing mortality will continue to contribute to LWD amounts, and likely increase with climate-related changes.
3. The middle elevations in the Watershed are more productive, have significantly higher fuel loads and are more at risk of large scale, high severity fire.
4. The high fuel loads including many older larger decayed pieces, make prescribed underburning and mop-up, and even pile burning, difficult and hazardous after 100+ years of fuel accumulation.
5. Large woody debris are also key ecosystem elements of healthy older forests, serving many important ecological functions. Retaining a balance between this and increasing elevation of fire management concerns will present an ongoing challenge.

Lower Watershed Downed Woody Debris

Unit	# of Plots	Pieces per acre by size class (inches)				
		3-4	5-9	10-19	20+	Total
A1	3	165.1	309.2	177.7	0	652.0
B	14	18.4	33.6	6.0	0	58.0
C	5	82.1	24.6	0	0	106.7
D	2	0	304.0	18.0	0	322.0
E	9	2.9	10.2	5.5	0	18.6
F	2	296.5	125.6	0	0	422.1
G	15	22.4	18.3	2.0	0	42.7
H	4	0	58.9	59.5	0	118.4
J	5	18.2	63.2	0	0	81.4
K	14	4.2	11.4	4.0	0	19.6
L	6	70.5	23.0	9.8	0	103.3
M1	4	21.4	100.1	0	0	28.5
M2	3	14.0	5.8	0	0	19.8
N	8	32.0	34.8	4.1	0.4	71.3
P	11	19.8	10.5	0	0	30.2
Q	6	39.0	77.4	4.3	0	120.7
R	5	101.5	22.7	16.3	0	140.5
S	6	20.9	29.2	0	0	50.1
U	6	21.5	7.6	0	0	29.1
W1	3	123.1	97.6	22.8	0	243.5
W2	4	2.1	220.9	1.0	0	224.0
Total*	135	33.9	46.1	7.9	0.04	87.9

*Weighted by unit acreages

Winburn downed woody debris

Unit	# of Plots	Pieces per acre by size class (inches)				
		3-4	5-9	10-19	20+	Total
1	33	5.5	10.2	2.4	0.7	18.8
2	9	21.1	22.9	12.8	1.3	58.1
3	8	26.6	22.7	2.8	1.8	53.9
4	3	72.3	249.6	28.9	16.3	367.1
5	10	32.4	24.3	5.9	1.5	64.1
6	6	16.5	29.8	17.5	11.6	75.4
Total*	69	18.2	31.2	7.6	2.8	59.8

*Weighted by unit acreages

Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations

Accelerate Development of Older Forests of both Closed and Open Stand Structures

- Protect and encourage greater vigor in existing legacy trees
- Select vigorous larger second-growth trees of preferred species and, through careful stand management, aggressively maintain/increase their vigor, growth and subsequent resistance to insect, fire, drought, climate and other mechanisms of cumulative stress/decline
- Shift to greater numbers of more drought tolerant species to grow larger (e.g. pines)
- Rake accumulated bark mounds from around pines. Only 1 foot of raking is needed to minimize cambial heating damage of legacy tree during fire events. Already completed at Winburn; maintain as necessary
- Carefully manage snags and large woody debris; avoid too many or too few
- Keep overall stand densities from becoming excessive; carefully and regularly monitor.
- Restore a frequent, low severity disturbance regime. Utilize prescribed fire if appropriate and possible, and matched to site and stand conditions.
- Promote structural heterogeneity on multiple scales
- Incorporate openings, clumps and spatial patterning designed to fit the site and stand condition.

Refugia

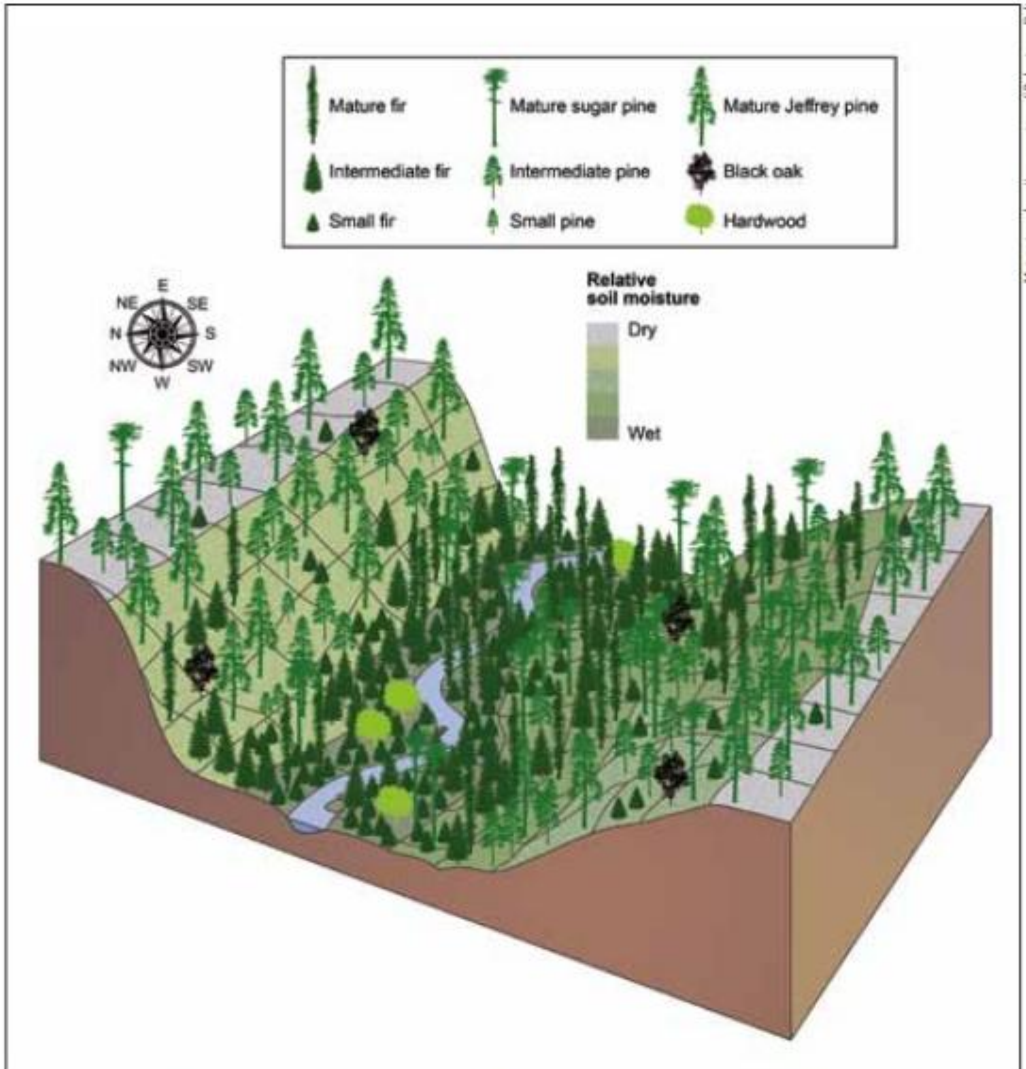


Figure 10—Landscape schematic of variable forest conditions produced by management treatments that differ by topographic factors such as slope, aspect, and slope position. Ridgetops have the lowest stem density and highest percentage of pine in contrast to riparian areas. Midslope forest density and composition varies with aspect: density and fir composition increase on more northern aspects and flatter slope angles.

Source: North et.al. 2009. An Ecosystem Management Strategy for Sierran Mixed-Conifer Forests

"Refugia are habitats that buffer climate changes and allow species to persist in—and to potentially expand under—changing environmental conditions. Our landscape scale study suggests that cold-air pools, an important type of small-scale refugia, have unique fire occurrence, frequency, and severity patterns in frequent-fire mixed conifer forests of California's Sierra Nevada: cold-air pool refugia have less fire and if it occurs, it is lower severity. Active management, such as restoration and fuels treatments for climate change adaptation, may be required to maintain these distinctive and potentially important refugia."

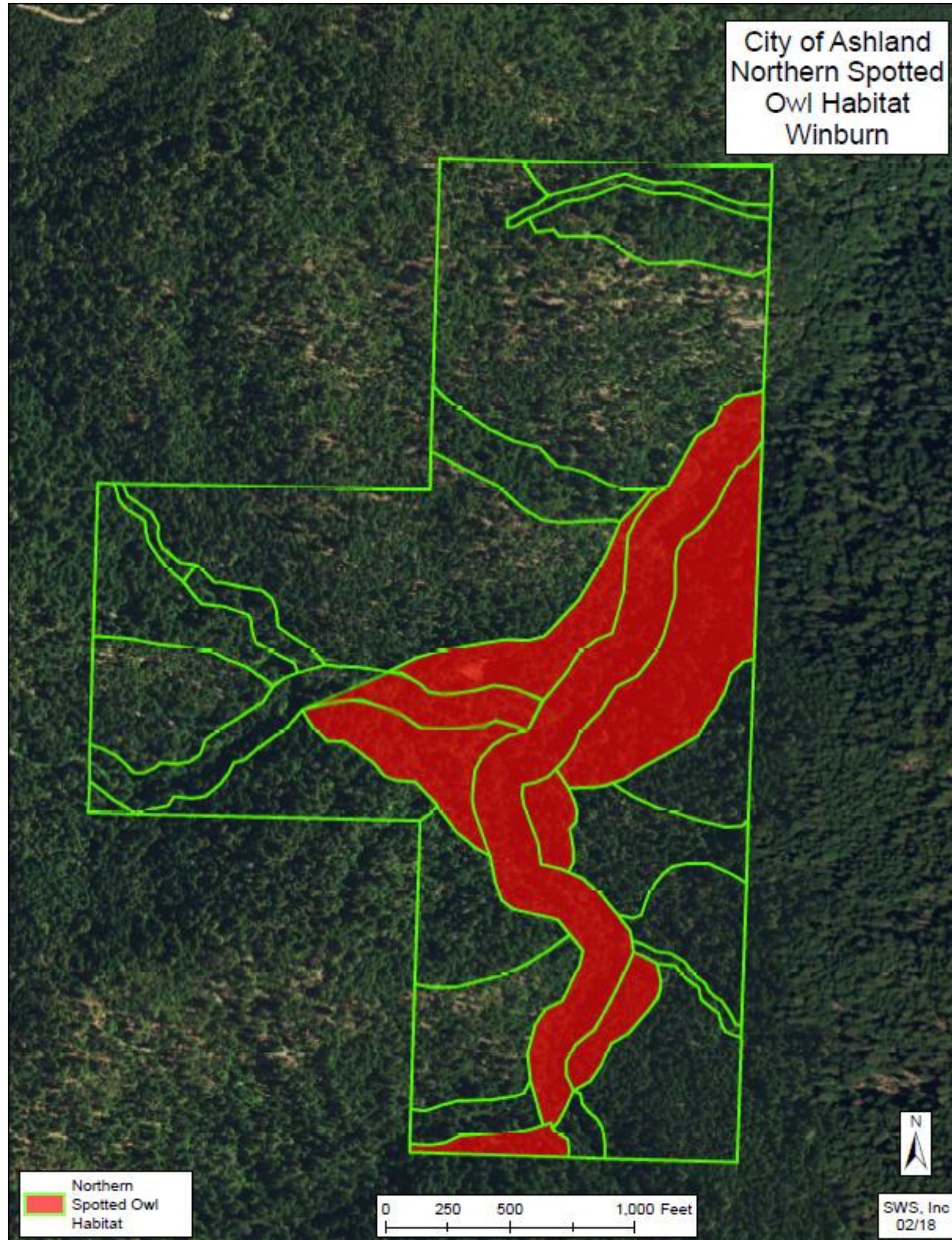
- Wilkin et.al. 2016. Climate Change Refugia, Fire Ecology and Management

"Refugia most often located on lower slope positions and north and east aspects."

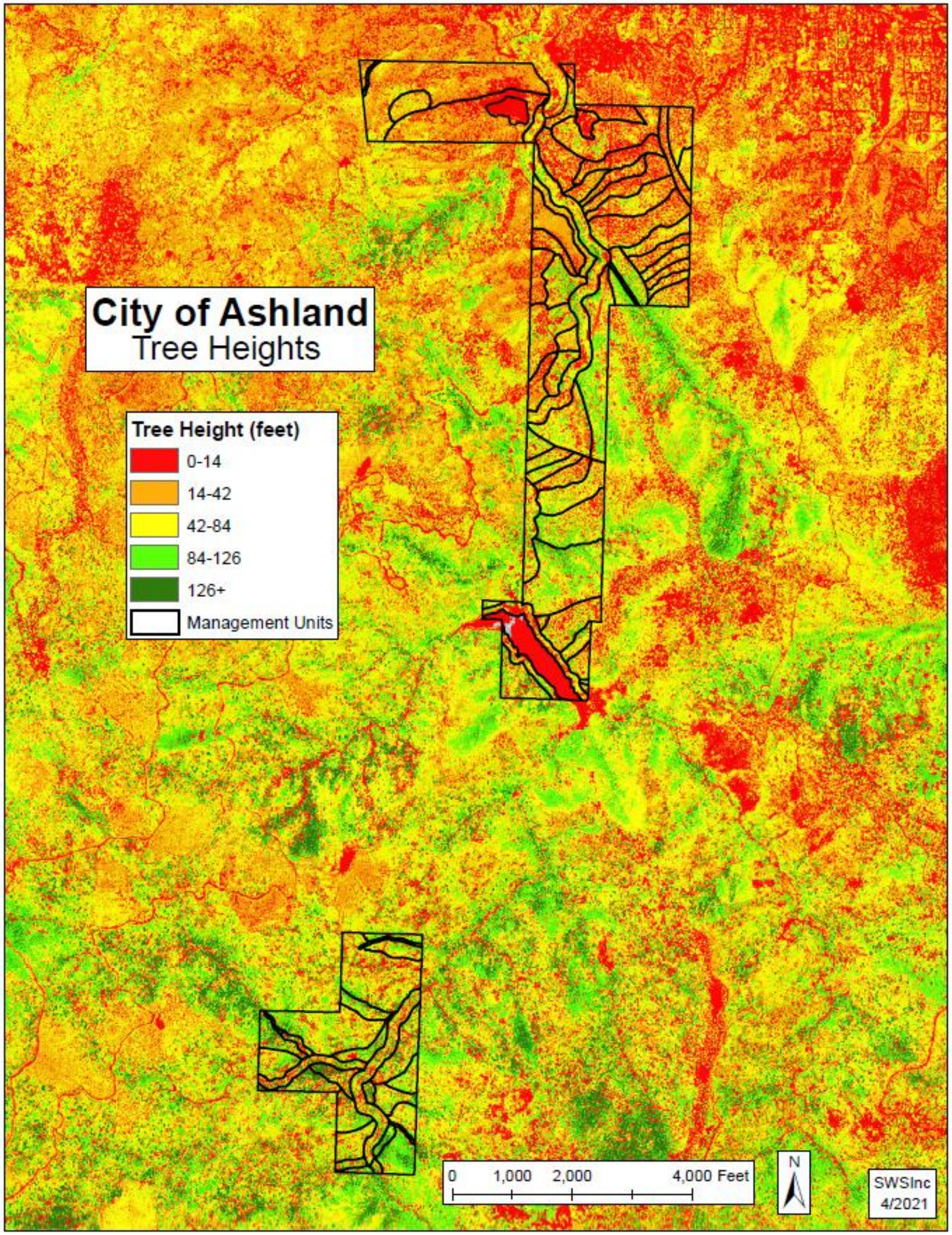
-Taylor and Skinner 1998. Fire history and landscape dynamics in a late-successional reserve, Klamath Mountains, California, USA.

Refugia on the Winburn Parcel

Units 3, 6 and aquatic/riparian habitat along West Fork Ashland Creek; naturally cool, moist habitat locations



Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Management Recommendations



Tree heights can be used to help identify refugia as the tallest trees are typically located in the coolest, moistest environments (i.e. valley bottoms, more northerly aspects) with subsequent high site productivities. These locations, often within and adjacent riparian woodlands, are often both fire and climate refugia.

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

Main Point- The likelihood of increasing scale and severity of disturbance and subsequent loss of ecological benefits and ecosystem services associated with more frequent low severity disturbance is the most significant climate change induced vulnerability on the City of Ashland Forestlands

1. **Persist in trying to minimize the potential for large scale, high severity disturbance. Most severe vulnerability on City of Ashland Forestlands**
   a. **Fire- the most important large scale, high severity disturbance to avoid/minimize (Persist! Change- do more!)**
   b. **Insects- more significant agent of disturbance than usually realized (Persist)**
   c. **Pathogens- the most underrated of the common disturbance agents, with long-term effects (Persist,Change)**

2. **Encourage frequent low severity disturbance and in the process help create a diversity of desired stand structures, densities and compositions. The City of Ashland is a great example of accomplishing objectives while re-engaging in frequent, low to moderate severity "planned disturbance" (Persist, but increase the pace and scale of treatments)**

3. **Post high severity disturbance. Options for providing for Ecosystem Services are dramatically reduced…and not easily replaced in any short or medium time frame. Persist in trying to avoid, or at least minimize, the need to address this issue by taking more aggressive management actions sooner. KEEP GREEN FORESTS AND THE ECOSYSTEM SERVICES THEY PROVIDE!**

What kind of forest do we want?

What kind of disturbance do we want?

How can we minimize negative outcomes from a looming huge disturbance agent?

(**i.e. Climate Change**)

Active Stand Management =

“Planned Disturbance”

Frequent Low severity Small scale	→	Infrequent High severity Large scale

Active Management i.e. “Planned Disturbance”

In essence, vegetation management responsibly applied should emulate (not duplicate) the historic disturbance regime, utilizing silvicultural practices i.e. “planned disturbances” such as variable density thinning, thinning-from-below, prescribed underburning, etc. Strategically arrange them, both spatially and temporally, to help maximize achievement of pre-designated objectives.

Keep Green Forests!

The question of how much it will cost to keep green forests may not be as important as how much will we lose if we don't!

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

1. Minimize the potential for large scale, high severity disturbance: a. Fire

a. Continue stand density reduction and slash treatment, including prescribed underburning **(Persist)**

b. Avoid development of outbreak levels of mortality and subsequent fuel accumulations; build vigor in stands that can release from thinning treatments ahead of stand decline where insects can gain a foothold and elevate mortality (**Persist, Change**)

c. Continue strategic location of fuel reduction treatments followed by ongoing maintenance. Increase size and area of fuel reduction zones to allow opportunities during more severe fire behavior **(Persist, Change)**

d. Middle elevations of Ashland Watershed (Winburn) are most at risk due to increased site productivity , a similar lack of disturbance and resulting fuel tonnages and fire prone vegetation; prioritize elevate fire management activities over time at Winburn **(Persist, Change)**

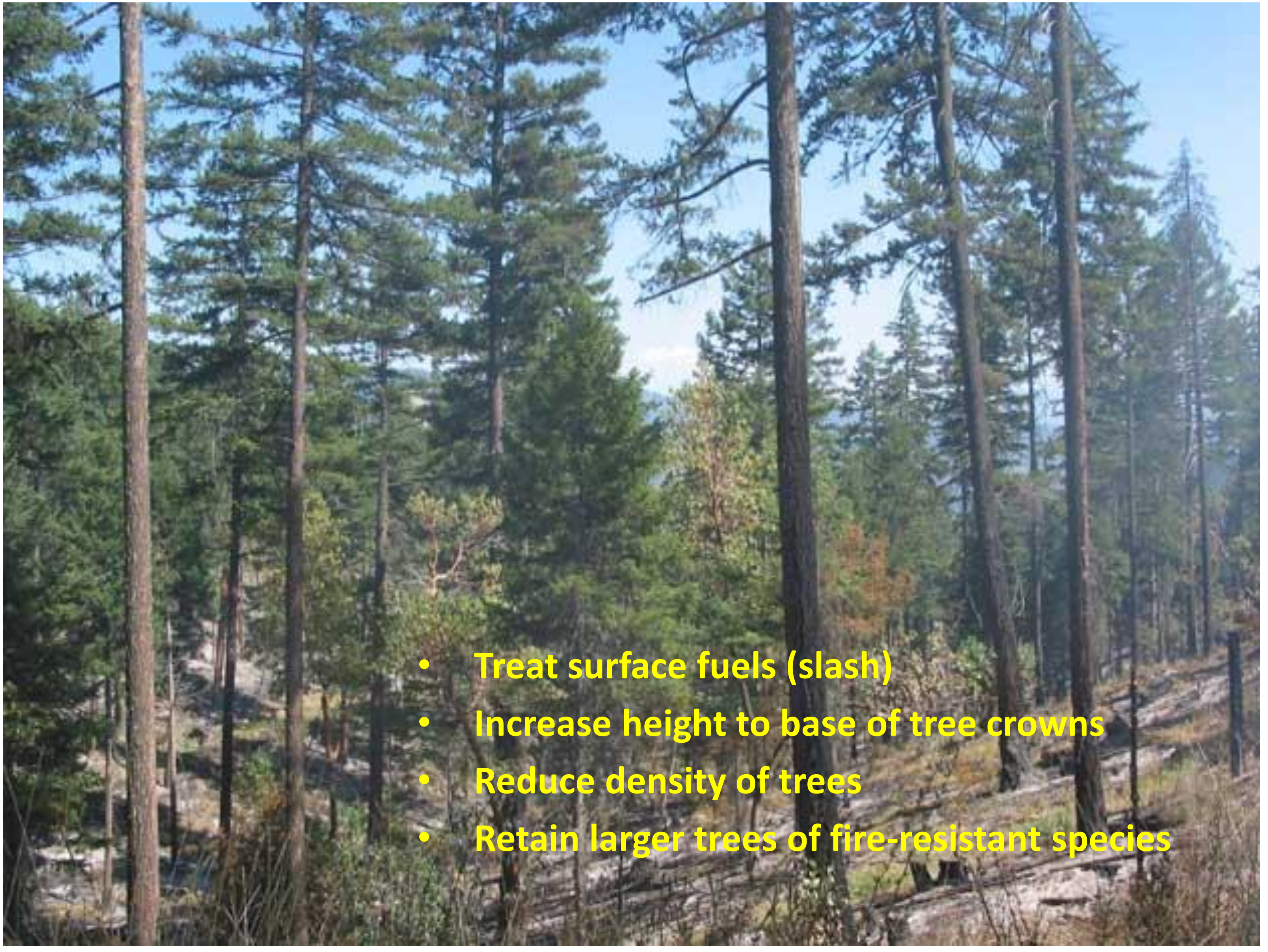
e. Begin developing plans and considerations for when landscape level conditions might allow accomplishment of fire management objectives during severe wildfire events. Further develop use of Potential Operational Delineations (PODS). Conduct fire management planning at larger scales of reference than only City ownership and with other key partners (**Persist, continue to prioritize consideration of fire management at larger scales of reference).**

f. Prioritize ongoing maintenance of areas already treated. Do not lose investment in key acres and/or treat more acres than can be maintained. These treated and maintained areas, stategically located, will continue to provide the greatest benefit, especially those close to the urban environment. Regular ongoing monitoring of the need for maintenance. (**Persist**)

“The status quo of primarily focusing on fire suppression policies will inevitably result in large, high severity wildfires that will not conserve many of the values that managers and the public desire from forests (high quality water, aesthetics, wildlife habitat for many species, recreation, carbon sequestration)”.

Stephens et. al. 2010. Operational approaches to managing forests of the future in Mediterranean regions within a context of changing climates

Four Principles of Fuels Management



Source: Agee and Skinner. 2005. Basic principles of forest fuel reduction treatments.

Create Fuel Discontinuities in Horizontal and Vertical Directions

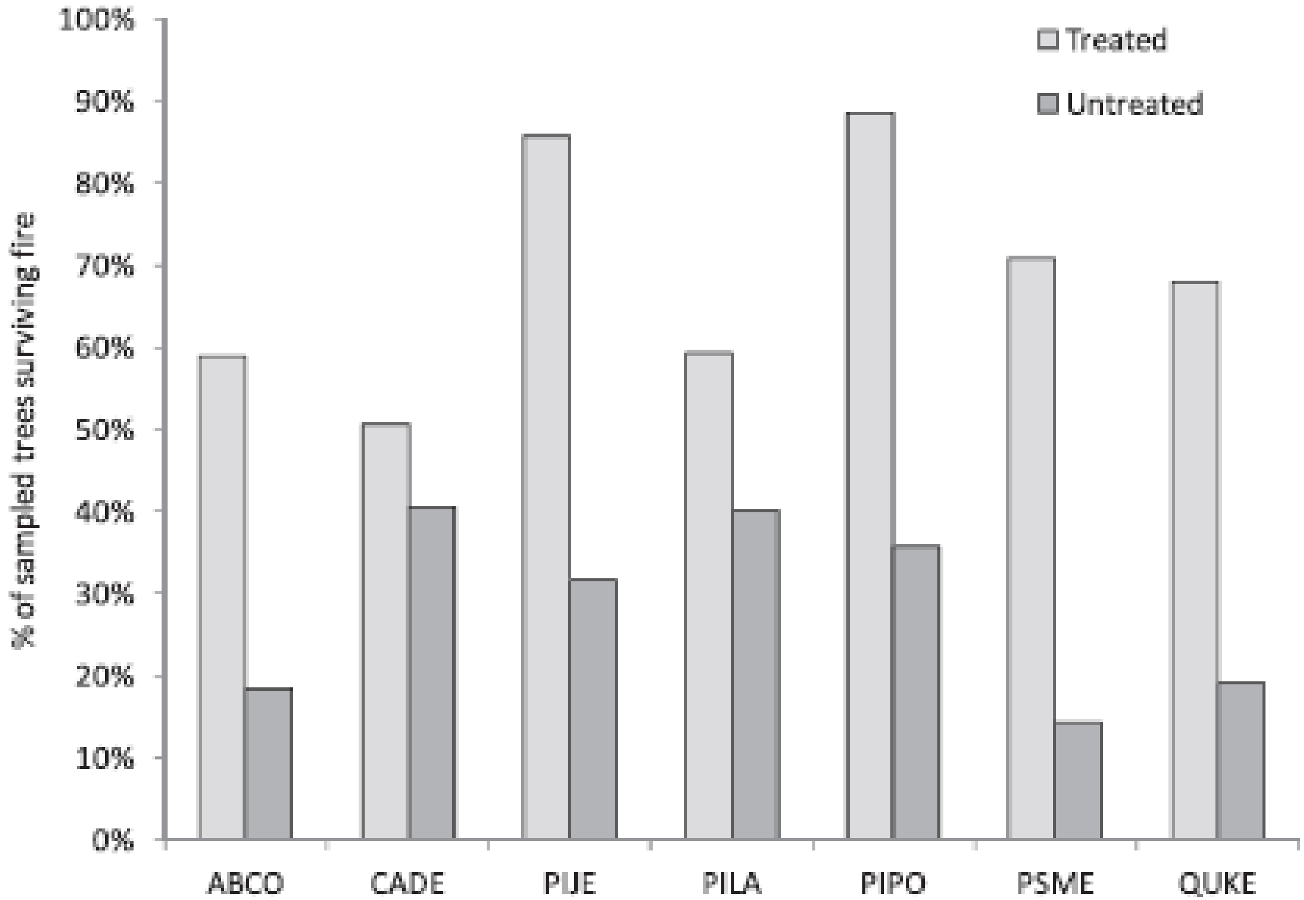
Horizontal- Fuelbreaks, canopy gaps

Vertical- Thinning-from-below

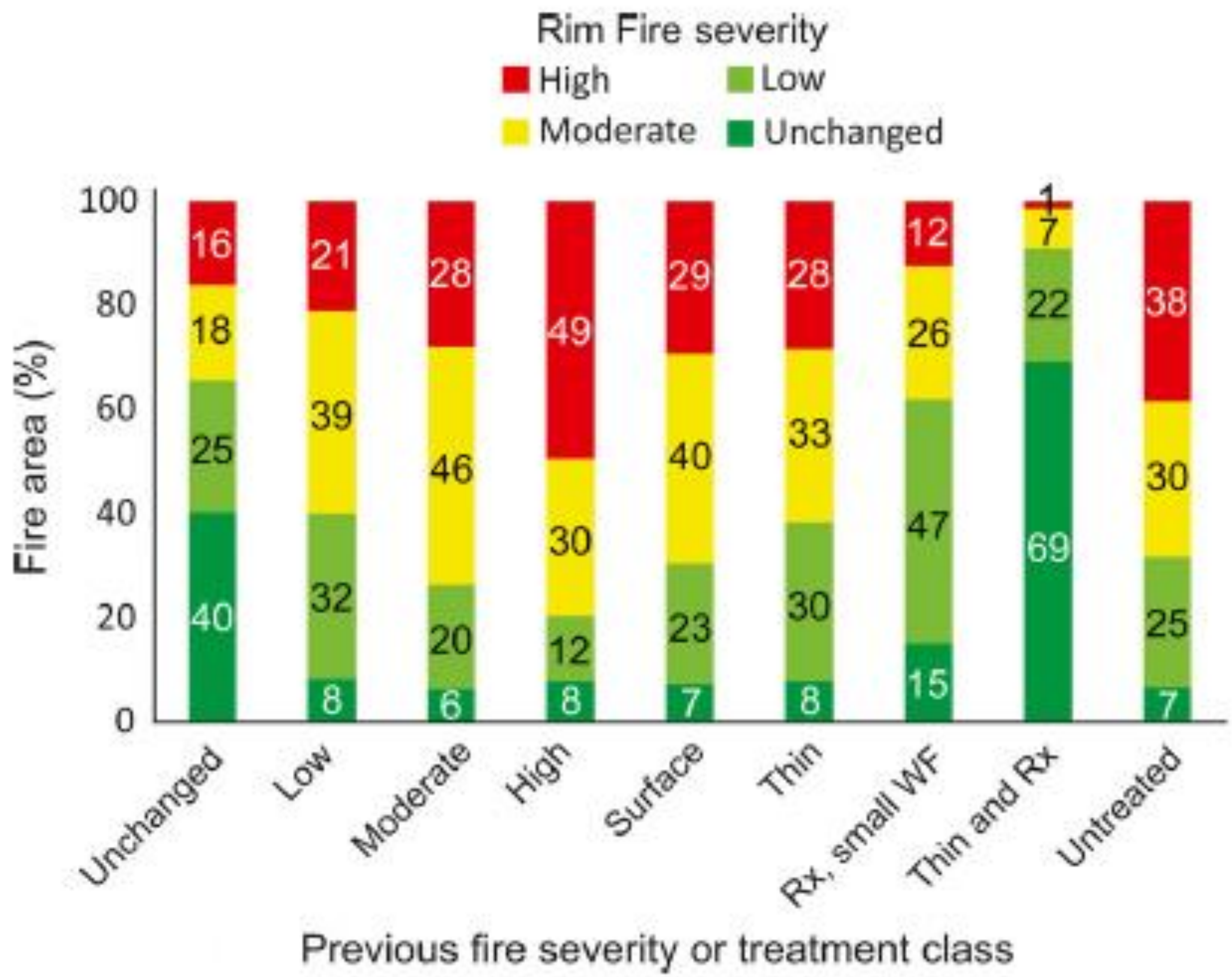
Both- Variable Density thinning

Effects of Fuels Treatments in 12 Wildfires in California

Percent Tree Survival by Species



Source: Safford et.al. 2012. Fuel treatment effectiveness in California yellow pine and mixed conifer forests.

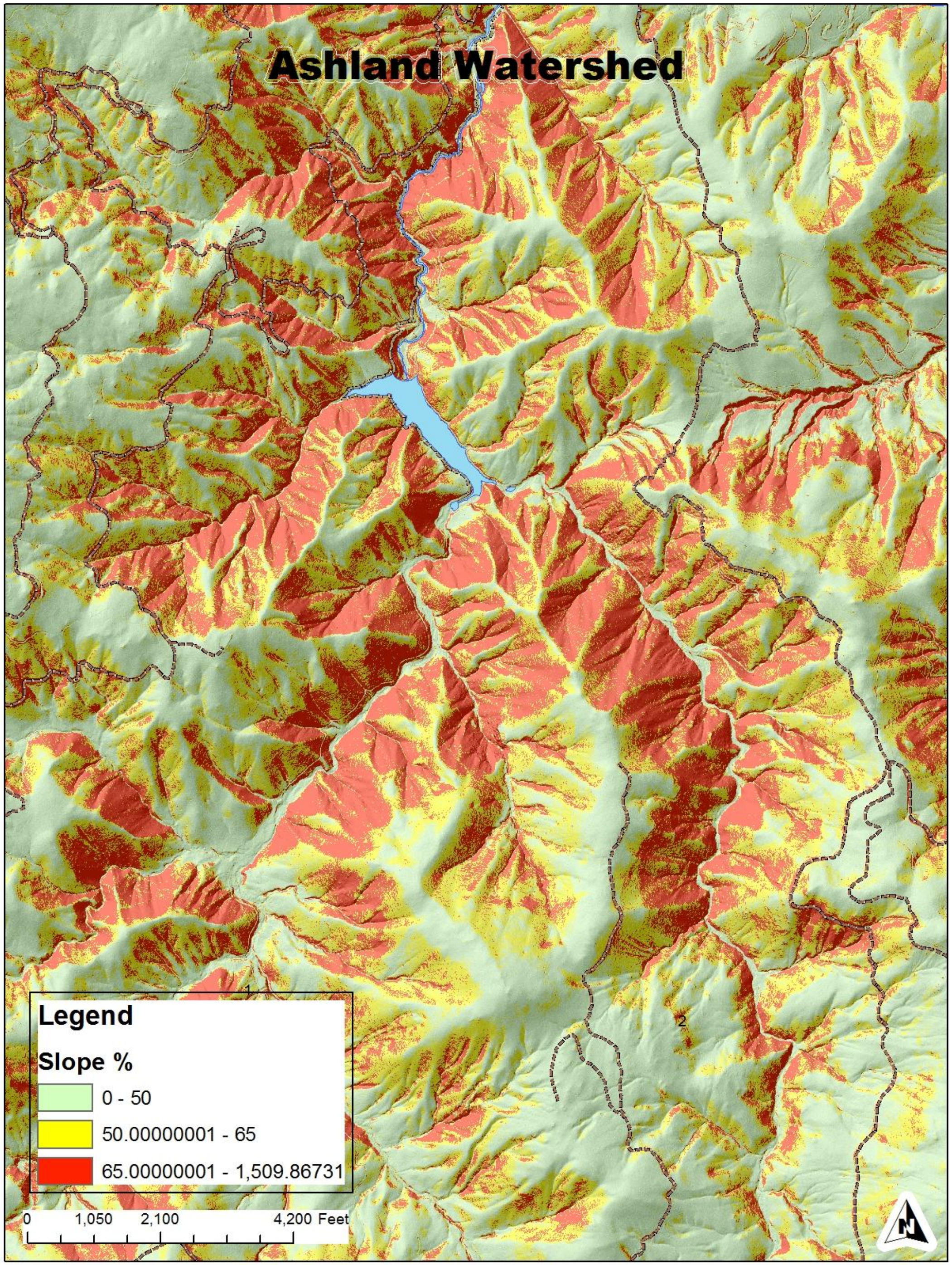


Source: Lyderson et. al. 2017. Evidence of fuels management and fire weather influencing fire severity in an extreme event.

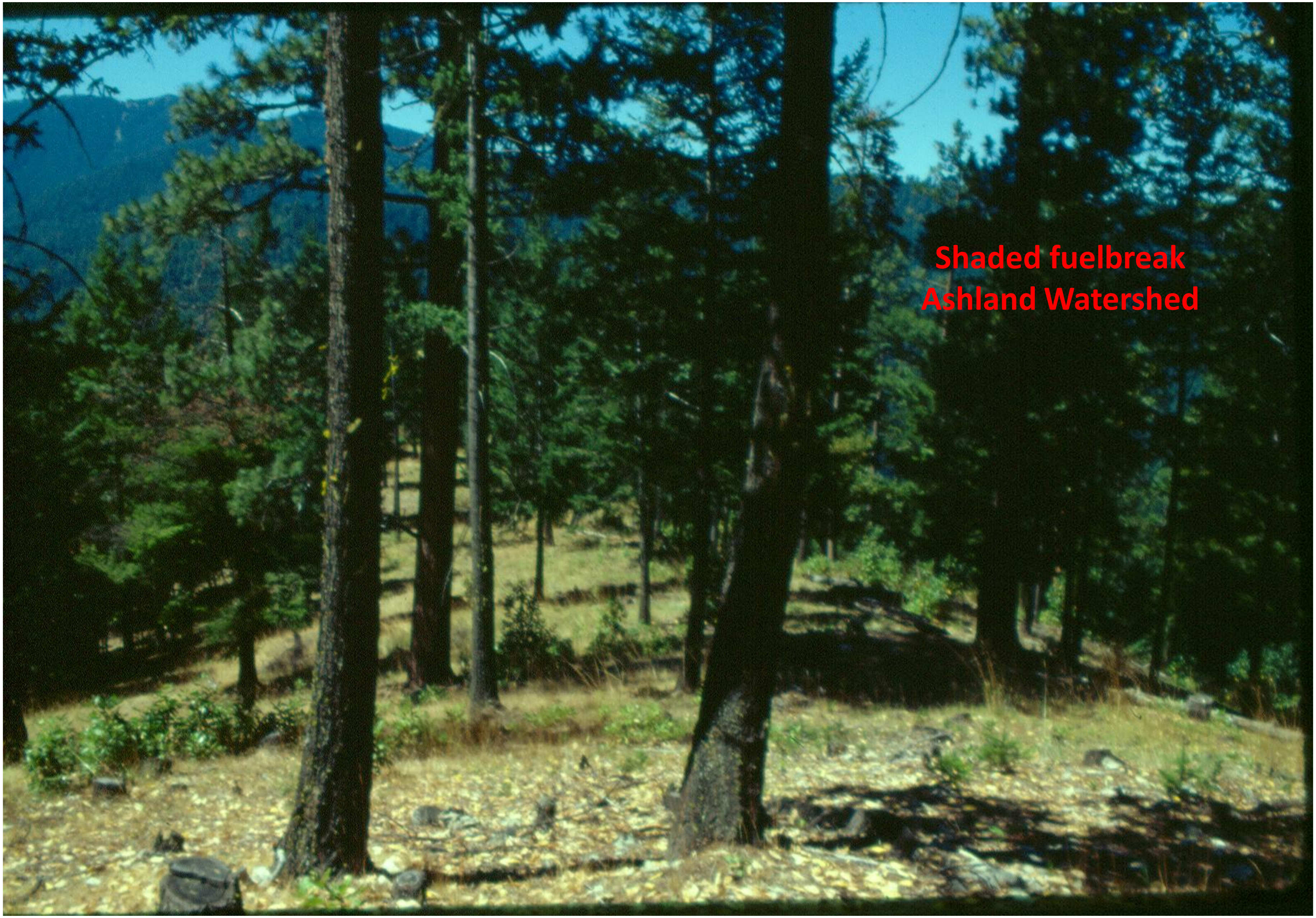
Percentage of Landscape Needed for Fuels Treatment (SPLATS, Etc.)

Several recent studies have indicated that strategically locating treatment within a small fraction of the landscape (e.g., 18%–20%) can significantly limit landscape fire spread and severity (Finney 2001, Calkin et al. 2011, Collins et al. 2011, Ex et al. 2019, Tubbesing et al. 2019).

Source: Stephens et.al. 2021.Forest Restoration and Fuels Reduction: Convergent or Divergent?

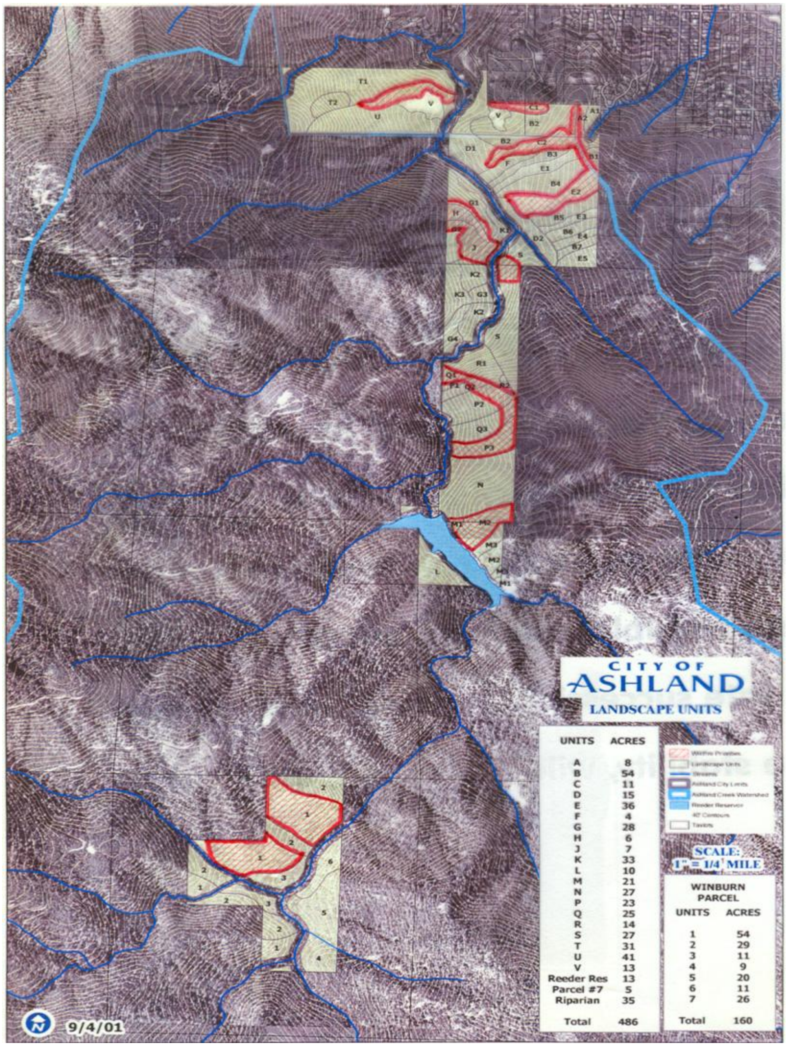


Although much of the Ashland Watershed is steep, including the City ownership, fire management objectives should be able to largely be accomplished while avoiding the steeper portions of the landscape which, coincidentally, are the areas less likely to benefit from fuels treatments designed to reduce fire behavior and/or effects.


Shaded fuelbreak
Ashland Watershed

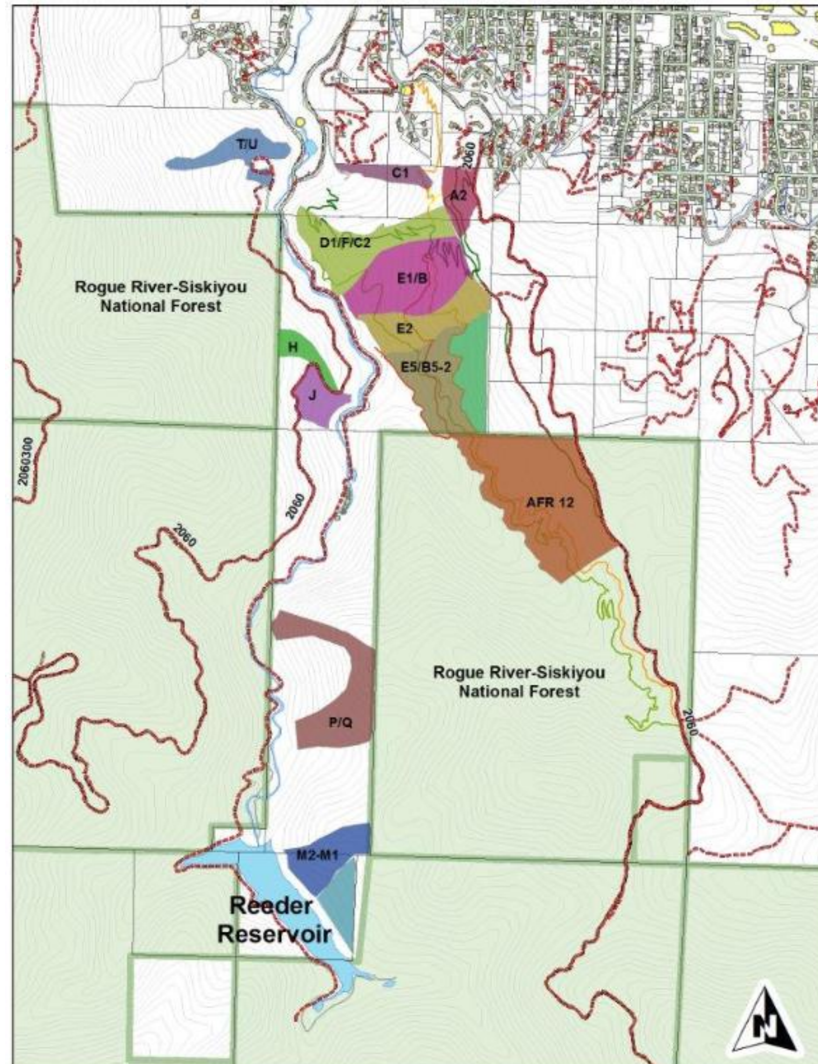
Spatial Priorities for Treatment to Stop Advancing High Severity Wildfire

- Ridgelines- broader is better; up to ¼ mile in each direction if possible.
- Perennial streams with broad floodplains and vegetation with high foliar moisture year-round.
- Gentle to moderate southerly aspects.



City of Ashland Fire
Management Priorities (1996)

City of Ashland Fire Units
Underburned 2021



Strategic Climate Adaptation Fire Management Priorities

Phase 1: Continued prescribed underburning

Lower Watershed (maintenance)

- Units B,C,D,E,F,J,H

Phase 2: High Priority Clusters

Lower Watershed

- A1/A2
- B1/B2
- C2/F/D
- B3,E1,B4,E2,
- H/J
- P/Q
- M1/M2

Winburn

- 1,5

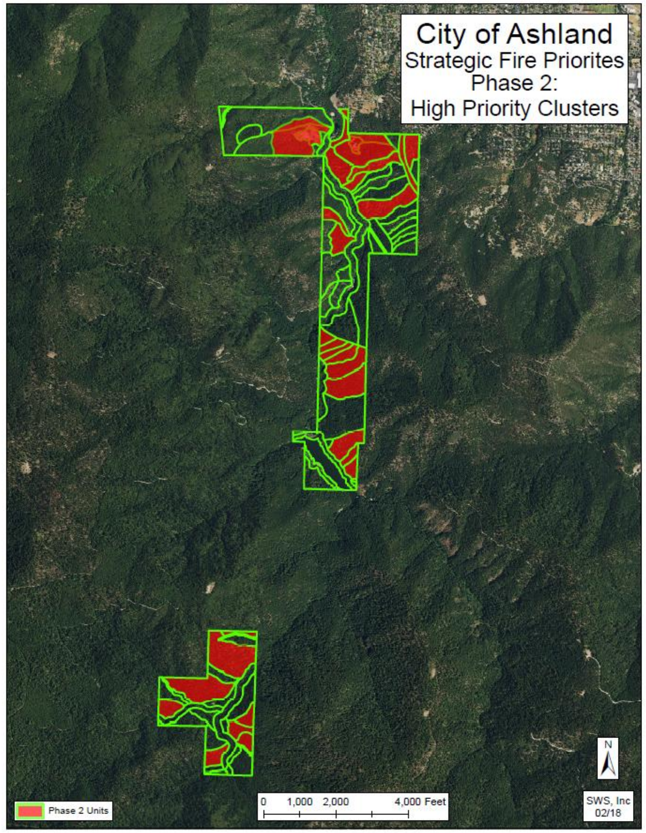
Phase 3: High Severity Blocks

Lower Watershed

- B1-E5,
- H/J/G2/K2/G4 (with USFS),
- M1/M2 (with USFS),
- P/Q (with USFS),
- Siskiyou Mtn. Park/Epstein/USFS

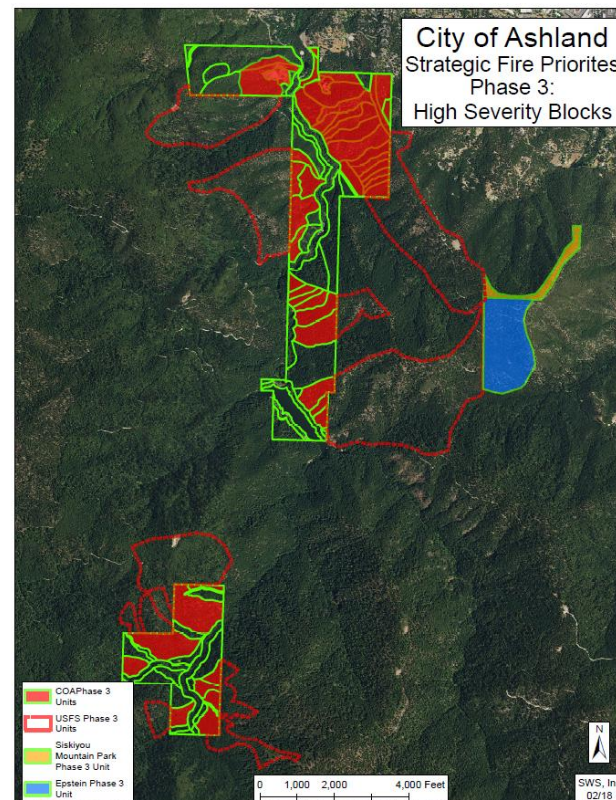
Winburn

- 1,4,5 (with USFS)



Phase 2

Phase 3



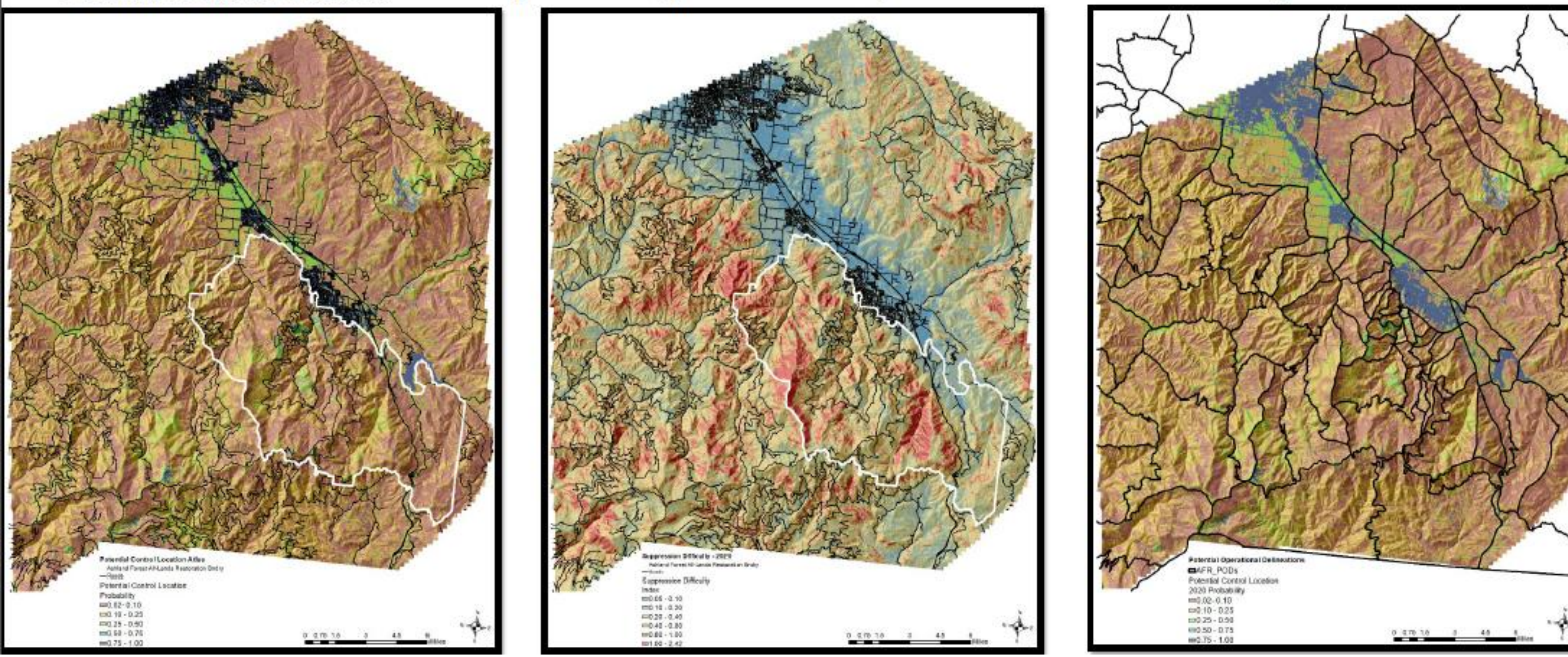
How much is enough? With ongoing increases in temperature and expanded fire seasons?

1. Plan strategically.
2. Expand footprint of “planned disturbance” (thinning, prescribed fire)
3. Avoid steeper landslide-prone slopes, at least initially
4. Create larger fuel reduction zones as opportunities for increased successful suppression in high severity events
5. Landscape level approach (PODs)
6. Maintenance, maintenance…and more maintenance (i.e. ongoing frequent, low to moderate severity disturbance); do not treat more acres than can be maintained

PODs (Potential Operational Delineations)

“By integrating quantitative risk science, expert judgement and adaptive co-management, this process provides a much-needed pathway to transform fire-prone social ecological systems to be more responsive and adaptable to change and live with fire in an increasingly arid American West.”

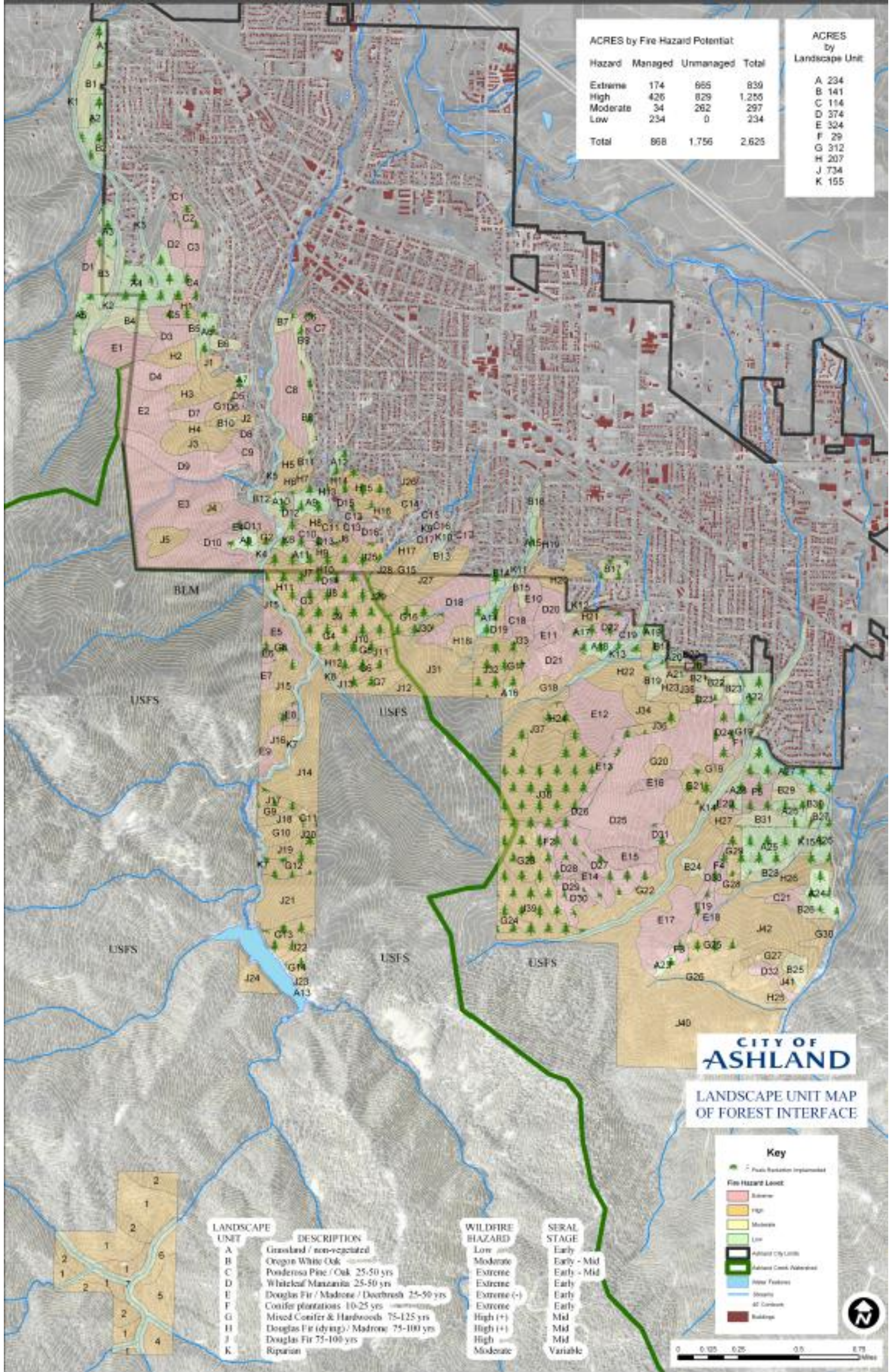
Potential Control Locations + Suppression Difficulty Index + Local knowledge = PODs



Source: Dunn et.al. 2020. Wildfire risk science facilitates adaptation of fire-prone social-ecological systems to the new fire reality.

Continue to restore frequent, low to moderate severity planned disturbances (e.g. multi-cohort, multi species variable density thinning) to shift stand densities, species and structures and ultimately to restore historical functional processes

- To reduce and maintain reduced fuels and vegetation on a regular basis
- To maintain continuous canopies and sufficient stand densities to continue to retard understory development of ladder fuels (i.e. let the vegetation do the work)
- To reduce windthrow potentials,
- To maintain or promote certain wildlife or aesthetic values
- To continue to provide future opportunities for economically viable thinning
- To maintains options to more rapidly change direction as needed in response to rapidly changing environmental variables
- To take advantage of all those important ecological relationships and outcomes that were accomplished through frequent, low severity disturbance that we have yet to understand, let alone implement .



Landscape level planning initiated in the Wildland Urban Interface by City of Ashland in 2002

- continue tracking and changing as necessary
- use to insure ongoing maintenance is regularly accomplished
- incorporate into larger scales of reference

Slide from: Main and Uhtoff, Small Woodland Services Inc. 2002. The Ashland Wildland/Urban Interface- Wildfire Management Inventory, Analysis, and Opportunities.

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

1. Prevent large scale, high severity disturbance: b. **Insects**

a. Stand density reduction; maintain high tree vigor; thin well in advance of drought (**Persist** in favorable locations)

b. Multi-aged, multi-species (but site and stand appropriate!) management; most insects are host-specific; understand species differences **(Persist)**

c. Intensive, microsite level management (Main and Schmidt 2020); variations in elevation, topography, soils, aspect, stand condition and likely other factors **(Persist)**

d. Shift (change) species at lowest productivity sites; thinning may not always produce an immediate response (Main 2006, Main and Schmidt 2020) **(Persist, Change)**

Annual Cooperative Aerial Mortality Survey- Number of Dead Trees, Rogue/Illinois Valleys, Siskiyou Foothills, Umpqua Interior Foothills, and Inland Siskiyou Bioregions

Species	2000	2001	2002
Sugar Pine	112	144	699
Ponderosa Pine	249	417	20,986
Douglas-fir	413	321	32,148

Source: Southwest Oregon Forest Insect and Disease Service Center

2001 was not the time to do thinning; 2-5 years (or more) before would have increased likelihood of success!

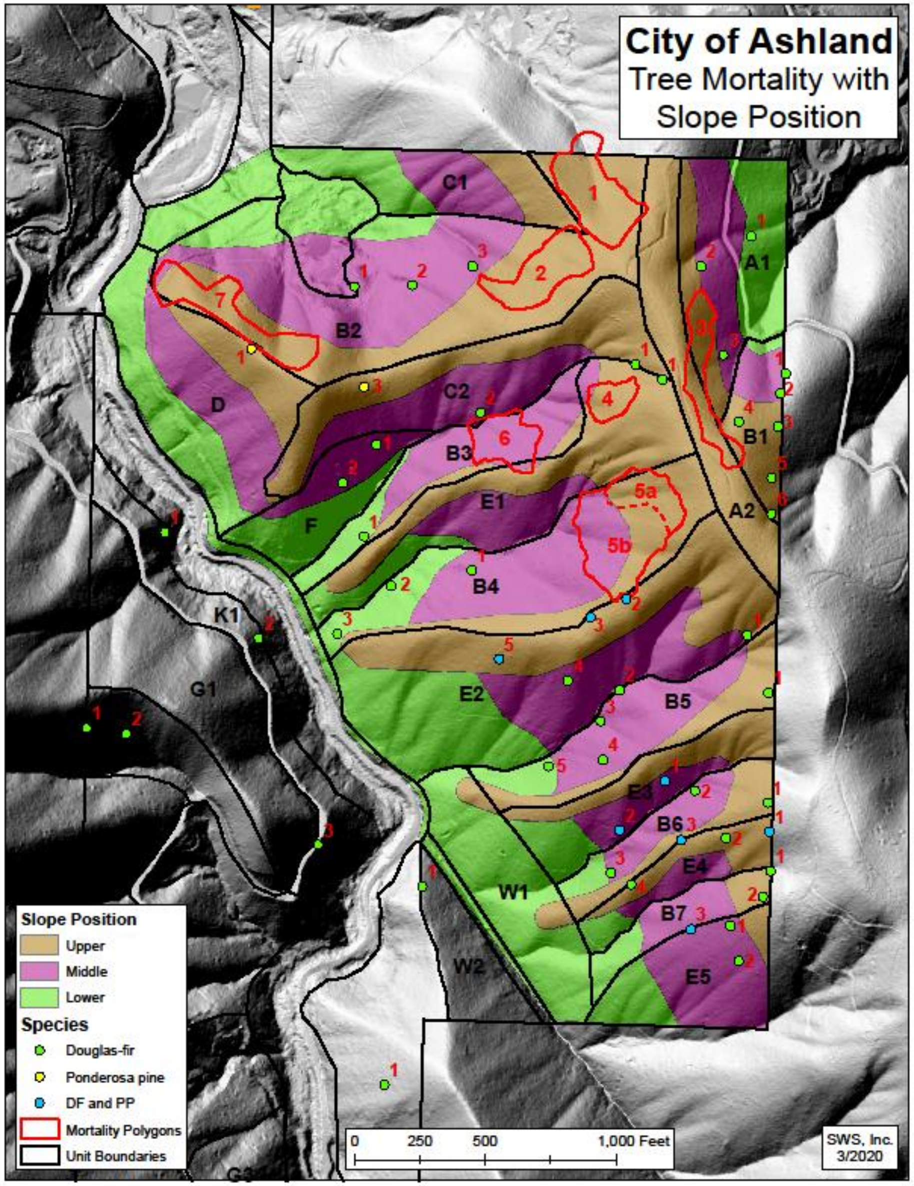
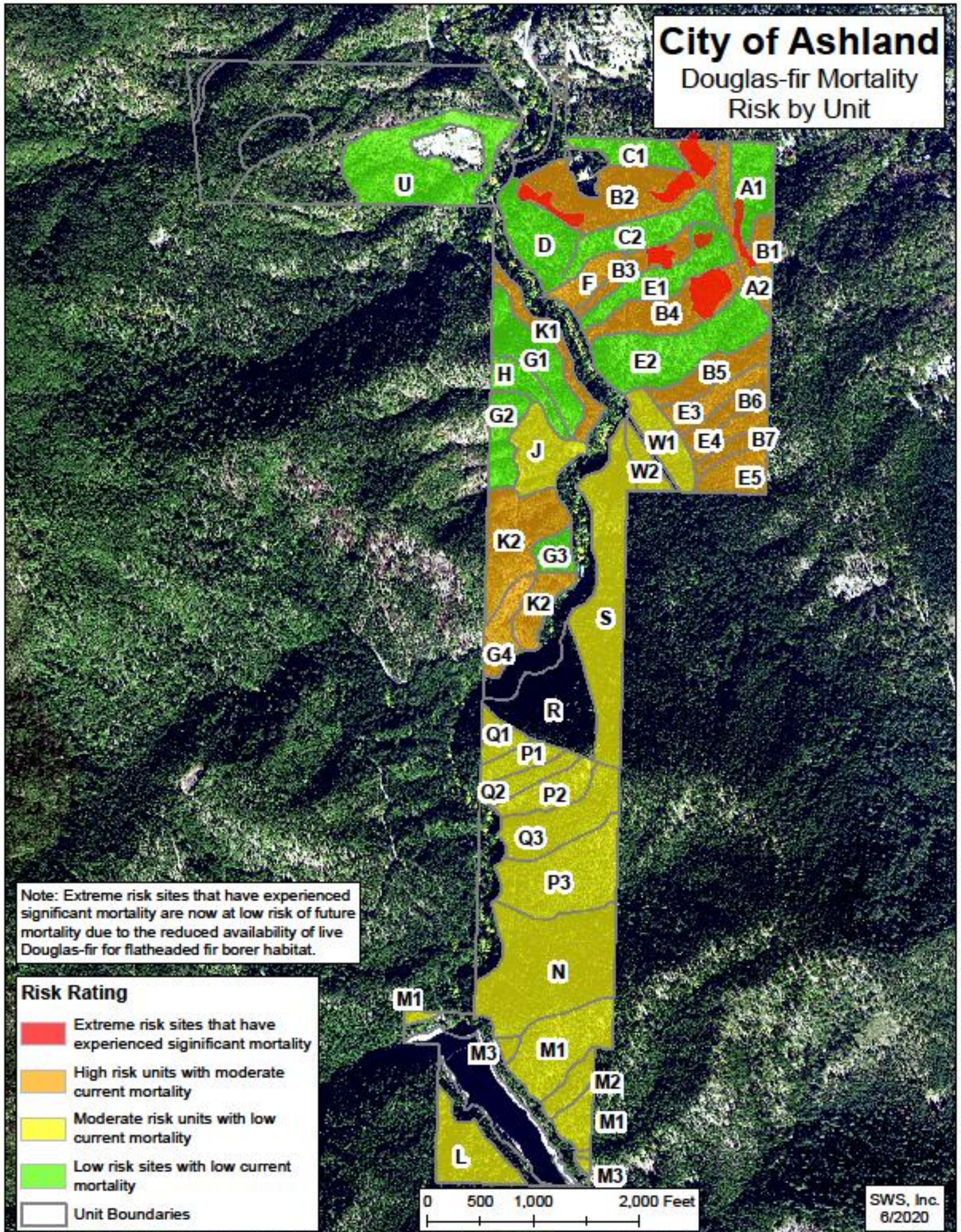


Table 2: Estimated conifer snags 8"+ DBH by slope position, Units A-F, W1

Slope Position	Acres	Douglas-fir	Pine	Total	Snags/ Acre
Upper	60.2	429	10	439	7.3
Middle	51.4	175	6	181	3.5
Lower	37.6	35	0	35	0.9

It is more difficult to expect favorable thinning response of Douglas-fir in the brown-shaded upper third slope locations. Red outlined polygons are areas where extensive mortality of Douglas-fir has occurred; very limited mortality has occurred in the green-shaded lower third slope positions.

Source: Main and Schmidt. 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis



Additional mortality of Douglas-fir can be expected in the near future in the orange shaded areas, hopefully in endemic rather than outbreak levels. Although less susceptible, mortality in the more productive yellow shaded areas may be minimized by further stand density reduction well ahead of major climatic stressors (e.g. drought).

Source: Main and Schmidt. 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis

Shifting to More Favorable Species Composition

Rust-resistant sugar pine seedling planted in recently burned pile location in Unit LW-B2; February 2021

Photo credit: Chris Chambers

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

1. Prevent large scale, high severity disturbance: c. **Pathogens**

a. Douglas-fir dwarfmistletoe
- retention in spatially explicit locations for owl habitat and other wildlife values; reduction elsewhere.
- individual tree management (rating, isolation, etc)
- mapping and monitoring

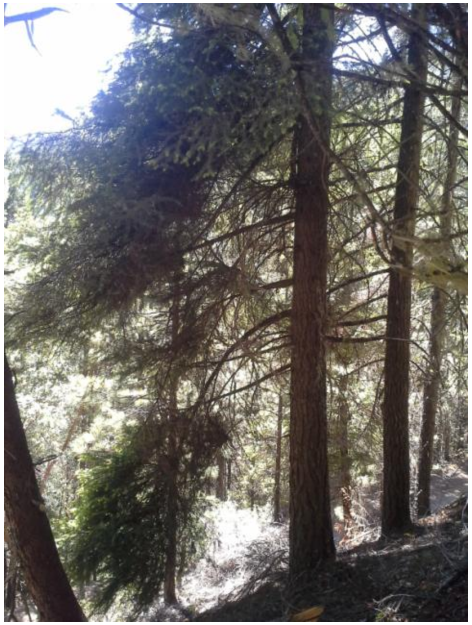
b. Laminated root disease
- mapping and monitoring
- opening creation is good, alternative species enhancement

c. Smoke

d. Others (ongoing monitoring)

Dwarfmistletoe disease in Douglas-fir

Important wildlife habitat value, especially large brooms for spotted owl nesting habitat, but also can aggravate fire behavior



The 6-Class Dwarf Mistletoe Rating System

Frank G. Hawksworth

Instructions

Step 1—Divide live crown into thirds.

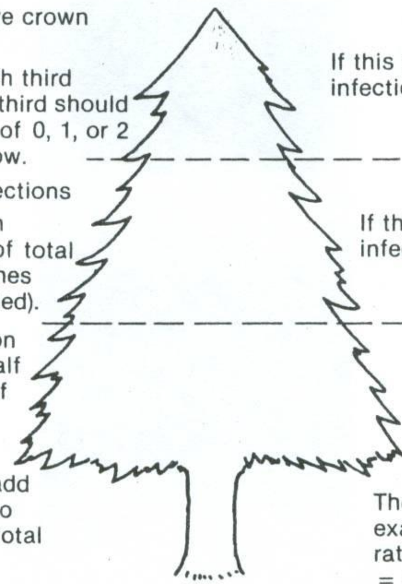
Step 2—Rate each third separately. Each third should be given a rating of 0, 1, or 2 as described below.

0—No visible infections

1—Light infection (one-half or less of total number of branches in the third infected).

2—Heavy infection (more than one-half of total number of branches in the third infected).

Step 3—Finally, add ratings of thirds to obtain rating for total tree.



Example

If this third has no visible infections, its rating is 0.

If this third is lightly infected, its rating is 1.

If this third is heavily infected, its rating is 2.

The tree in this example will receive a rating of 0 + 1 + 2 = 3.

2017 Douglas fir dwarf mistletoe infection summary

Lower Watershed

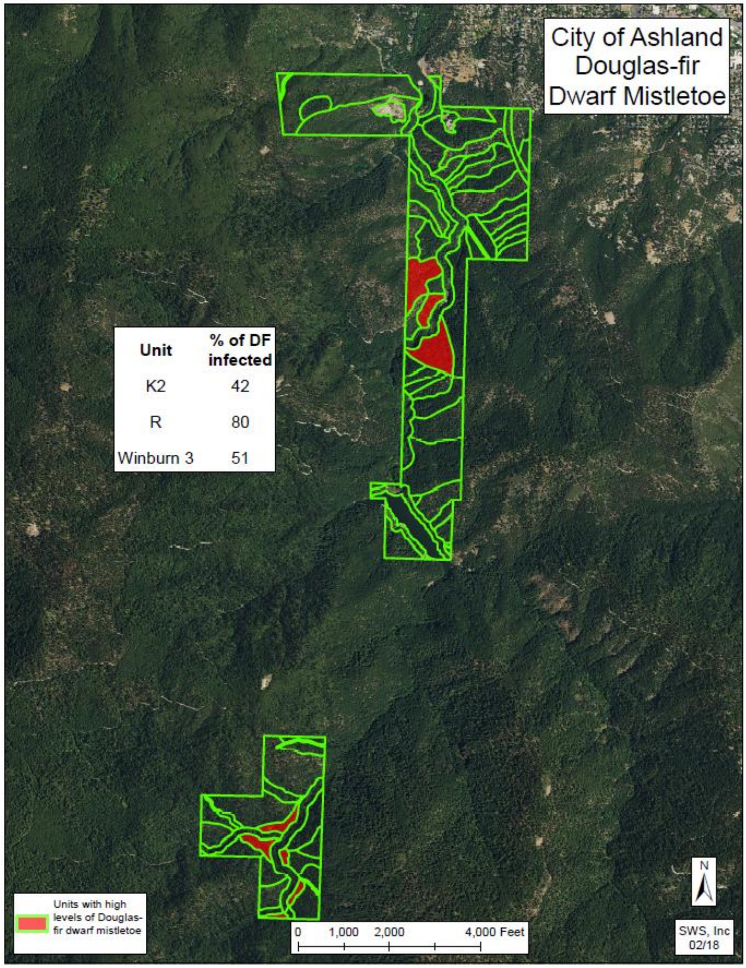
Unit	# of plots	Trees per acre by dwarf mistletoe rating								
		1	2	3	4	5	6	Total	% of PSME Infected	Average DMR
G3	5	-	1[1]	-	-	-	-	1[1]	<1	2.0
J	6	10	2	3	5	-	-	20	26	1.9
K2	6	2[1]	-	2[1]	2[1]	-	25	31	42	5.4
L	6	20	6	11	1[1]	-	-	38	11	1.8
M2	3	2[1]	1[1]	1[1]	2[1]	-	-	6	2	2.5
N	8	11	-	7[1]	-	-	-	18	10	1.8
R	5	127	20	32	6[1]	5[1]	20[1]	210	80	2.8
S	6	5[1]	-	-	-	-	-	5[1]	2	1.0
Total	45	-	-		-	-	-	-	26[2]	2.5

1. **Units with no mistletoe (12 out of 20 units) are not included in table.**
2. Less than 3 tree samples with mistletoe.
3. Total % is only for units with dwarf mistletoe and were weighted by unit acreages.

Winburn

Unit	# of plots	Trees per acre by dwarf mistletoe rating								
		1	2	3	4	5	6	Total	% of PSME Infected	Average DMR
1	33	11	8	3	1[1]	3	3[1]	29	25	2.4
2	9	8	7	2	1[1]	1[1]	<1[1]	20	12	2.2
3	8	24	19	6	5	1	10	65	51	2.5
4	3	6	7	-	-	-	-	13	16	1.5
5	10	9	3	4	1	1	1	19	15	2.2
6	6	8	8	1 1	1	6	1	35	13	2.8
Total	69	-	-	-	-	-	-	-	22	2.3

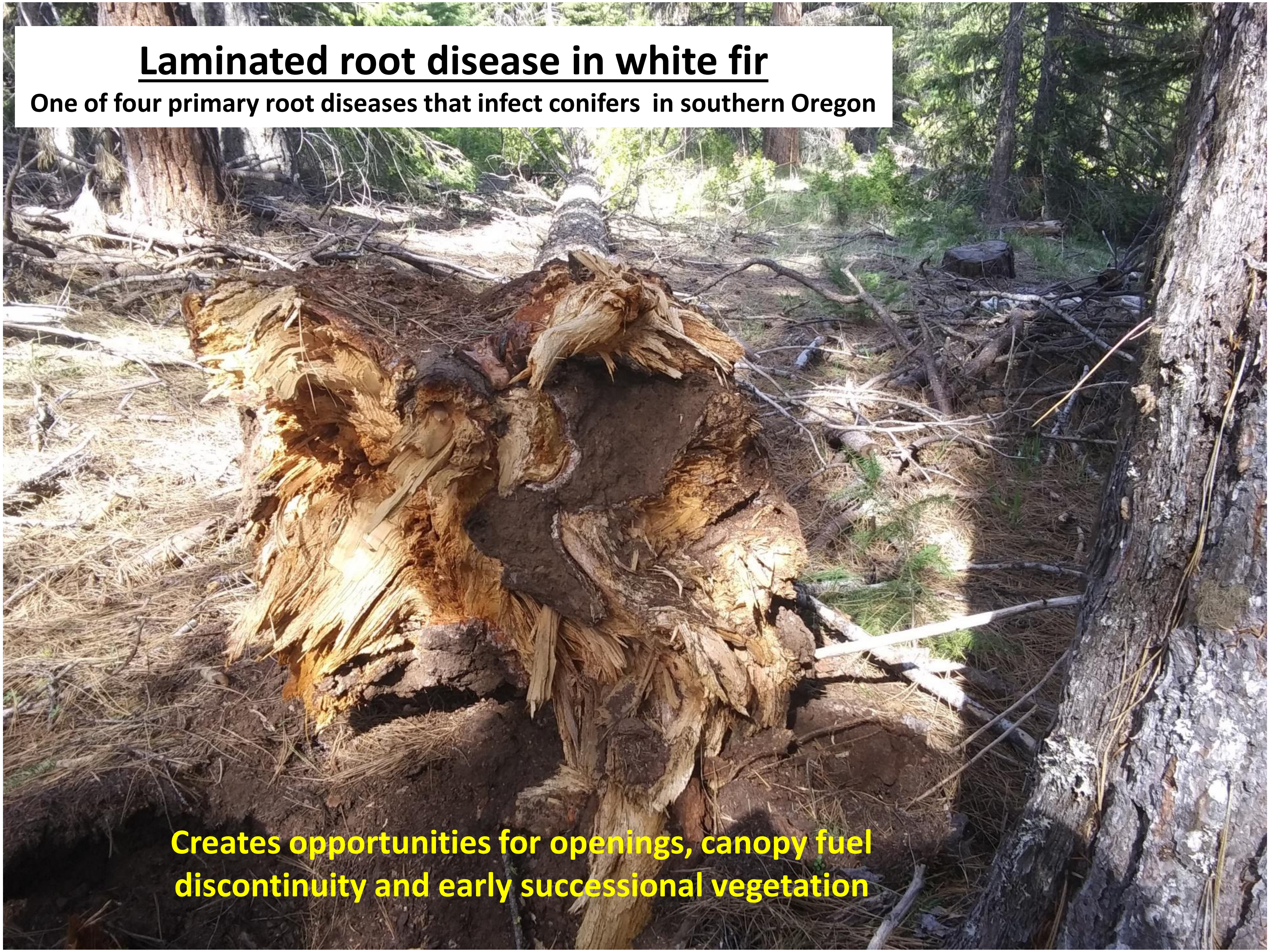
1. Less than 3 tree samples with mistletoe.
2. Totals were weighted by unit acreages.



Source: Main and Schmidt. 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis

Important Points- Douglas-fir Dwarfmistletoe

1. Dwarfmistletoe infection in Douglas-fir is much more abundant at Winburn (all units) than in the Lower Watershed (40% of the units).
2. Dwarfmistletoe is particularly abundant in three units- Unit 3 at Winburn and Units R and K2 in the Lower Watershed. Significant stand level decline is occurring in the 2 units in the Lower Watershed (both R and K2 have significantly lower radial growths in dominant and co-dominant crown classes than the average for the Lower Watershed).
3. Dwarfmistletoe can be managed to retain its inherent important wildlife habitat values at spatially explicit locations (i.e. especially for owl habitat at Units 3 and 6 at Winburn and for Fisher resting habitat). Both species rely on prey species that common utilize dwarfmistletoe brooms.
4. DF dwarfmistletoe can aggravate fire potential through increased torching possibilities; limit amount of DF dwarfmistletoe in units/areas prioritized for fire management.


Laminated root disease in white fir
One of four primary root diseases that infect conifers in southern Oregon
Creates opportunities for openings, canopy fuel discontinuity and early successional vegetation

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

2. Promote frequent, low to moderate severity disturbance regime

a. Emulate the historic more frequent low to moderate disturbance regime that organisms have adjusted to over millenia in ways we are only beginning to understand. Recognize that historic frequent, low to moderate severity fire resulted in a diversity of stand structures , compositions and densities – a desired direction for planned management today and in the future. Both thinning and prescribed underburning have advantages and disadvantages; utilize either/both as appropriate. **(Persist)**

b. Avoid necessarily having to reach some idealized stand condition in a single entry but rather trend towards more open, less dense stand conditions in most situations. Ease stands out of severe stagnation that has occurred with 100+ years in the absence of disturbance; utilize staged thinning and other moderate stand modifications when necessary.

c. Utilize more frequent low to moderate disturbance as part of multi species, multi cohort management regime that retains desired structures of vegetation including maintenance of canopies and sufficient stand densities to continue to retard understory development of ladder fuels. Simultaneously, variable density thinning including retention of clumps and gaps/openings should be part of stand management prescriptions when appropriate. Prescribed burning will likely also occur in a range of low to moderate severities, but should be done to avoid high severity disturbance at any but the smallest scales; creating small openings should be desired, although less likely to be controlled by location than in stand density reduction by thinning. **(Persist,Change)**

d. Assess the ability of a stand/unit to release following treatment (Main 2006, Main and Schmidt 2020), especially in lower elevations and/or moisture limited sites and stand conditions. The decreased potential for release will move up in elevation over time with increasing cumulative stress associated with projected warming temperatures and longer droughtier summers **(Persist, Change)**

e. Regularly respond and adjust to emerging increases in other stressors (drought, insects, pathogens, etc). Thin well in advance of drought. A wide range of densities are acceptable and should be determined for each individual site/stand. **(Persist, Change)**

f. Develop desired snag and LWD amounts to be retained by site, varying with the need to 1) provide for important ecological attributes and functions; 2) adjust to meet fire management objectives . Avoid higher undesirable amounts by regular monitoring and treatment of emerging excessive fuels (snags, large woody debris, etc) that exceed desired targets. **(Persist, Change)**

g. Start newly initiated stands early with frequent, low severity disturbance (e.g. Units LW-C1,2). Allow desired seedlings to gain sufficient size to survive first prescribed underburn; in these situations, utilize manual low to moderate severity thinning treatments until prescribed underburning can be applied without excessive damage to developing seedlings. **(Persist)**


Two prescribed underburns above Ashland
April 14, 2021

An example of infrequent, high severity disturbance. More frequent, low severity disturbance has been rare on other ownerships due to administative realities, over-riding profit motive and other factors.


We have vastly changed the type, frequency,
severity and scale of disturbance

Unit E2, City of Ashland, 2013

•1996-97 – Non-commercial thinning, piling, burning (Small Woodland Services Inc.)

•2004 – Helicopter thinning (Superior Helicopters), piling, burning (SWS).

• 2013 – Prescribed underburn (Grayback Forestry)

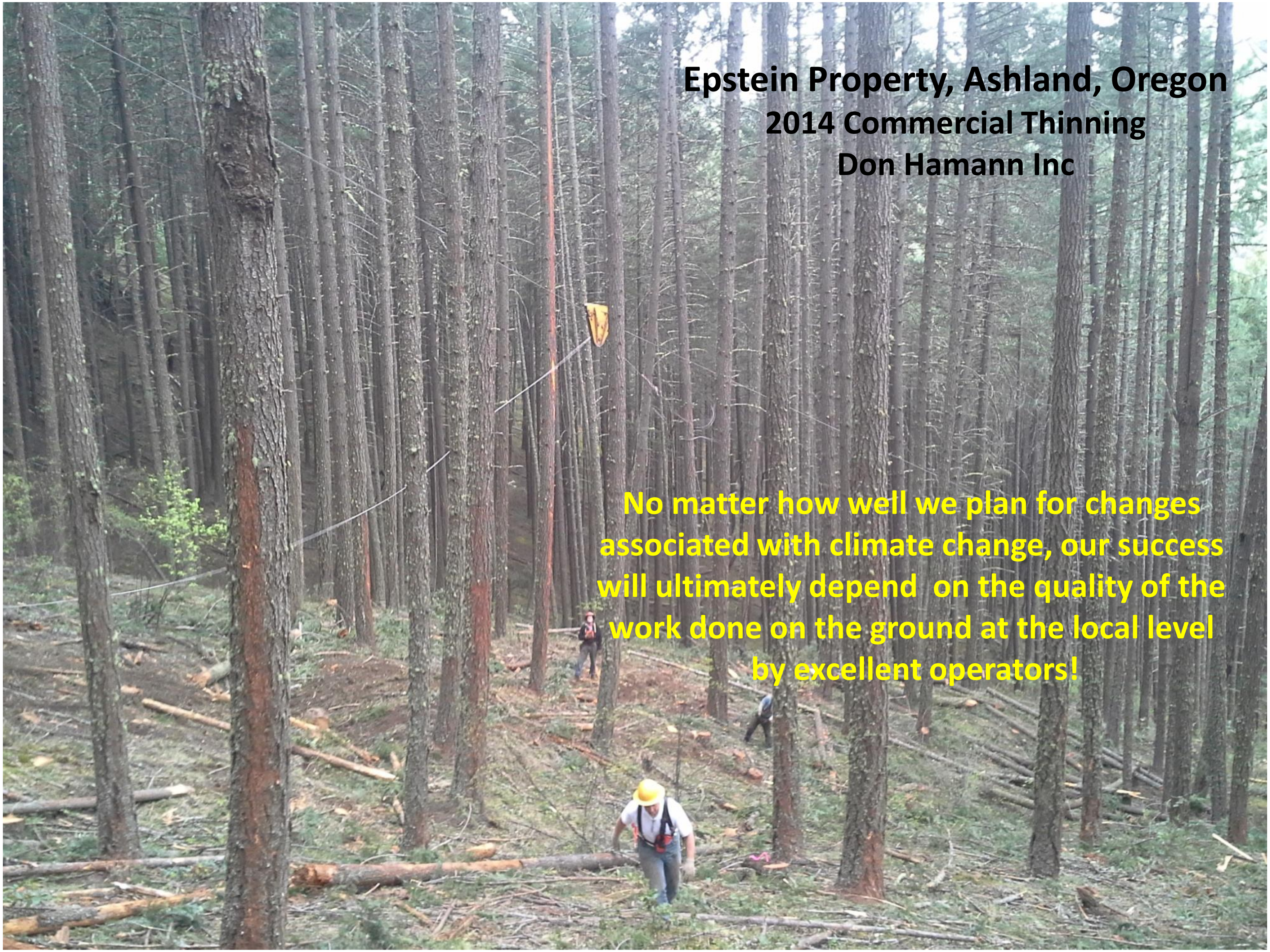
• 2014- Plant ponderosa pine seedlings (SWS)

Restoring frequent low severity disturbance through multiple conservative interventions (i.e. adjusting stand density, species and structure so that a more desirable and sustainable functional process can occur)

City of Ashland “Alice Trail”- 1997

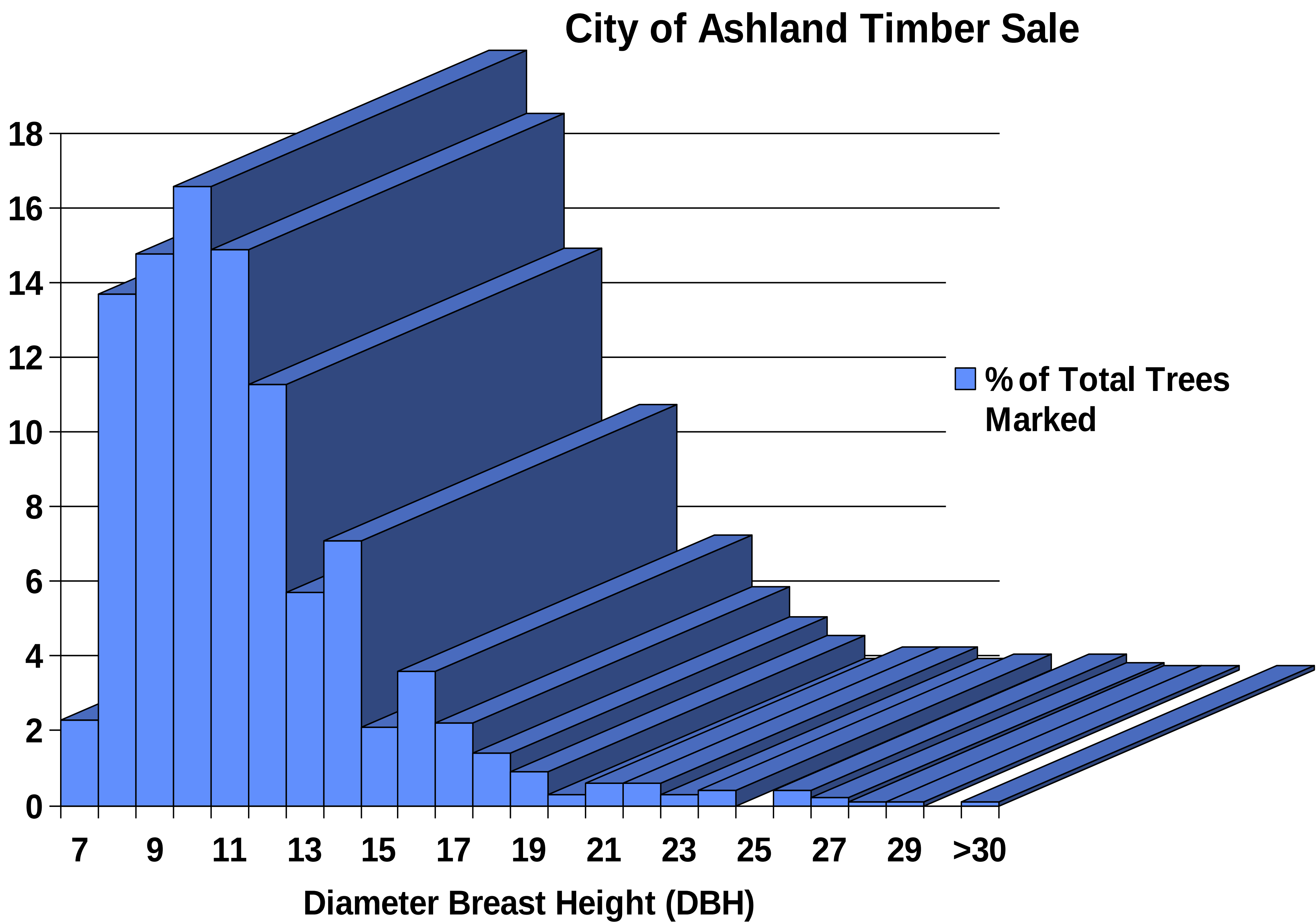
"Alice Trail"- post thinning/slash treatment 1998

“Alice Trail”- 2015


Epstein Property, Ashland, Oregon
2014 Commercial Thinning
Don Hamann Inc
No matter how well we plan for changes associated with climate change, our success will ultimately depend on the quality of the work done on the ground at the local level by excellent operators!

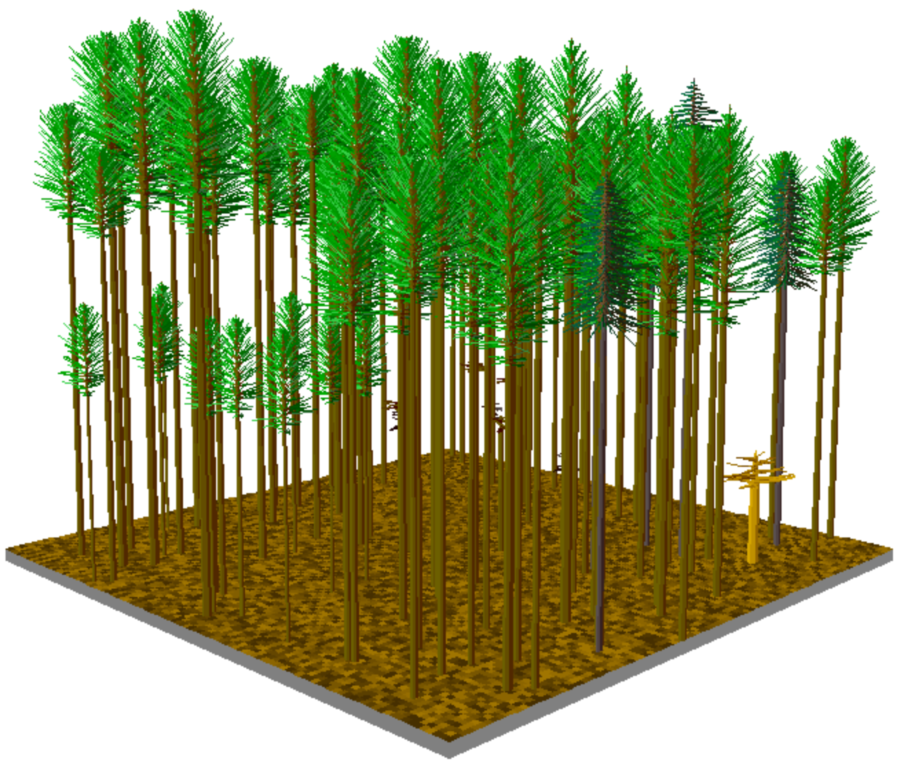
Thinning and fuel reduction using helicopters on City ownership (2004) combining removal of dead and dying trees with variable density thinning.

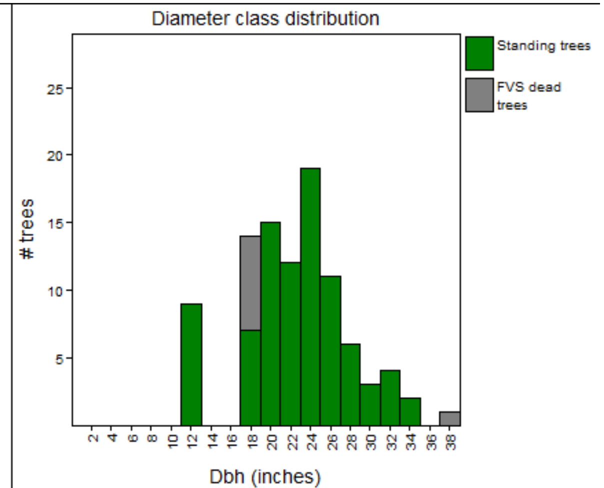
Superior Helicopters
Grants Pass, Oregon

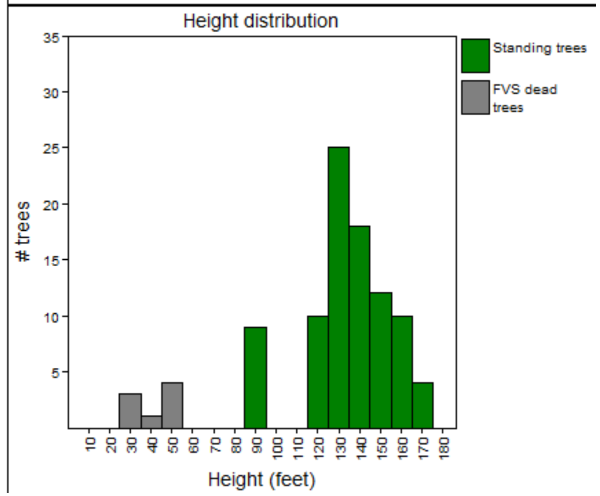


City of Ashland Timber Sale
18
16
14
12
10
8
6
4
2
0
7
9
11
13
15
17
19
21
23
25
27
29
>30
Diameter Breast Height (DBH)
% of Total Trees Marked

Winburn Unit 4

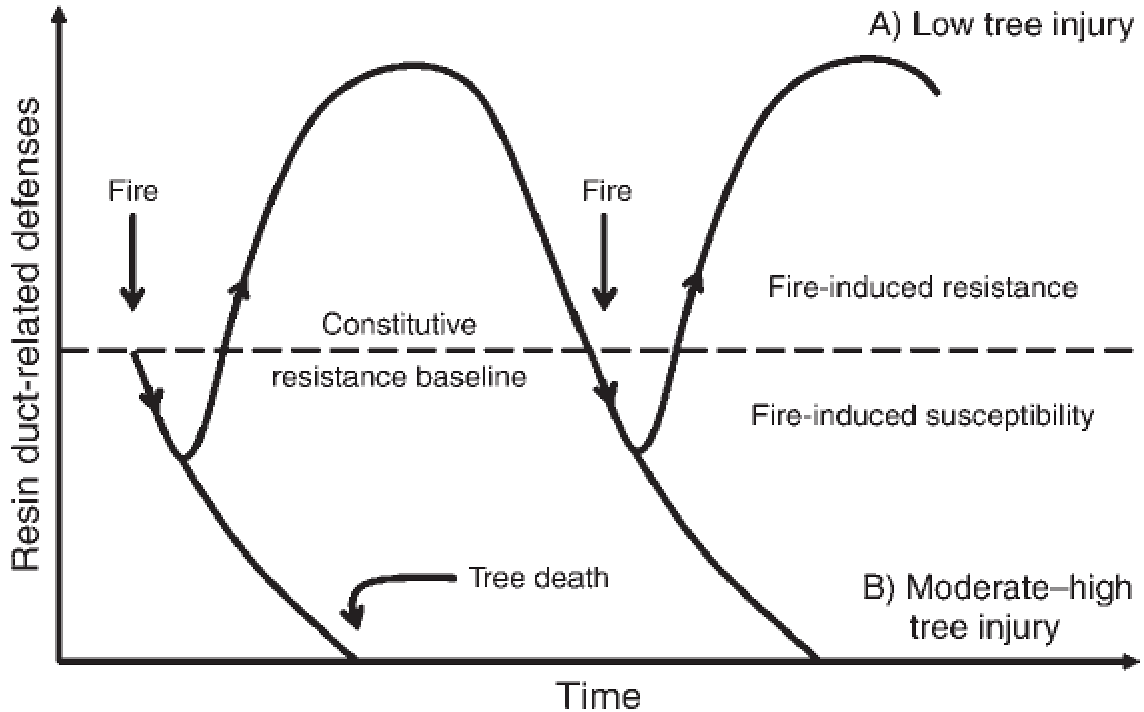






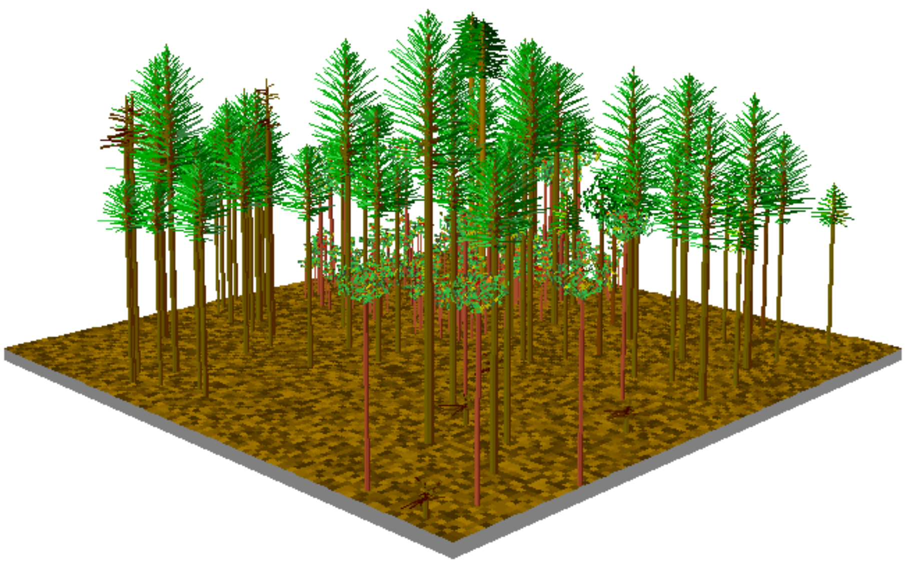
Prior to thinning, this dense, even-aged stand grew without disturbance since inception, much like some of the stands on the City ownership. Trees retained in this thinning have small crown ratios and very high height:diameter ratios and will likely not release, even if they don't blow over! Alternatively, this stand could have been thinned in several stages earlier in stand development, allowing preferred leave trees to more slowly and safely build more acceptable crowns over time.

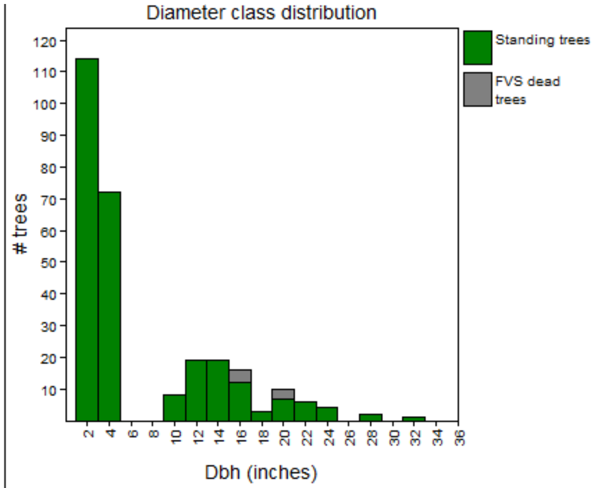
Induced defense that protects ponderosa pine over time requires a more frequent, low to moderate severity disturbance that stresses but doesn't kill an individual tree while preparing it for future disturbances

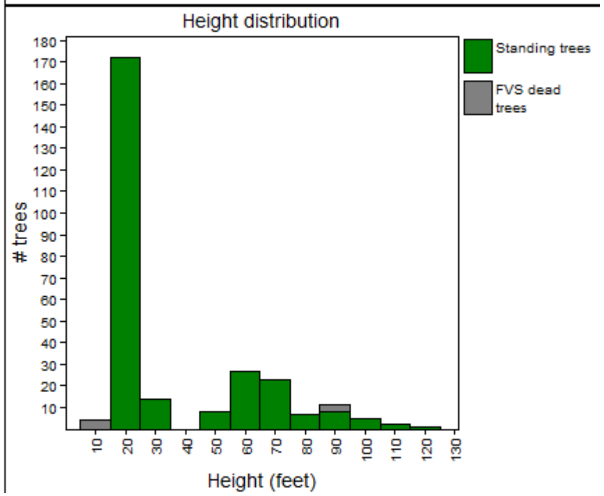


Source: Hood et.al. 2015. Low-severity fire increases tree defense against bark beetle attacks.

Unit LW-H- 2017 Inventory








2007 Prescribed underburn,Unit LW-H
Cross-boundary treatment with US Forest Service

2017 Regeneration Stocking Survey

Table 1: Conifer stocking (trees <4.5' tall)

Parcel	Trees per acre by species						
	DF	WF	PP	SP	IC	PY[4]	Total
LW	42	1	10	1	21	3	78
Winburn	160	277	11	8	147	55	658

Table 2: Hardwood stocking (trees <4.5 tall)

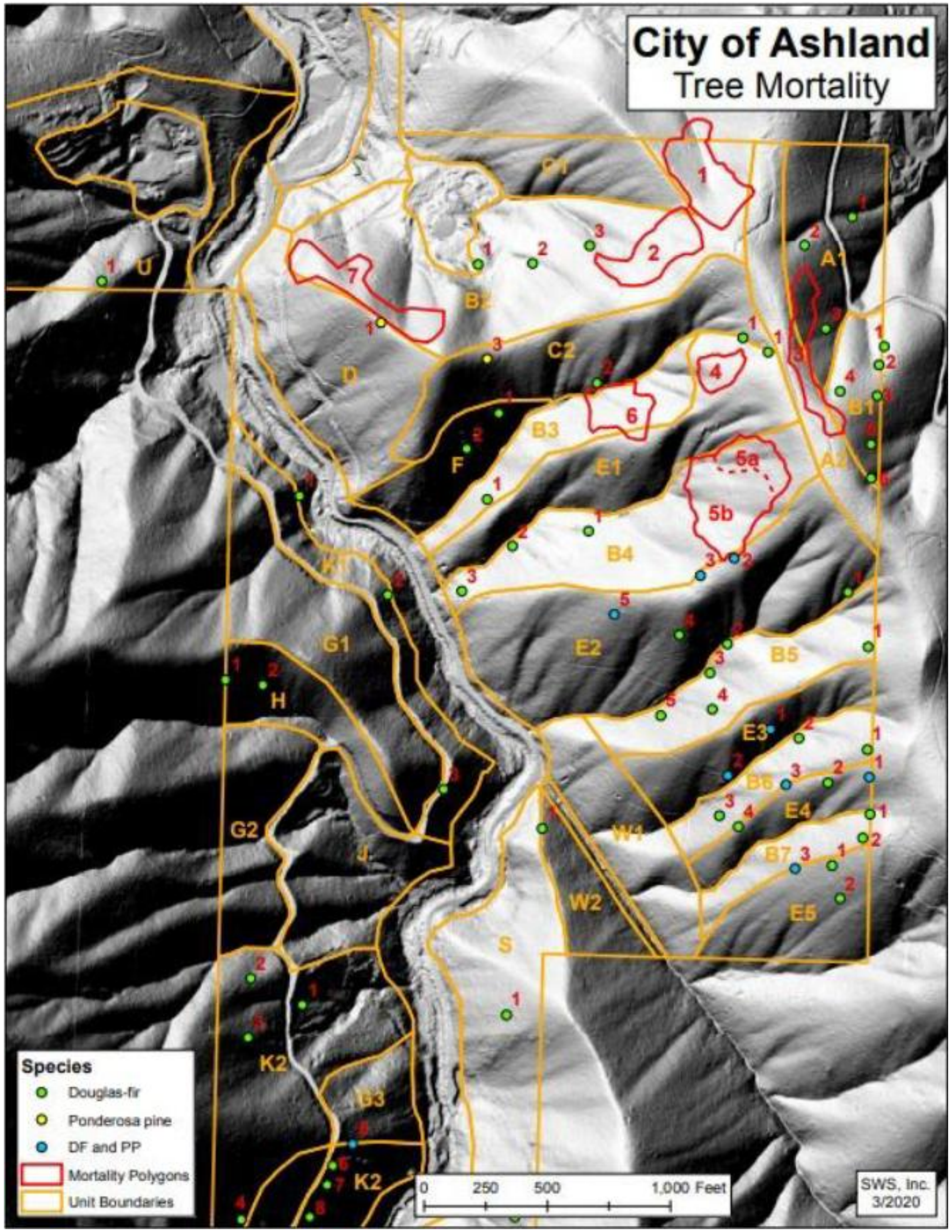
Parcel	Trees per acre by species						
	Pacific Madrone		Black Oak		Chinquapin		Total[3]
	Seedlings	Clumps	Seedlings	Clumps	Seedlings	Clumps	
LW	222	96	12[1]	7[1]	0	0	337
Winburn	303	49	0	0	0	5[2]	357

1: QUKE was only found in 6 units - A1, E, F, G, K, and R.
2: CACH was only found on one plot.
3: Totals are the sum of all seedlings and clumps.
4. PY=Pacific Yew

Lack of disturbance strongly selected against shade intolerant, drought tolerant species that are highly desired in warmer, drier climates- namely pines and oaks.

Source: Main and Schmidt. 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis

Small openings created during prescribed underburning can create opportunities for early successional, shade intolerant vegetation, as well as break up canopy fuel continuity.



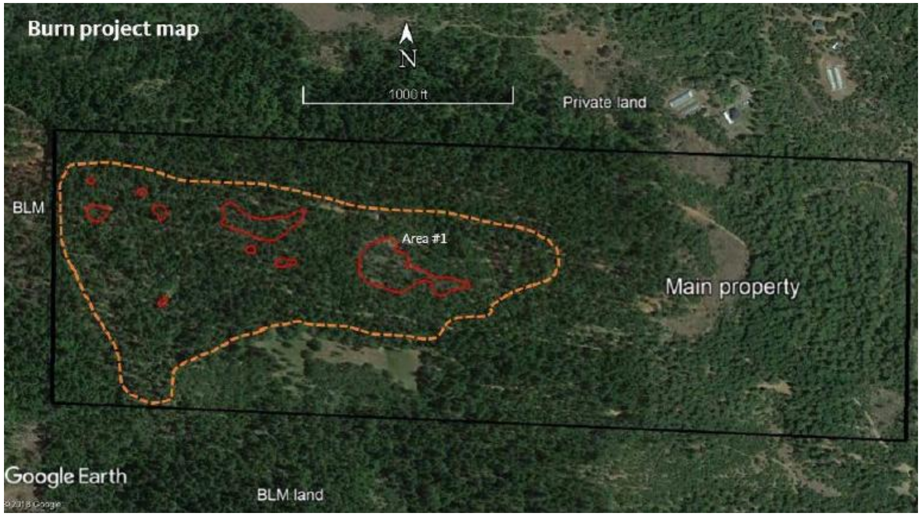
Strategy

Use more frequent low severity silvicultural treatments to avoid major pulses of outbreak levels of mortality that can:

1) create a high amount of fuels
2) burn at high intensities for long duration with effects on soils
3) contribute to possibilities for severe erratic fire behavior
4) be very expensive to treat using manual slash treatment methods.

Source: Main and Schmidt. 2020. City of Ashland 2020 Mortality Monitoring Results and Analysis

Initiate prescribed underburning early in stand development but after young trees of desired species have grown large enough to survive low severity fire.



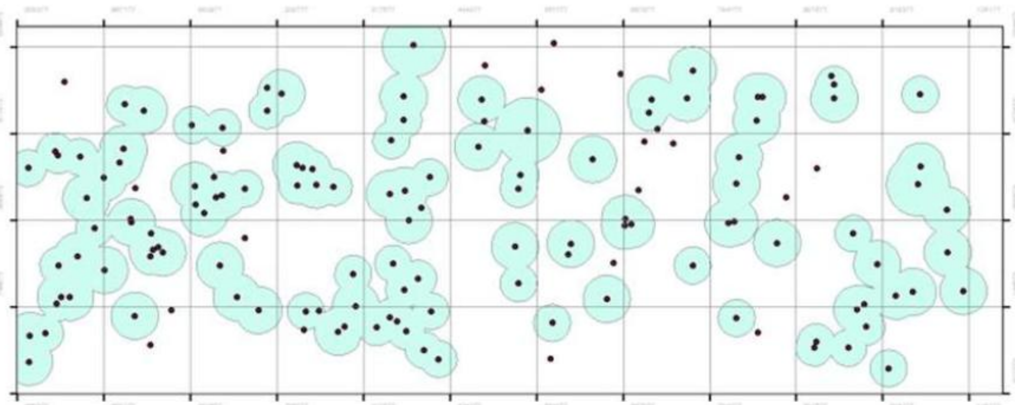
Local Prescribed Underburning:

Restoring a Frequent, Low-severity Disturbance Regime

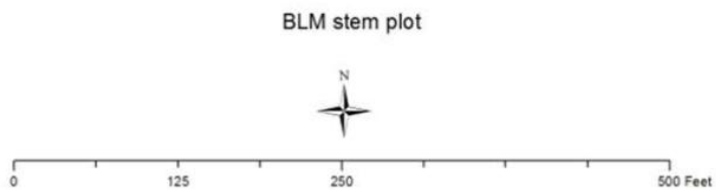
Photo: Marty Main

Source: Bennett and Main. 2018. Prescribed Underburning in Southwestern Oregon: A Case Study

Stem map with groups & openings



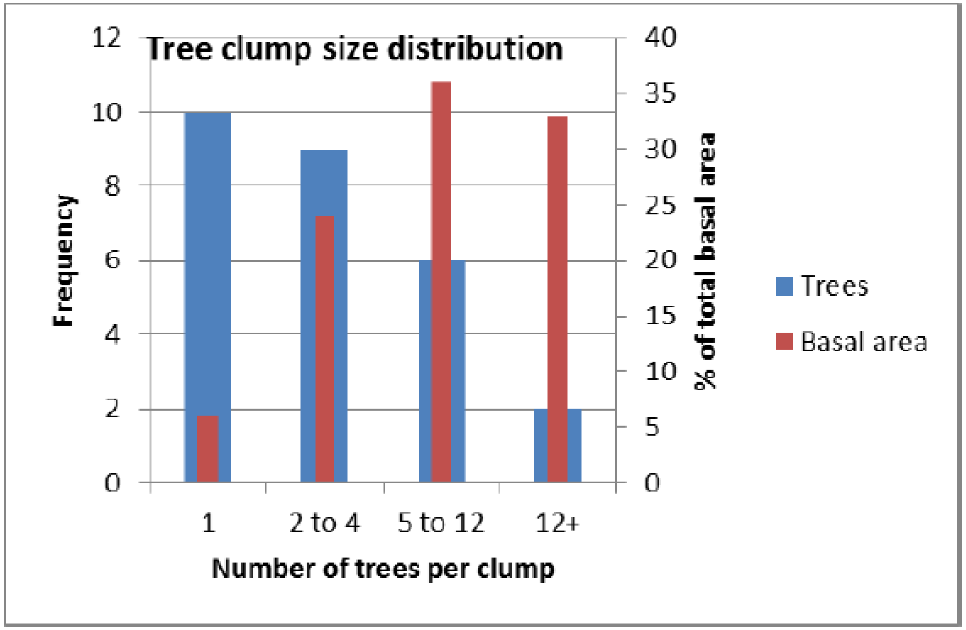
Map includes existing live trees that are 130+ years old. Areas not occupied by mapped tree crowns may contain younger trees or may represent openings without trees. Squares are 1/10th-acre, 66’ wide and tall



“Previous individual stem-mapping and stand-reconstruction work in adjacent older forests provided a historical template of forest spatial conditions used as a reference to guide implementation of forest management, including the prescribed underburn. Rather than try to specify the exact size and location of gaps to mimic the historical template, the owner chose to let fire produce its own random pattern, essentially encouraging the very process that historically produced structural diversity on both a stand and landscape level.”

Source: Bennett and Main. 2018. Prescribed Underburning in Southwest Oregon: A Case Study

Groups (variable width crowns)



		Single trees	2-4 trees	5-12 trees	12+ trees
Total # (on 3.75 ac)		10	9	6	2
BA/ac		6	24	36	33
Number per acre		3	2	2	1

Source: **Using spatial reference data to inform silvicultural prescriptions: A case study from SW Oregon.** Bennett and Main. 2012 (unpublished)

A preliminary assessment of stand-scale treatment impacts on forest characteristics and ecological indicators in the context of climate change.

Strahan 2020

- Tree treatment scenarios (reduce basal area by 25,35 and 50%), and no treatment
- Simulated one wildfire in year 35, prescribed underburning every 10 years
- Used data from AFR; FVS model and several extensions; simulated over 70 years

Results

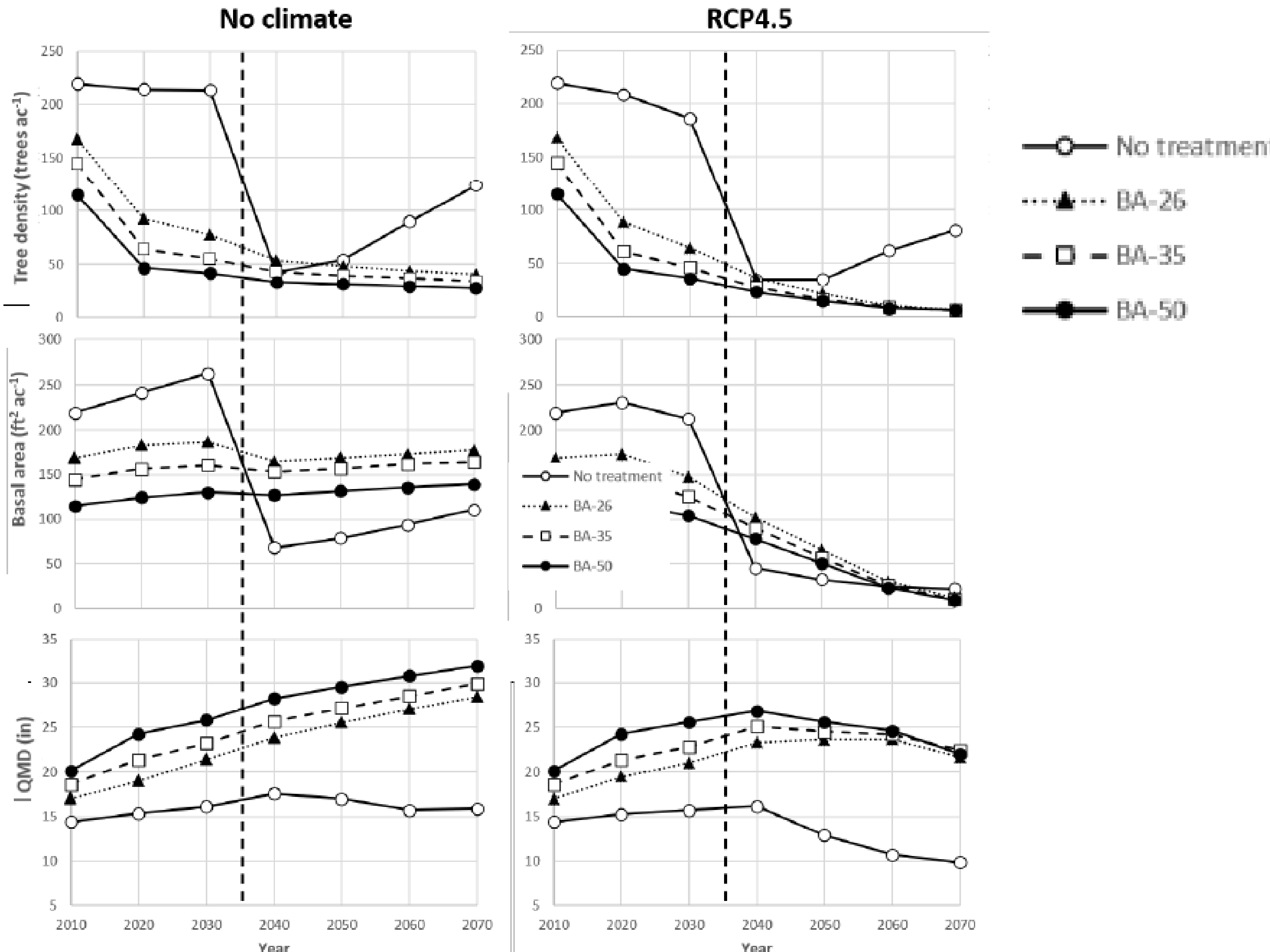
1. **Under current climate (no climate change), the No treatment scenario most vulnerable to wildfire ; the 3 treatment scenarios of thinning and prescribed underburning could be maintained for 60 years and likely longer.**
2. **Under climate change scenarios, a drastic change in forest density resulted regardless of management scenario.**

    a. More basal area in larger diameter trees in the 3 treatment scenarios than in the No treatment scenario

    b. Pacific madrone is dominant species in all simulations that include climate change, regardless of management scenario.

    c. Changes were accelerated by the simulated wildfire in year 25

    d. Thinning treatments an help mitigate wildfire effects under climate change.



Changes in forests structure from 2010 – 2070 for four different management scenarios shown in legend. The dashed line indicates simulated wildfire in 2035.

Source: Strahan 2020

In order to accomplish the manipulation of vegetation to achieve objectives, including successful climate change adaptation, we will need at the local scale:

1. Public acceptance of active forest management (i.e. planned disturbances) to achieve pre-designated objectives.
2. Land managers who are intimately connected with their lands, ecosystems and resources at a scale that makes that possible.
3. Promotion of a high quality workforce capable of implementing the work desired and the operational space in which to do it.
4. An adequate investment in ecosystem infrastructure as if our lives depended on it.
5. Efficient ways to process economically available forest products.
6. Integration of above-listed ecologic, social and economic realities across time and space. Outcomes will be no better than the weakest link in that process.

Vegetation: Functional Processes and Disturbance

Adaptation Options for Management

3. Be prepared for post high severity disturbance

a. **Do everything possible to keep green forests, but acknowledge that we no longer can insure that we can keep wildfire from impacting for communities, property and lives and forest ecosystems (Change).**

b. **Acknowledge that ecosystem services are much more limited following large scale, high severity disturbance and considerable time will be needed for ecological integrity to be restored even while accepting that some areas may return to a new permanent altered state. We cannot necessarily change these outcomes with post-fire rehabilitation practices. (Change)**

c. **Not only will climate change increase the likelihood and severity of fire in forest ecosystems but it will accentuate the cumulative degree of disturbance over time in ways that are hard to predict but likely will be even more impactful (Change).**

d. **Possibilities for natural regeneration of conifers decreases with increasing scale of high severity fire. Strong increases are expecetd in species that prefer infrequent, high severity fire, such as stump-sprouting species like Pacific madrone. (Change)**

e. **Through management actions, strive to continue to reduce percentage amount of high severity fire when (not if) fire occurs (Persist, Change).**

f. **Use the disturbance to establish desired species moving forward more well-adapted to future climate change. (Change)**

Wildlife, Habitat Management and Biodiversity Conservation

The simplest and most important wildlife management procedure in general across all ownerships and scales of reference has historically been to encourage the greatest possible diversity of vegetation, in terms of age, structure, and species composition. This general strategy for wildlife management is well-aligned with general vegetation management strategies for climate change adaptation on the City ownership.

4. Wildlife, Habitat Management and Biodiversity Conservation

Climate Change Key Vulnerabilities

1. Homogeneity of habitats over time- decreased structural diversity limits wildlife habitat now, increased potential for high severity fire and continued homogenization limits wildlife habitat in the future.

2. Loss of refugia as areas to reduce thermal stress particularly for species specialized for cooler habitats.

3. Important older forest habitat values are threatened, especially at middle elevation sites (e.g. Winburn).
-fire
-loss of big tree structures likely to continue to occur

4. Lack of Mid and Late Open Structural states and associated habitats

5. Specific wildlife species
-Northern Spotted Owl
-Fisher

4. Early to mid seral shrubfields, oak woodlands and grasslands vulnerable due to proximity to Ashland
- unique wildlife population assemblages, including pollinator habitat
- conflict with fire management goals

5. Specific habitat features. Numerous other specific impacts with climate change (Mawdsley 2009)

6. Human influence on wildlife habitat values close to and within COA
- Trails- increasing human use; fragmentation.
- Dogs

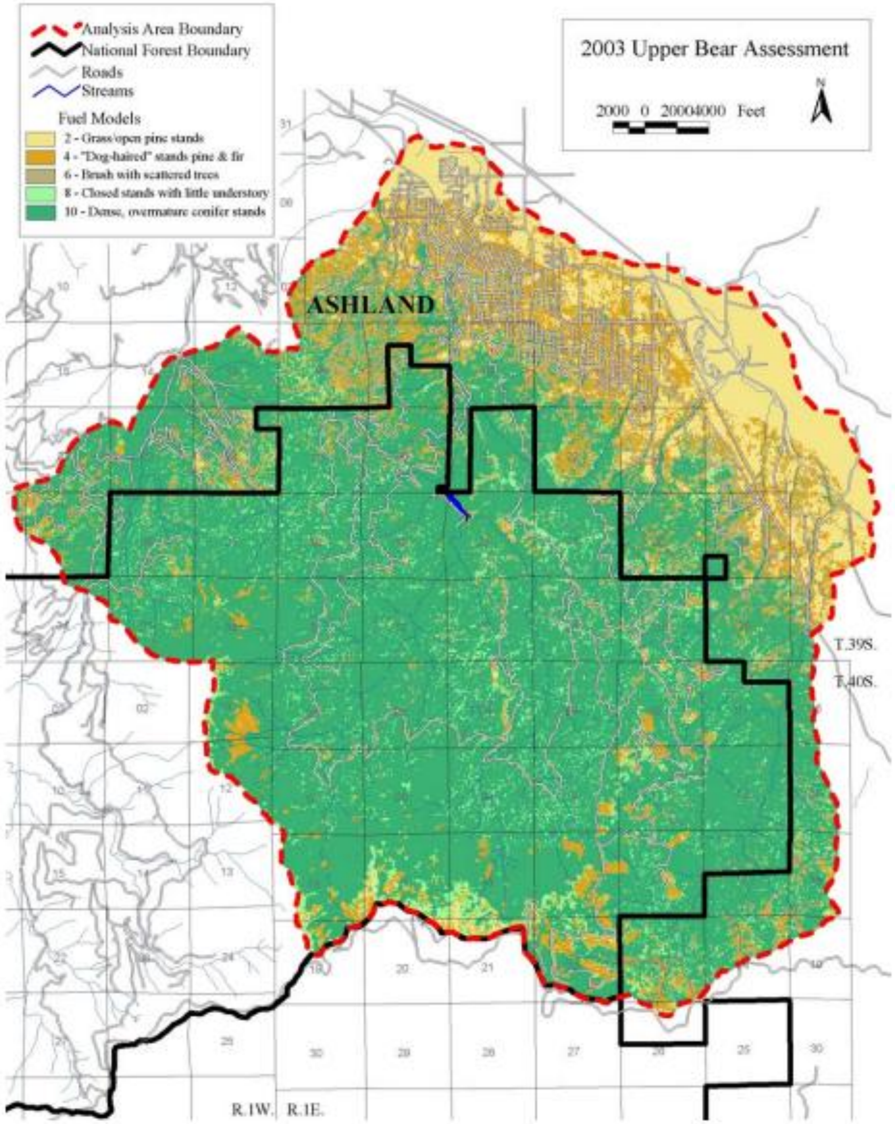
7. Biodiversity and Landscape Connectivity

Current Vegetation Communities on City Ownership

- Rocky areas/skeletal soils (rare)
- Early to mid-seral dense chaparral shrubfields (rare- only at lowest elevations; seldom intermixed with forests)
- Early-seral regenerating coniferous forests (rare; Unit LW-C; new- Unit LW-B2 and other polygons)
- Early to mid-seral hardwood dominated forests- a) oak woodlands b) Pacific madrone (common at lower elevations)
- Emerging early mid-seral dense mixed conifer/hardwood forests in the stem exclusion stage of stand development
- Closed, mid-seral mixed conifer/hardwood forests
- Older, open, mid-seral mixed conifer/hardwood forests with abundant openings (uncommon, but developing with mortality/management in Lower Watershed)
- Older mid-seral, closed dense mixed hardwood/conifer forests (Lower watershed parcel)
- Older mid-seral, closed dense mixed conifer forests (Winburn Units 2,4)
- Late-seral closed mixed conifer forests (common at Winburn)
- Late, open mixed conifer and mixed conifer/hardwood forest (Rare; developing in Winburn Unit 1)
- Riparian woodlands of various types (along Ashland Creek; rest of riparian network is intermittent or ephemeral except Weasel Creek at Winburn)
- Other habitat features- springs/seeps, ponds, cliffs, rocky outcrops (Rare)

Each of these habitat types support its own cadre of wildlife species, including species that are uniquely adapted for that type as well as generalists that are adapted to and utilize multiple habitat types. This diversity of habitat types in close proximity, especially on the existing steep environmental gradients, is an important mechanism of resilience, particularly in an era of rapid climatic warming. Maintenance of this is possible if high severity disturbance can be avoided.

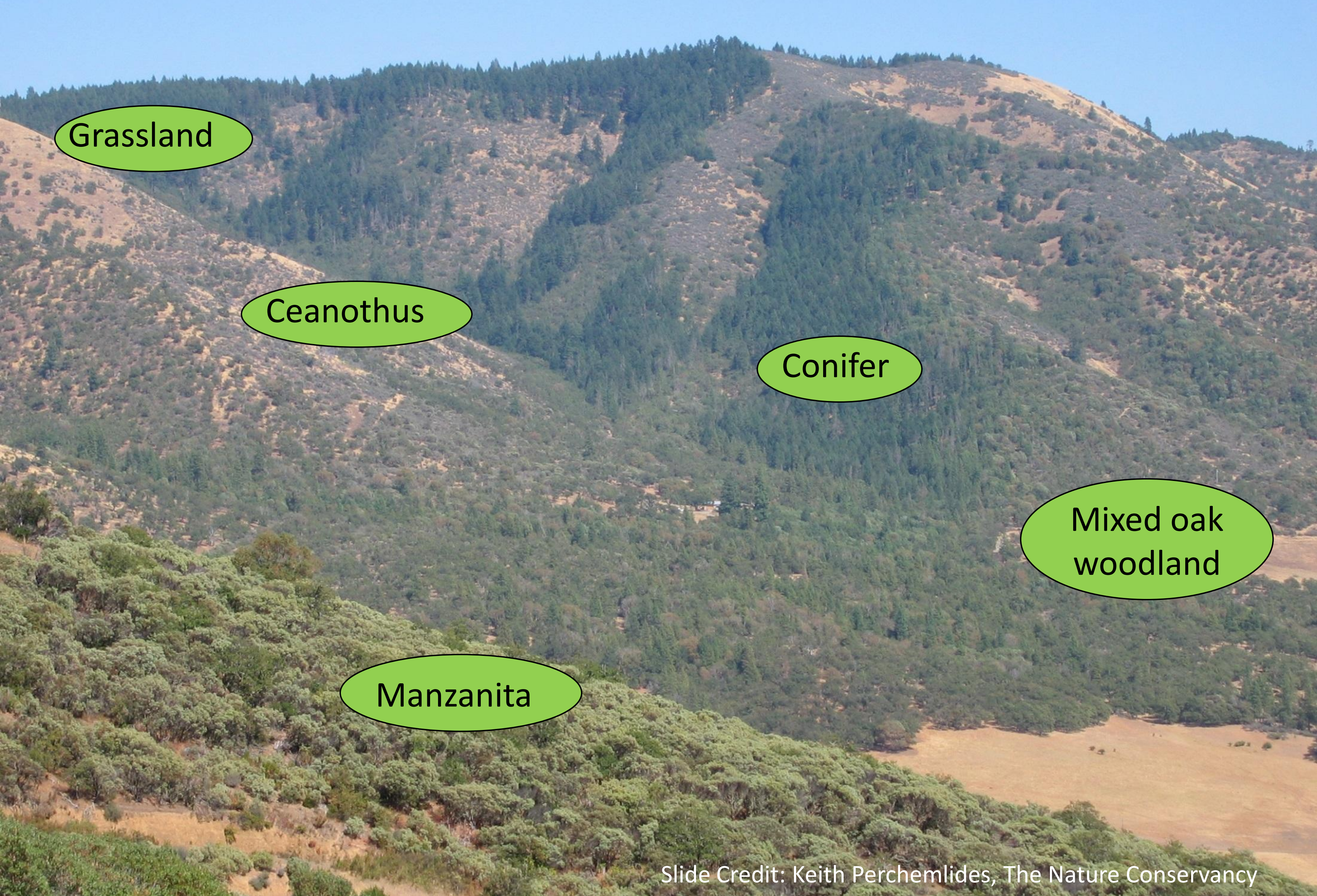
MAP 3-5. Fuel Model Map



The USDA Forest Service uses the most current and complete data available. Existing resource data and locations are approximate. Geographic Information Systems (GIS) data and product accuracy may vary. Using GIS products for purposes other than those for which they were intended may yield inaccurate or misleading results.


Ashland Research Natural Area (RNA)- looking up
East Fork of Ashland Creek towards Mt. Ashland;
note continuous vegetation

Diversity of vegetation and wildlife habitats



Slide Credit: Keith Perchemlides, The Nature Conservancy

Refugia

Cooler, moister areas where impacts from increasing temperature and fire are potentially reduced

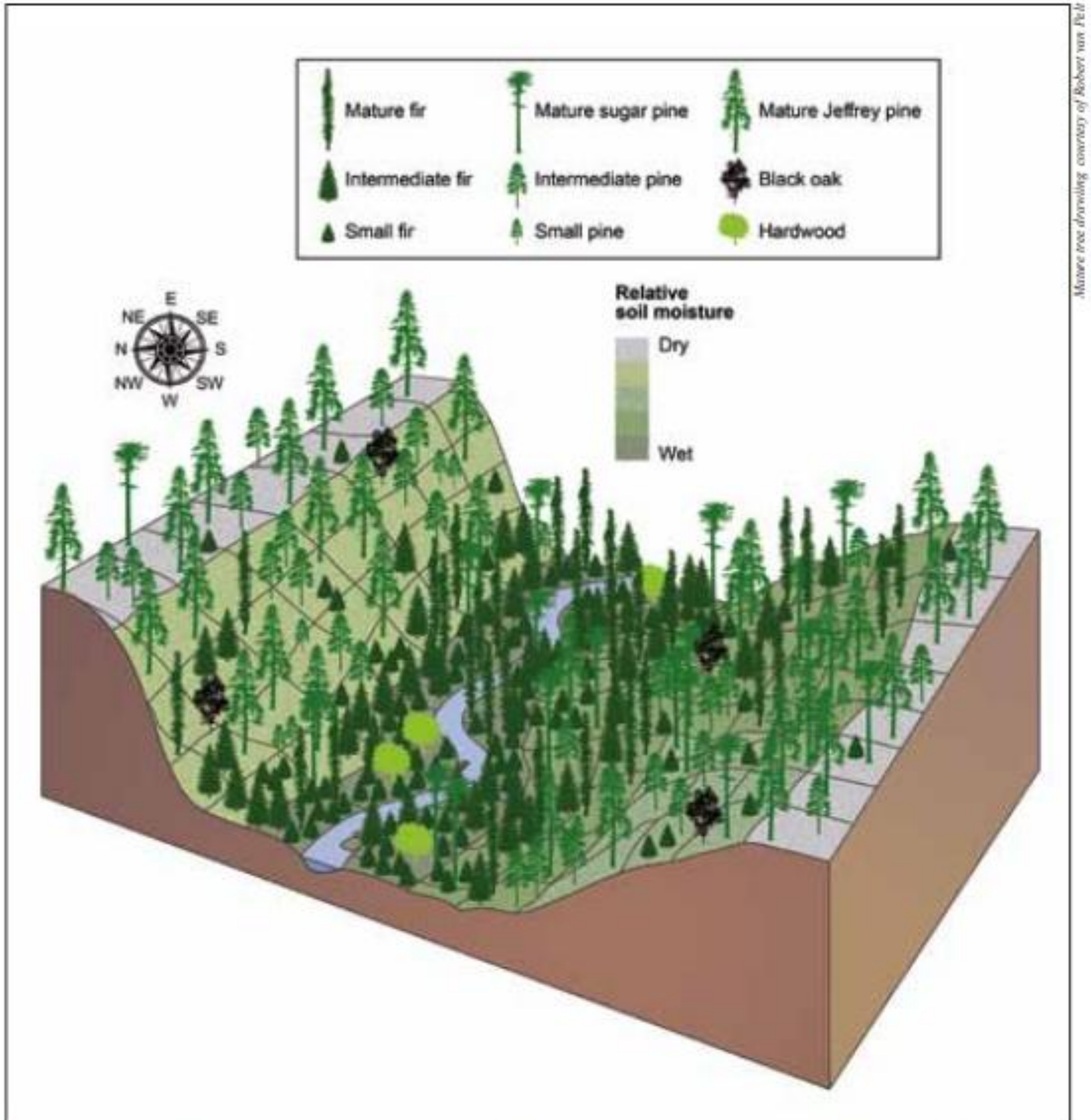


Figure 10—Landscape schematic of variable forest conditions produced by management treatments that differ by topographic factors such as slope, aspect, and slope position. Ridgetops have the lowest stem density and highest percentage of pine in contrast to riparian areas. Midslope forest density and composition varies with aspect: density and fir composition increase on more northern aspects and flatter slope angles.

Slide Credit: North etal 2020. An Ecosystem Management Strategy for Sierran Mixed-Conifer Forests.

Table1. Percentage of large trees dead in 40 randomly located stand examination plots in the Ashland Research Natural Area arrayed by species and diameter class.

Tree Species	*% of all trees dead*		
	>17" dbh	*> 24" dbh*	*> 30" dbh*
Ponderosa pine	***23.6***	***26.7***	***32.0***
Sugar pine	***50.0***	***50.0***	***50.0***
Douglas-fir	***19.5***	***43.9***	***53.1***
White fir	***30.0***	***46.6***	***20.9***
Incense-cedar	***0***	***0***	***0***
All Conifers	***25.2***	***40.0***	***30.8***

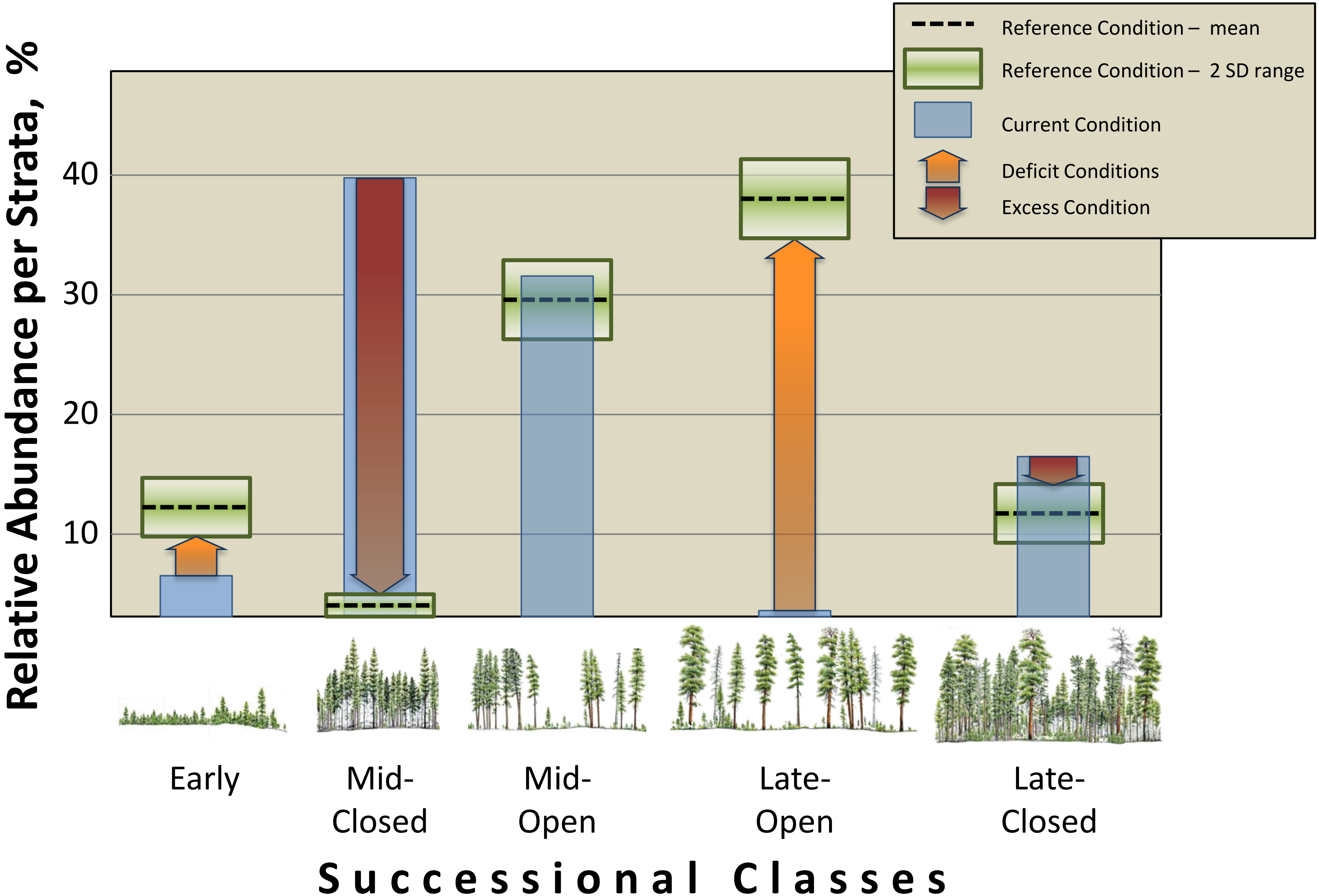
Table 2. DF Dwarf mistletoe Infection by DBH and Stage of Infection Ashland Watershed Research Natural Area (40 plot sample)

Dwarfmistletoe Infection Rating	***>20"dbh (n=55)***	***20-30"dbh (n=42)***	***30"+dbh (n=13)***
0	***62%***	***69%***	***38%***
1,2,3	***13%***	***12%***	***15%***
4,5,6	***25%***	***19%***	***46%***

Dwarf mistletoe Infection Rating as per Hawksworth: 0= no infection, 1=very lightly infected in lower one-third of crown, 6=heavily infected throughout crown

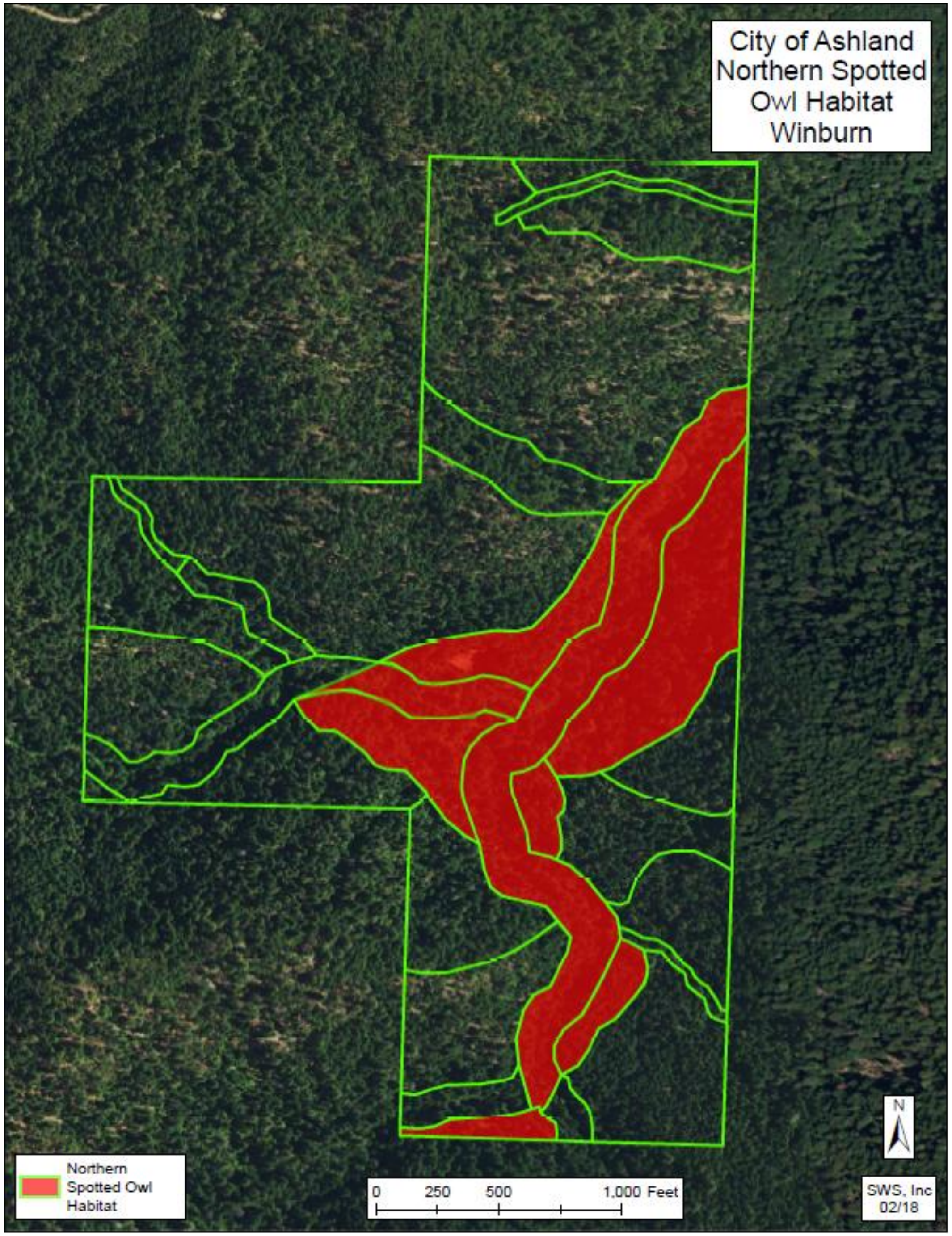
Source: Main (2009), with data from Southwest Forest Insect and Disease Service Center. Large Tree Mortality in the Ashland Research Natural Area (unpublished)

Landscape Resilience and Natural Range of Variation



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

Slide Credit: Jim Thraillkill, US Fish and Wildlife Service


City of Ashland
Northern Spotted
Owl Habitat
Winburn
Northern
Spotted Owl
Habitat
0
250
500
1,000 Feet
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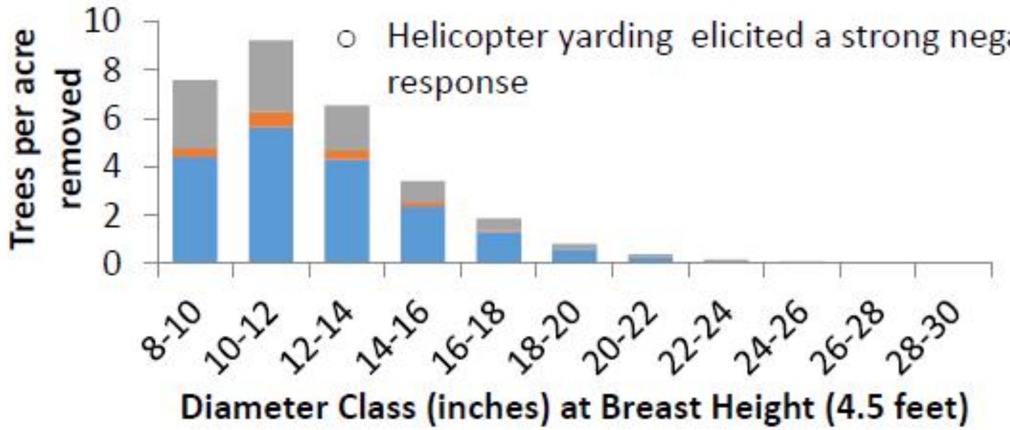
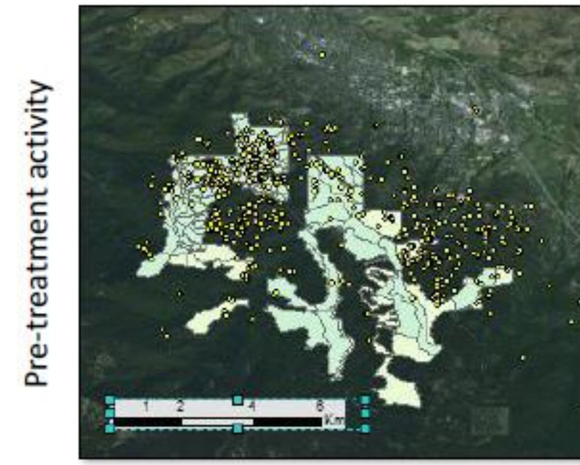
SWS, Inc
02/18

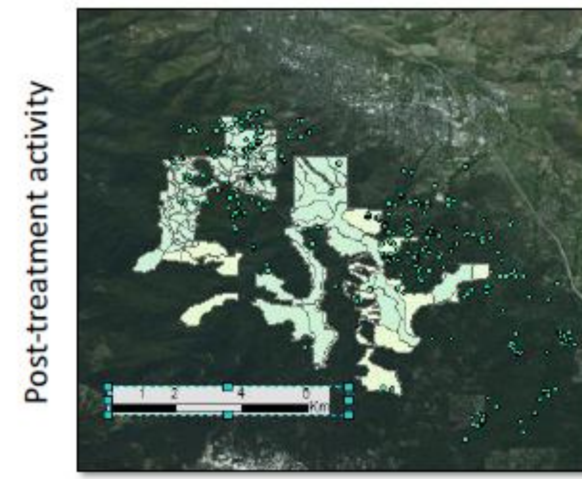
RECENT RESEARCH RESULTS – ASHLAND FISHER PROJECT

Observations

- > 80 percent of all observed rest sites are mistletoe platforms. Trees were all Douglas firs from 14 to 40+ inches DBH.
- Found widely varying responses to disturbance
  - Non-commercial and commercial felling and road haul did not seem to illicit a response.
  - Helicopter yarding elicited a strong negative response







Note the range of the Fisher that includes most of the wildland urban interface and lower portion of the City of Ashland ownership

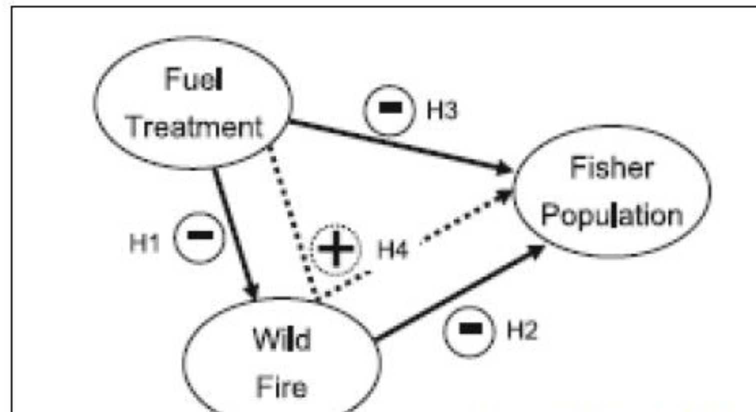
Source: Thompson, 2016. Fisher Habitat Conservation and Fuel Management (powerpoint)

Trade-offs: conserving habitat vs. reducing fuel density

Before treatment – large structures, dense canopy & complex understory. Good for fisher but flammable

After treatment – not so good for fisher, but less flammable

After wildfire – unsuitable for fisher



Spencer et al. 2011

Source: Thompson, 2016. Fisher Habitat Conservation and Fuel Management (powerpoint)

2017 Inventory Results

Snags

Changes in Snag Abundance, 2007-2017

Lower Watershed

Unit	# of Plots	Snags per acre by diameter class							
		5-11"		11-19"		19"+		Total	
		2007	2017	2007	2017	2007	2017	2007	2017
A1	3	0	0	0	14	0	0	0	14
B	14	10	19	5	10	0	0	15	29
C	5	13	7	0	3	0	1	13	11
D	2	0	0	8	8	0	0	8	8
E	9	0	0	12	9	2	2	14	11
F	2	0	0	0	0	0	5	0	5
G	15	0	0	1	2	0	1	1	3
H	4	0	0	5	4	3	2	8	6
J	6	0	0	0	0	2	3	2	3
K	13	0	8	6	6	2	6	8	20
L	6	0	0	0	5	3	3	3	8
M1	4	0	0	4	4	0	0	4	4
M2	3	69	126	0	9	2	2	71	137
N	8	21	35	8	8	1	1	30	44
P	11	0	14	0	4	1	1	1	19
Q	6	0	0	6	4	1	1	7	5
R	5	11	17	13	12	4	3	28	32
S	6	10	5	2	2	2	6	14	13
W1	3	0	14	0	0	0	0	0	14
W2	4	40	61	19	10	0	2	59	73
Total*	129	7	12	5	6	1	2	13	20

Winburn

Unit	# of Plots	Snags per acre by diameter class							
		5-11"		11-19"		19"+		Total	
		2007	2017	2007	2017	2007	2017	2007	2017
1	33	8	14	3	2	3	4	14	20
2	9	30	11	6	14	6	3	42	28
3	8	0	0	0	0	4	2	4	2
4	3	19	0	7	7	1	1	27	8
5	10	6	35	4	6	7	8	17	49
6	6	0	10	0	6	3	4	3	20
Total*	69	12	13	3	5	4	4	19	22

*Totals weighted by unit acreages

Important Points- Snags

1. **Total snags, 2007-2017**

   Lower Watershed- 62% increase, mostly 5-11” dbh.

   Winburn- 16% increase.

2. **17”+ dbh total snags** (functionally most important size class)

   Lower Watershed- 4/acre

   Winburn- 5/acre

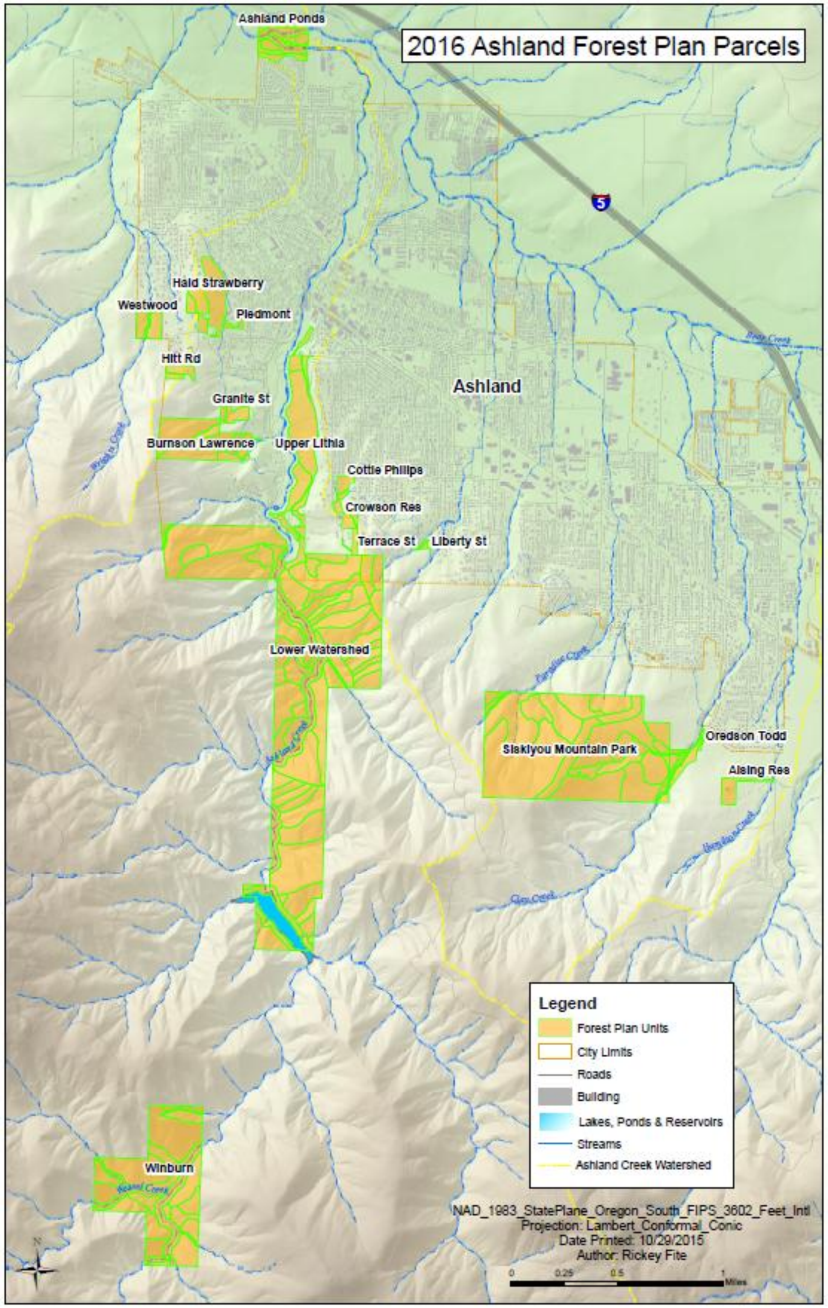
   - Both meet standards as described in Restoration 2 (2016 Ashland Forest Plan).

It is expected that snag amounts will continue to increase in the near future, especially during droughty periods and with projected climate change. Inventory and management of snag numbers, within defined acceptable ranges, will be an important objective moving forward.

Global climate change is already having significant effects on species and ecosystems Effects described to date include:

- shifts in species distributions, often along elevational gradients;
- changes in the timing of life-history events, or phenology, for particular species;
- reductions in population size (especially for boreal or montane species);
- extinction or extirpation of range-restricted or isolated species and populations;
- direct loss of habitat due to sea-level rise, increased fire frequency, bark beetle outbreaks, altered weather patterns, glacial recession, and direct warming of habitats (such as mountain streams);
- increased spread of wildlife diseases, parasites, and zoonoses (including Lyme borreliosis and plague);
- increased populations of species that are direct competitors of focal species for conservation efforts;
- increased spread of invasive or non-native species, including plants, animals, and pathogens.
- effects on demographic rates, such as survival and fecundity;
- decoupling of coevolved interactions, such as plant–pollinator relationships;

Source: Mawdsley 2009. Review of Climate-Change Adaptation Strategies for Wildlife Management and Biodiversity Conservation



There is a strong intersection between wildlife use and expanding human use of the Ashland Watershed, a trend that is likely to increase with climate change with associated impacts on wildlife.

Trail Density Estimates- City of Ashland Ownership Examples

Location	Acres	Trail Miles	Trail Miles/Sq. Mile
COA- Lower Watershed	645	6.32[1]	**6.25**
Siskiyou Mtn. Park	271.5	4.74[1]	**11.2**
Upper Lithia Park	41	2.10[1]	**32.8**
COA- Lowest 140 acres	140	6.32[2]	**28.9**

[1]from Ashland Forest Plan, 2016, Table 3-1
[2]estimated- all or almost all trails in COA Lower Watershed in this area (BTI, Red Queen, Alice etc)

0.48 trail miles/square mile - Trail density on US Forest Service lands in the Ashland Creek Watershed, the highest amount of all watersheds analyzed (Page 3-43**,** Ashland Trails Project Environmental Assessment, December 2014)

Trails- Estimates of Disturbance to Wildlife

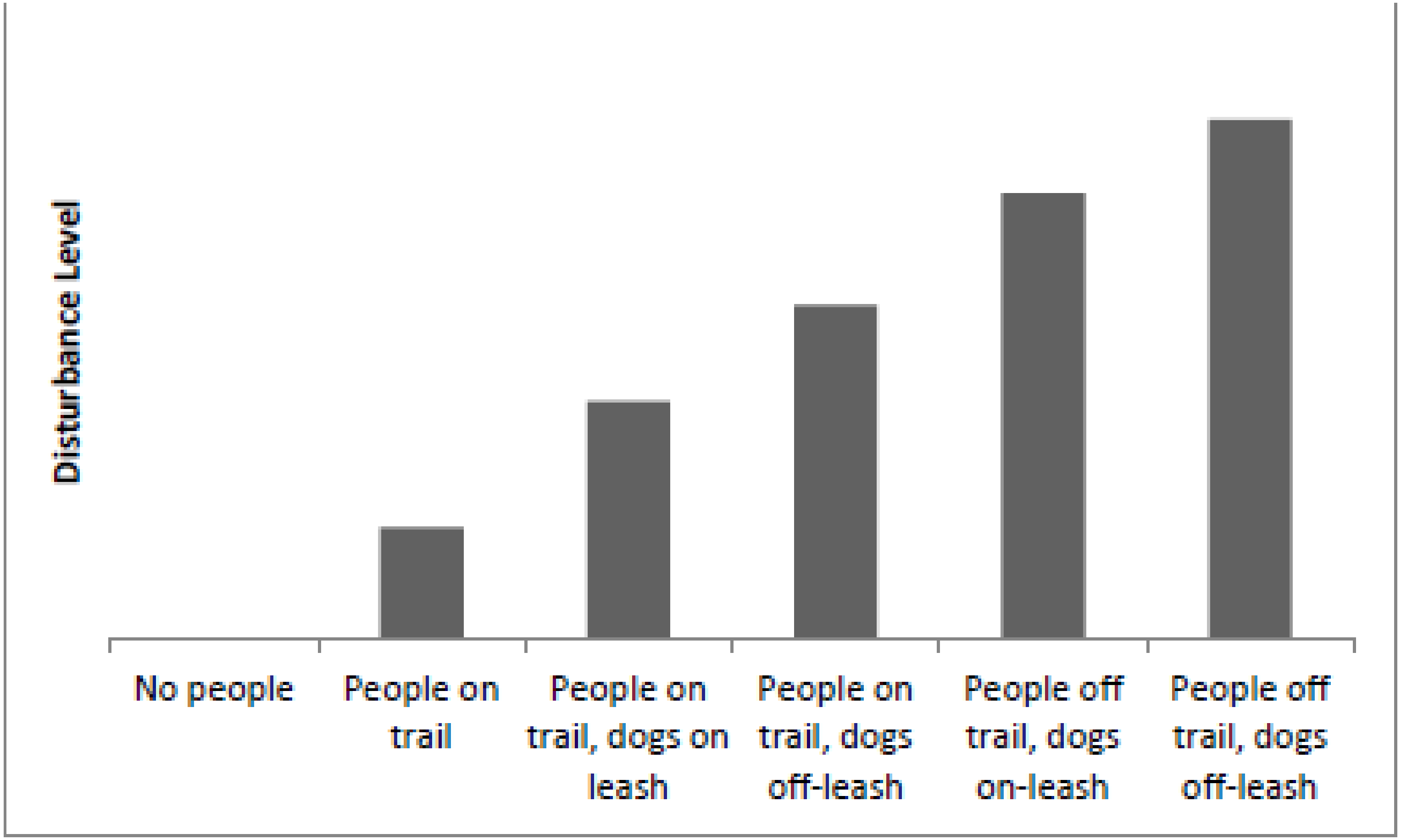
"Each alternative considered in this EA is expected to result in some degree of disturbance to wildlife in the action area, particularly species that are dependent on late-successional habitat. The following analysis assumes that disturbance would occur **within 100 meters** of existing roads, System Trails, historic trails, and unapproved trails in the action area"

- Pg. 3-47, Ashland Trails Project Environmental Assessment, December 2014

Disturbance to Wildlife per Mile of Trail (with 100 meter buffers)

1) Acreage Amount- 79.5 acres
2) Fragmentation of Habitat

Figure 1. Conceptual illustration of the relative impacts on wildlife due to people without and with dogs.



Source: Hennings. 2016. The impacts of dogs on wildlife and water quality: A literature review.

“Although the effect of biodiversity on ecosystem functioning has become a major focus in ecology, its significance in a fluctuating environment is still poorly understood. According to the insurance hypothesis, biodiversity insures ecosystems against declines in their functioning because many species provide greater guarantees that some will maintain functioning even if others fail. These results provide a strong theoretical foundation for the insurance hypothesis, which proves to be a fundamental principle for understanding the long-term effects of biodiversity on ecosystem processes.”

Source: Yachi and Loreau 1999. Biodiversity and ecosystem productivity in a fluctuating environment: The insurance hypothesis.


Image © 2010 Jackson County GIS
Image USDA Farm Service Agency
Image © 2010 DigitalGlobe
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Google

Landscape Connectivity

“Based on empirical data and computer simulations examining species range shifts in response to climate change at leading edges of current distributions; it is clear that large protected areas connected through linkages, and stepping stones embedded in a permeable matrix promote population persistence and facilitate range expansion.”

Source: Keeley et al 2018. New concepts, models, and assessments of climate-wise connectivity

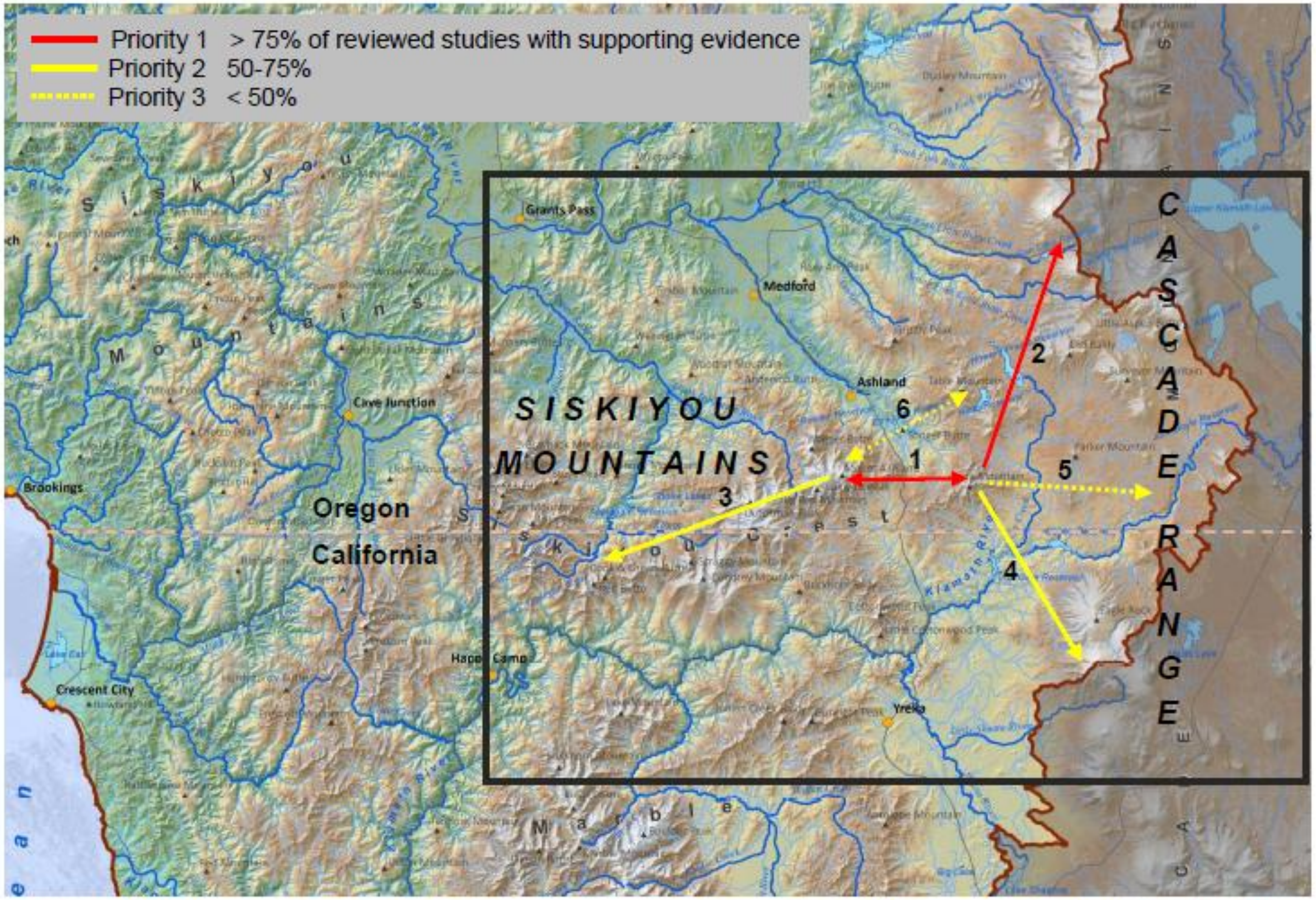
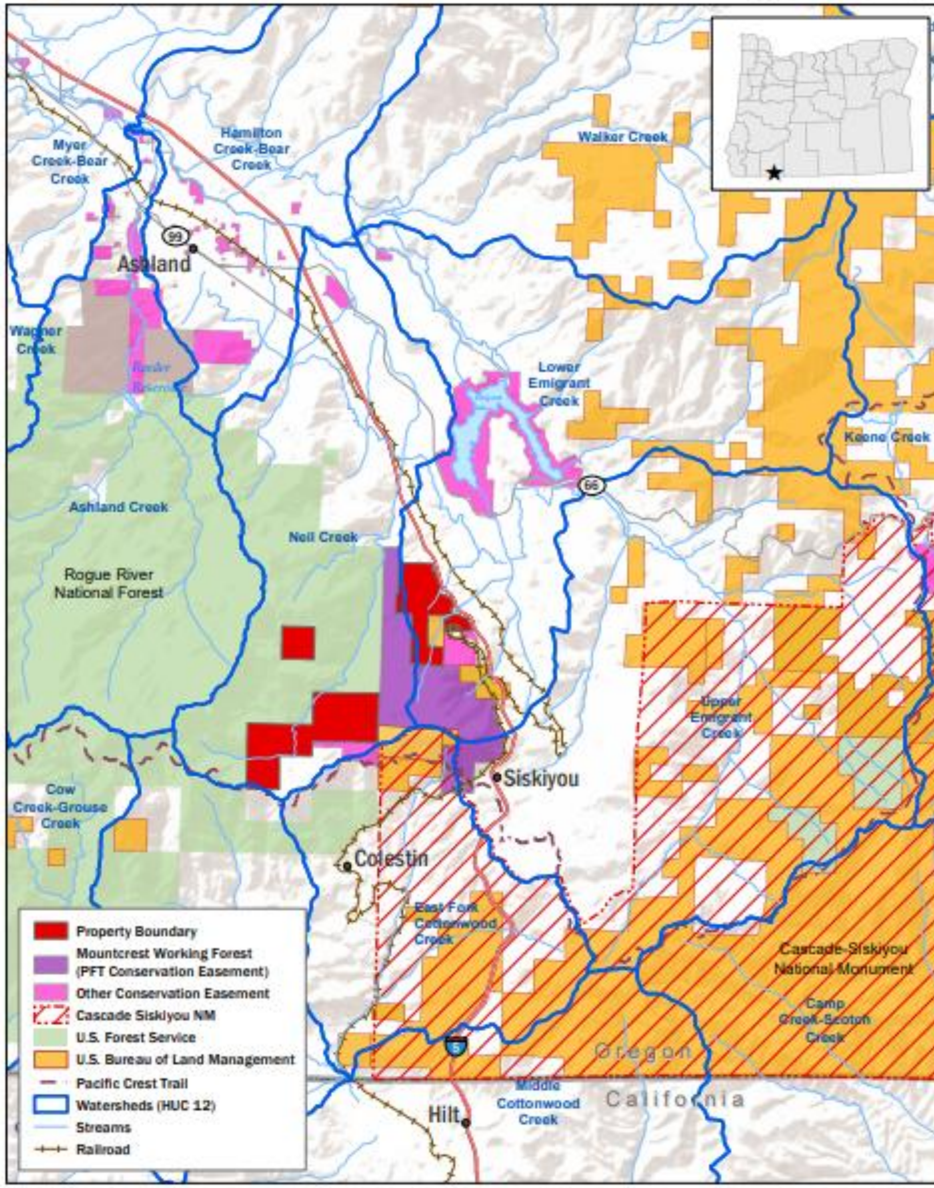


Figure 2. Generalized locations and prioritization of connectivity pathways in the Cascade-Siskiyou focus area (black rectangle) identified by studies included in this review. Linkages are classified into three priority classes based on the proportion of reviewed literature with supporting evidence for each pathway, and numbered from highest to lowest priority as follows: 1) Cascade-Siskiyou Land Bridge, 2) Southern OR Cascades; Cascade-Siskiyou NM to Rogue River-Siskiyou NF, 3) Siskiyou Crest; Mt. Ashland to western Siskiyous, 4) Southern OR Cascades; Cascade-Siskiyou NM to Klamath NF, 5) Klamath River Canyon; Cascade-Siskiyou NM to Klamath Falls BLM, and 6) Bear Creek Valley; Southern OR Cascades to Eastern Siskiyous. See Table 3 for scoring details used to assign prioritization.

Source: Frost 2018. A Review and Synthesis of Ecological Connectivity Assessments Relevant to the Cascade- Siskiyou Landscape in Southwest Oregon and Adjacent California

PACIFIC FOREST TRUST

Mount Ashland Forest Climate Resilience Project
Regional Conservation



0 2.5 5
Miles
N

Sources: Bureau of Land Management, National Hydrology Dataset, Pacific Forest Trust, Weyerhaeuser
Basemap: Sources: Esri, USGS, NOAA

4. Wildlife, Habitat Management and Biodiversity Conservation

Adaptation Options for Management

1. Manage and restore ecosystem function rather than solely focusing on specific components (species or assemblages) **(Persist, Change)**
    - a. Continue to reduce potentials for high severity fire; coordinate on larger landscape levels, particularly with USFS
    - b Address forest health concerns
        - -density/vigor continued implementation of frequent low to moderate severity disturbance regime using stand density reduction and prescribed fire;
        - -more open forests but retain refugia (3,6,riparian)
        - - continue to monitor and manage insect and disease disturbances, including spatially explicit management of dwarfmistletoe lam root disease in DF
        - - legacy tree management through stand level thinning
        - - manage LWD; reduce where possible particularly in strategically important fire management areas (1,4,5) but maintain for important habitat values

2. Continue to strive for vegetation and structural diversity at multiple scales of reference; manage for a high contrast landscape **(Persist, Change)**

3. Manage to retain important features and structural types for rare species- northern spotted owl, Pacific fisher **(Persist)**

4. Winburn- example
    - - Structurally diverse older closed canopy forest may become more rare (high severity fire); really important to maintain if at all possible
    - - Managing for mid and late open structural states and associated habitat values
    - - Retain thermal refugia (steep northerly aspects above major streams)
    - - Fire management objectives and large woody debris; determine on a site-by-site basis
    - - NSO potential habitat- spatially explicit retention of Douglas-fir dwarfmistletoe
    - - Functional perennial stream and associated values
    - - Accelerate development of replacement older forest values

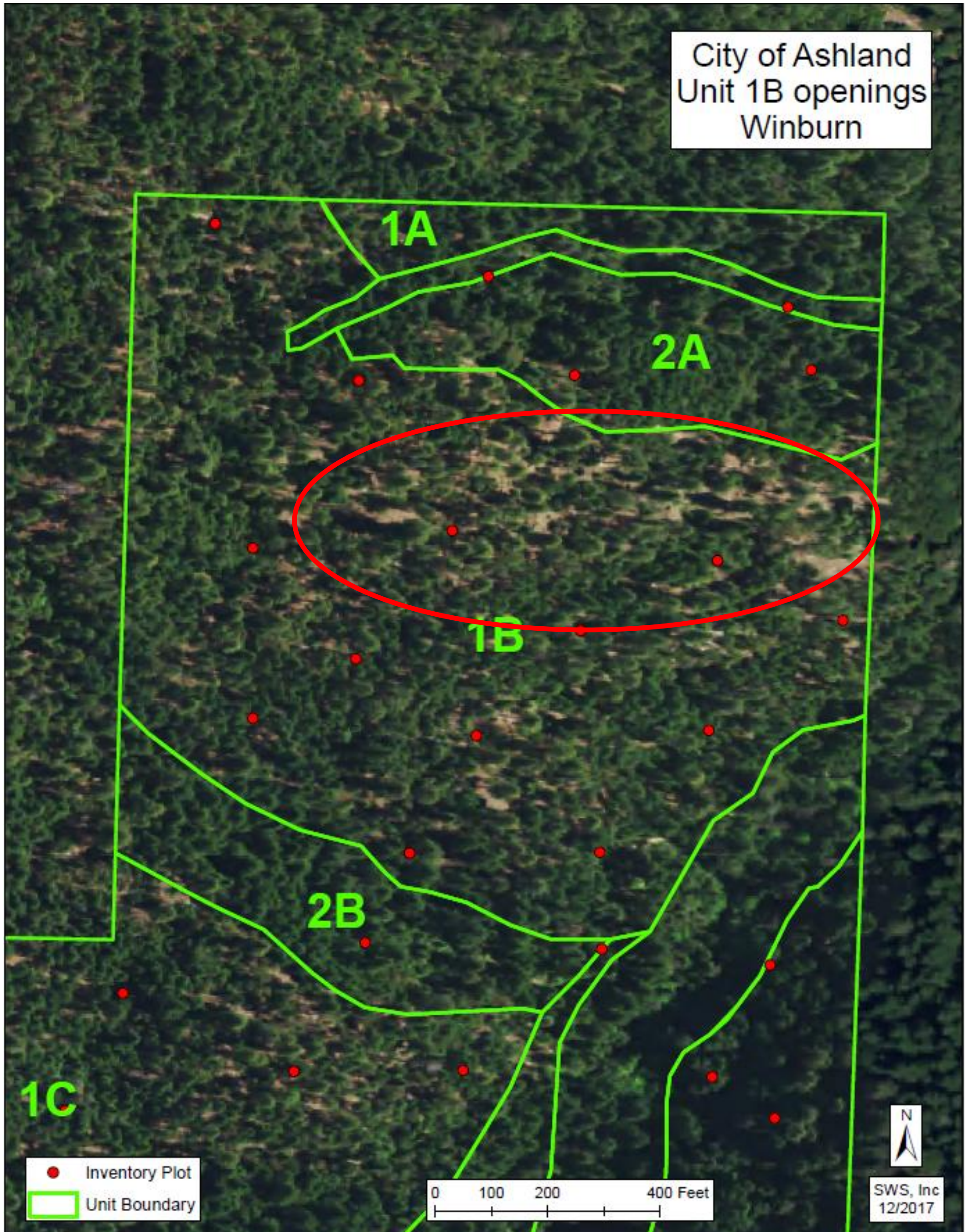
5. Retention of oak woodlands, shrubfields **(Persist, Change)**
    - - may be difficult except perhaps in locations somewhat removed from urban and semi-urban environment (e.g. Siskiyou Mountain Park) due to high fire danger)
    - - inventory shrub fields and locations for firesafe retention; retain small patches
    - - maintain patches of more open, less fire prone white oak oak woodland, white oak savannah, pine/oak woodlands
    - -plan for white oak woodland and pine/oak woodland expansion up in elevation with climate change, particularly on more southerly aspects

6. Reduce pressures on wildlife species from sources other than climate change **(Change)**
    - -Expanding human use has trade-offs with effects on wildlife habitat. Expect continued increased demand and seasonal shifts with temperature increases. Consider the concept of carrying capacity

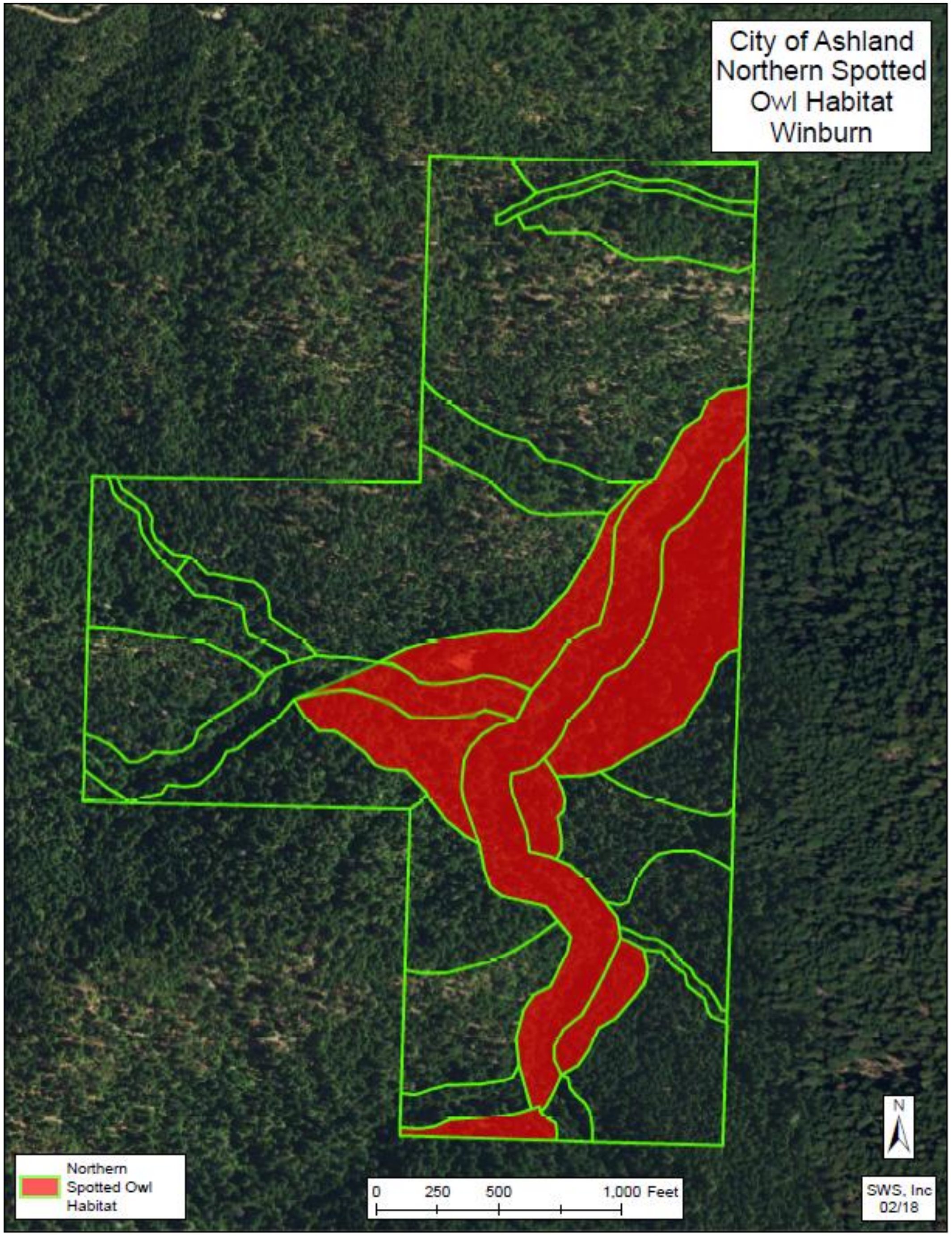
7. Landscape level connectivity (larger scope than City ownership) **(Persist)**
    - -Maintain protected areas network , protect movement corridors, important refugia; maintain landscape permeability to species movement throughout ownership/watershed and consider effects of trails, dogs, etc initiated on City ownership

City of Ashland, Unit LW-D

Insect-related mortality of Douglas-fir in 1995-96 created an extreme fire hazard and subsequent removal of large accumulation of snags and downed wood created a wildlife habitat benefit as an open forest structural type that was lacking on a landscape level.



A Late-seral, Open structural type, rare in the Ashland watershed or in southern Oregon, is being developed in the upper half slope positions in Unit 1b (and elsewhere in Unit 1) on the Winburn parcel.


City of Ashland
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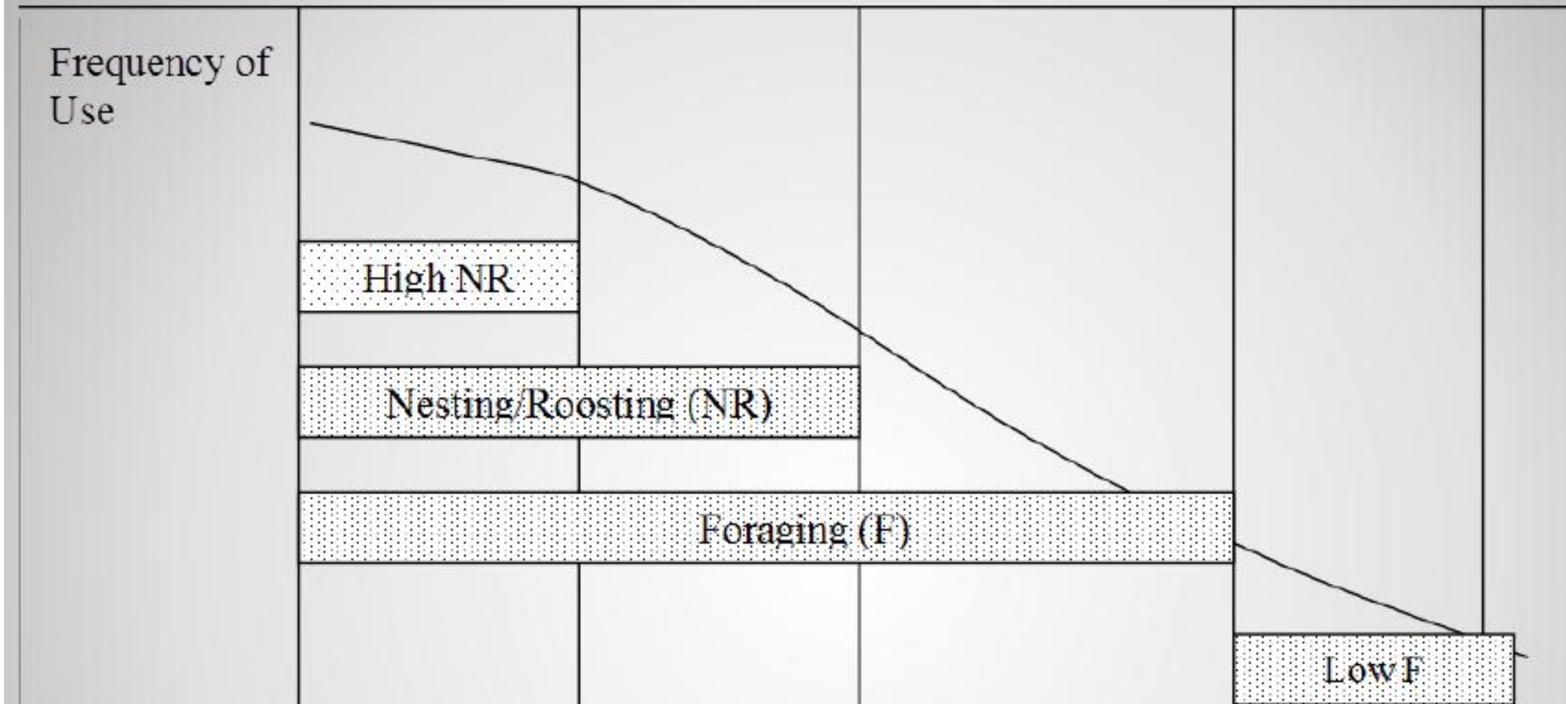
Northern Spotted Owl Habitat Features

_(Winburn parcel only on the City ownership)

1. Prefer older forests with large, older trees with average dbh > 17 “
2. 60+% crown closure; basal area >180-240 ft2/acre
3. Complex, multi-layer canopy
4. Prefer cooler, moister sites on lower topographical positions and more northerly aspects close to waterways
5. Importance of Douglas-fir dwarfmistletoe brooms as a habitat feature for owls and prey species
6. Large (>26”dbh; 12+/acre) trees with deformities, cavities etc for nesting

Stand level Features for Northern Spotted Owl Use

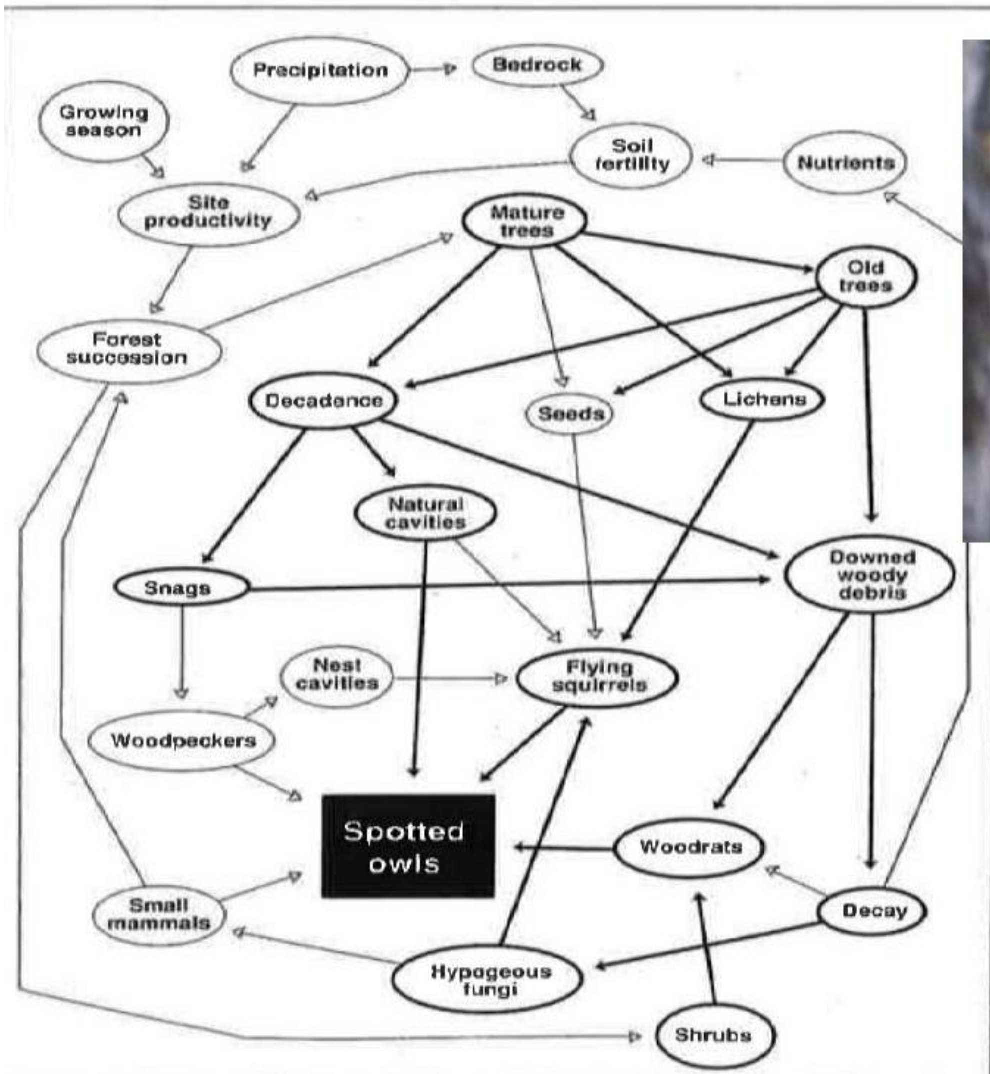


Basal Area	300+	200	150	120	80
QMD[1]	20"		15"	13"	11"
TPA > 26"[2]	50		8	5	
Canopy[3]	100%		60%		40%
Structure	Large tree/dense	Large/open to medium/dense		small/dense to open/brushy	

1: QMD= quadratic mean diameter of trees > 5 inches dbh
2: TPA>26"= trees per acres of trees >26 inches dbh
3: Canopy= percent cover of overstory trees

Slide Credit: Jim Thraillkill, US Fish and Wildlife Service

Once again- Complexity!



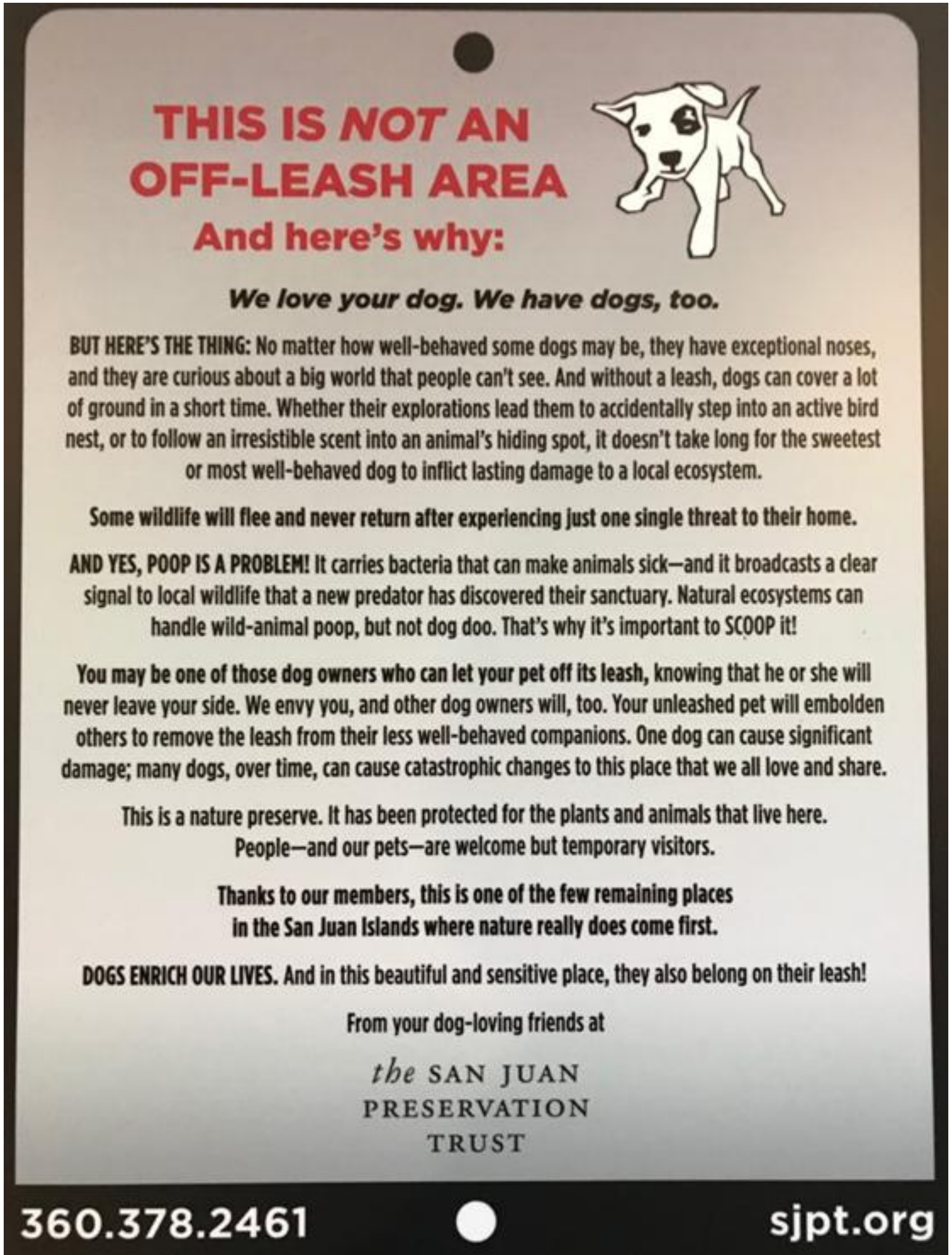
- Why large trees?
- Why downed wood?
- Why snags?
- Why multiple canopies?

And with climate change- increased vulnerability!

Slide Credit:
Jim Thraillkill

Pacific fisher habitat features

1. Nesting habitat- nadal dens, maternal dens; large trees with appropriate cavities.
2. Resting habitat- dwarfmistletoe brooms in Douglas-fir 14-40” dbh (80% of time).
3. Appear to be fairly adaptable to management activities, except helicopter use.
4. Prefer areas with abundant large woody debris.
5. Disperse treatments over space and time minimizes impacts to fishers
6. More use of the Lower Watershed parcel than at the Winburn parcel.



Consider a leash law on City trails to limit impacts to native wildlife.

5. Riparian

1. **The Ashland Forest Plan (2016) has a good description of streams and riparian habitat on the City ownership.**

2. **The riparian network on the City ownership is characterized by the primary mainstem fish-bearing Ashland Creek, several smaller stretches of perennial creeks and a large network of intermittent/ephemeral drainages.**

3. **The mainstem of Ashland Creek is highly altered from Reeder Reservoir below and through the city down through Lithia Park (1.45 miles and 34.42 acres, Ashland Forest Plan 2016, and includes the water treatment plant). Flows are adjusted through outlet from Reeder Reservoir and are primarily designed to meet municipal City water supply needs. Fish passage is blocked at the upper end of Lithia Park by the "swimming hole"- an old historic dam and reservoir. Standard riparian management strategies such as retention/promotion of large structural features (logs, rocks etc) are minimized in this stream location in deference to flood stage control (e.g. 1997). The viability of this stretch as a functional riparian habitat and aquatic ecosystem are reduced as a result. The potential for active restoration and/or improvement of riparian habitat values must be considered within the context of this highly altered aquatic/riparian environment. Very little active management within this area has occurred in the last 25 years.**

4. **The stream systems on the Winburn parcel, as part of West Fork Ashland Creek watershed, are much more functional riparian and aquatic ecosystems, with slightly over 1 mile and about 22 acres (Ashland Forest Plan) of riparian management area. No active management within this area has occurred within the last 25 years.**

5. **The steep topography and decomposed granitic base make for quick transition out of perennial stream conditions into drier uplands and more ephemeral riparian conditions, many of which have limited or no associated riparian vegetation. These areas generally interact with disturbance (e.g. fire) in a similar fashion to the adjacent uplands. Many of these ephemeral/intermittent channels are influenced by periodic debris slide processes that occur during major storm events (on adjacent US Forest Service lands they are often described and mapped as Landslide Hazard Zones (LHZ's).**


Ashland Creek above Reeder Reservoir

Riparian Areas and Management with Climate Change

A complex topic that deserves its own unique, in-depth sssessment

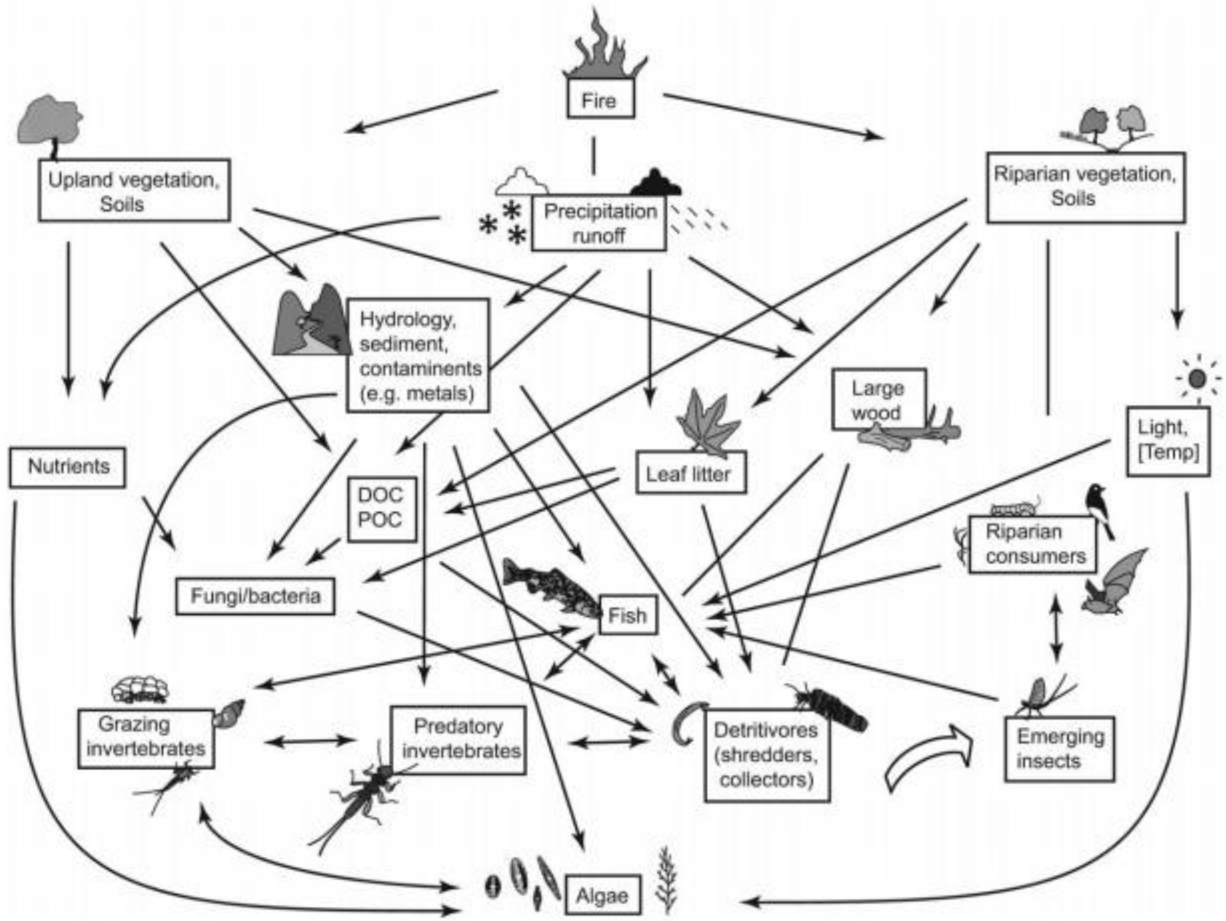


Figure 1. Path diagram showing probable cause–effect relationships leading from fire to stream communities. Lines without arrows indicate factors that are associated with each other, unidirectional arrows point from driver to response variables, and double-headed arrows indicate consumer–resource interactions where consumers depress and benefit from the consumption of their resources. Temp = temperature, DOC = dissolved organic C, POC = particulate organic C.

Slide Source: Bixby et.al. 2015. Fire effects on aquatic ecosystems: an assessment of the current state of the science

The median Fire Return Intervals (FRIs)s were approximately double in the riparian reserve sites compared to the upland sites. These data suggest that FRIs in riparian reserves may be more variable than in adjacent uplands and tend to be longer. Riparian areas may have enhanced the spatial and temporal diversity of landscapes by acting as occasional barriers to many low and moderate-severity fires.

“A Tree-ring Based Fire History of Riparian Reserves in the Klamath Mountains”, Skinner, 2003

Fire Return Intervals in Forested Riparian Areas

Location	Forest Type	Riparian Fire Return Interval (yrs)	Sideslope Fire Return Interval (yrs)	Citation
Blue Mountains, OR	Dry, Douglas-fir and Grand Fir series	13-36	10-20	Olson 2000
Elkhorn Mountains, OR	Dry, Ponderosa Pine, Douglas-fir series	13-14	9-32	Olson 2000
Salmon River Mountains, ID	Dry, Ponderosa Pine and Douglas-fir series	11-19	9-29	Barrett 2000
Cascade Range, WA	Dry, Ponderosa Pine and Douglas-fir series	15-26	11-19	Everett et al. 2003
No. Sierra Nevada Mtns, CA	Dry, Ponderosa/ Jeffrey Pine	10-87	10-56	Van De Water & North 2010
Dry Forest Type Average		**12-36**	**10-31**	
Cascade Range, OR	Mesic, Douglas-fir series	35-39	27-36	Olson and Agee 2005
Klamath Mountains, CA	Mesic, Douglas-fir series	16-42	7-13	Skinner 1997
Mesic Forest Type Average		**26-41**	**17-25**	

Stone et al. 2010. Fuel reduction management practices in riparian areas of the western USA. *Environmental Management 46:91-100.*

Slide Source: Kate Dwire powerpoint: *Fire and Fuel Reduction Treatments in Riparian Areas: Management in the Context of Climate Change*

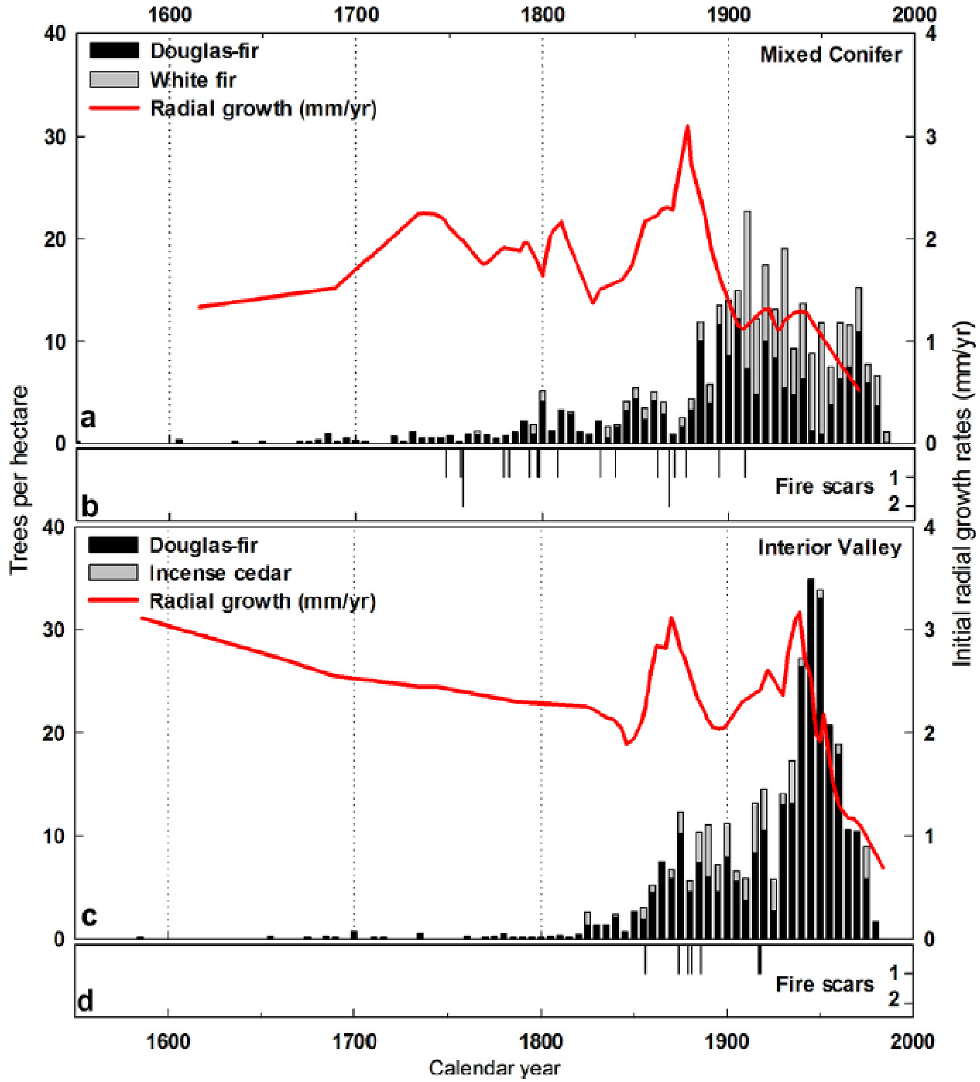
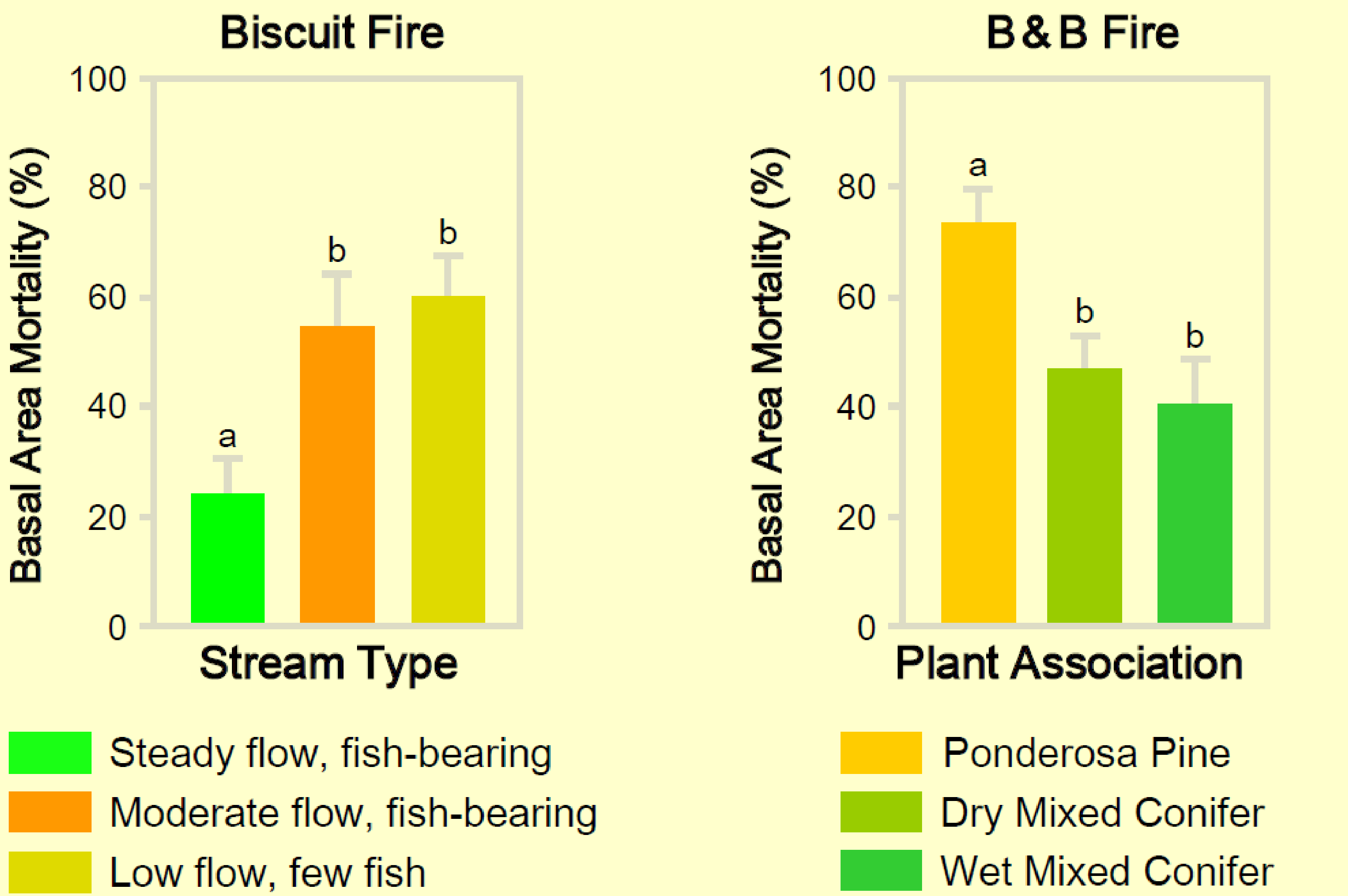


Fig. 2. (a) Average age distribution (left axis) of Douglas-fir and white fir on 11 Mixed Conifer riparian sites in the Rogue River basin, Oregon, with the smoothed initial growth rates (right axis, average of first 20 years) for a subsample of Douglas-fir. (b) Fire scars recorded at five Mixed Conifer riparian sites. (c) Average age distribution (left axis) of Douglas-fir and incense cedar on 12 Interior Valley riparian sites in the Rogue River basin, Oregon, with the smoothed initial growth rates (right axis, average of first 20 years) for a subsample of Douglas-fir. (d) Fire scars recorded at three Interior Valley riparian sites.

Densification of vegetation with fire exclusion and decline in radial growth in riparian forests

Fire exclusion effects on riparian forest dynamics in southwestern Oregon. Messier et.al 2011

Variation in Fire Severity within the Stream Network



(Halofsky and Hibbs 2008; slide by Alan Tepley)

5. Riparian

Climate Change Key Vulnerabilities

1. **Increased peak flows during winter**

2. **Decreased flows and longer summers of higher temperatures alter riparian vegetation and function.**

3. **Decrease in extent of riparian zone**
   - Intermittent reaches of riparian network may become more ephemeral and greater percentage of riparian network will more closely reflect adjacent upland vegetation conditions with associated increased availability for fire-related impacts

4. **Increased frequency, scale and severity of insect and fire-related disturbances**
   - Historically, fire severity tended to be reduced in riparian areas, particularly as compared to adjacent uplands, and riparian areas tended to act as firebreaks in many situations
   - With fire exclusion, riparian vegetation has become denser and, coupled with climate-change related increasing temperatures and lower summer precipitation/streamflow, possibilities for higher severity fire in riparian zones is increased

5. **Combined effect results in a potentially significant loss in ecosystem services.**

Increased Peak Flows in Winter

- Potential to move large wood and boulders and bury or scour within stream channels; affects channel form, impacts riparian vegetation and changes fluvial dynamics.

- Tends to promote more disturbance-tolerant vegetation, most notably red alder and willows in this situation.

- Affects erosion and sedimentation on a landscape basis; infill of Reeder Reservoir with effects on water quality and quantity and major cost associated with sediment removal.

- Increase potential for flooding and downstream effects on the built environment/infrastructure.

January 1, 1997

Ashland, Oregon

Drying and Warming of Riparian Areas in Extended Summer Season

- **Many of the same basic physical processes as described for vegetation in upland settings (e.g. increased moisture stress and subsequent plant and vegetation decline/mortality, etc)**

- **Decline/mortality of existing overstory trees may increase as trees used to cooler summer temps and more moisture availability have difficulty adjusting to new more droughty extended summer seasons.**

- **In conjunction with increased large wood deposition during peak winter flows, an unnatural accumulation of large woody debris may occur.**

- **Shifts to more drought and disturbance tolerant species within the riparian plant community composition as the areas become increasingly more like adjacent upland vegetation. Some replacement of deciduous hardwoods such as alder and bigleaf maple may occur (especially larger trees), as well as changes in understory vegetation (e.g. shrinking of extent of salal along West Fork Ashland Creek at Winburn). Upland species such as conifers and upland hardwoods may become more common, and perhaps as small trees at higher densities.**

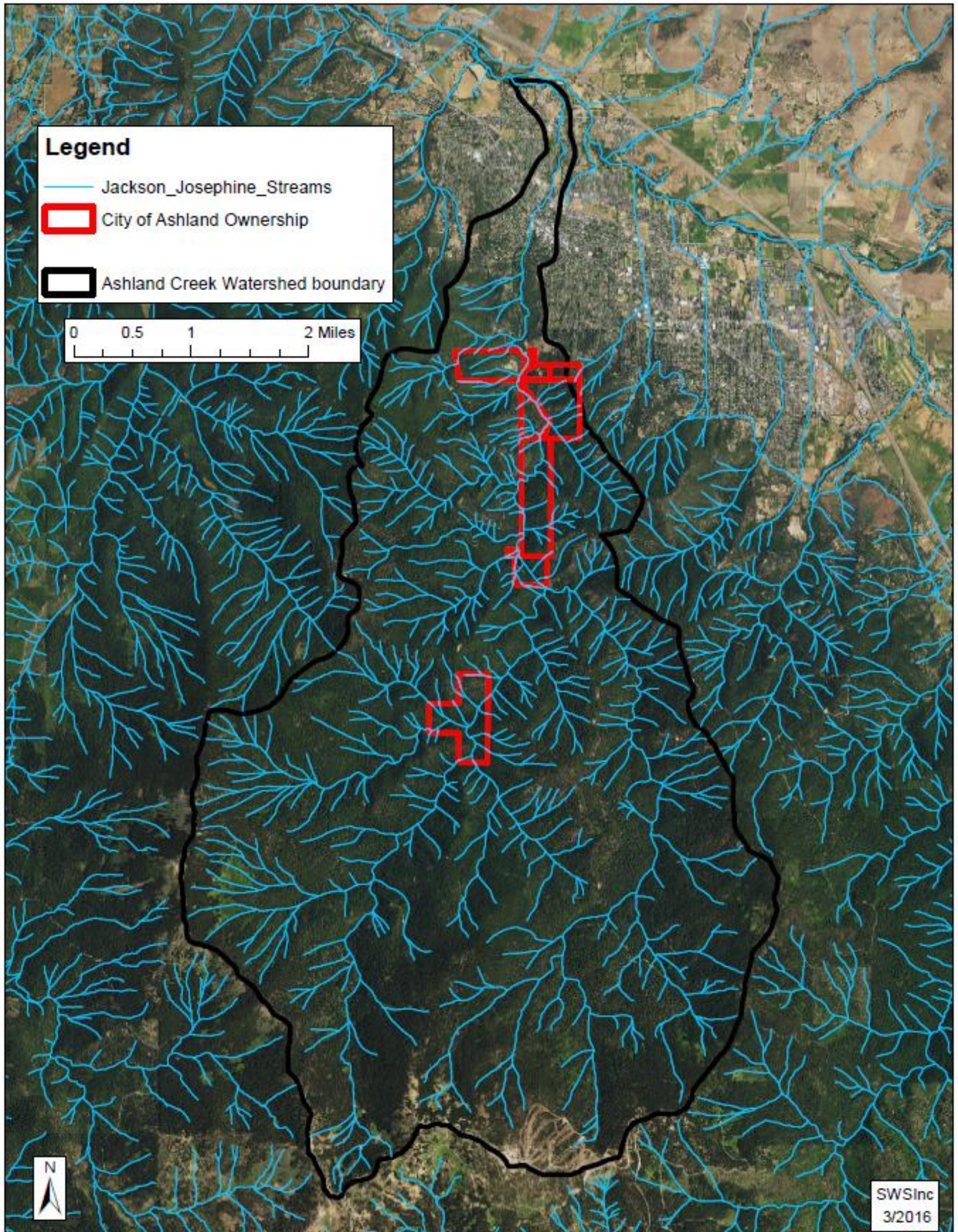
- **The opportunity for establishment of invasive, non-native species following disturbance may increase. Stream networks are corridors for movement of propagules either by water and/or wildlife, have high resource availability with greater likelihood of successful establishment and have inherent high levels of disturbance creating sites for establishment.**

Decrease in Extent of Riparian Zone

-**Increasing temperatures, decreasing summer streamflows and emerging more droughty conditions may lead to drying where perennial streams become more intermittent, intermittent streams become more ephemeral; and the extent of the riparian network decreases, particularly in the upper portions of the riparian network.**

-**Size of riparian-influenced buffers adjacent perennial and intermittent creeks may shrink**

- **Potential shrinkage in size and/or loss of key refugia may occur.**



With increasing temperatures and longer summer drought conditions, a greater percentage of the watershed becomes available for fire, particularly as intermittent and ephemeral streams convert to more upland types of more fire prone vegetation. Foliar moisture shrinks on a landscape basis creating greater opportunity for landscape level higher severity fire.

Climate Change Effects on Riparian Vegetation and Resulting Decline in Ecosystem Function and Services

Vegetation changes exacerbated by changes in climate can result in direct losses of important highly valued ecosystem services:

- stream shading and water cooling (although discharges form Reeder Reservoir tend to keep fairly cool water temperatures for fish)

- buffering capacity of riparian vegetation for capturing sediment delivery, maintaining water quality for Reeder Reservoir

- important wildlife habitat conditions (e.g. presence of food, water and cover in close proximity)

- loss of refugia that are often clustered along cooler, moister portions of the landscape, often in riparian areas.

- unique vegetation on a landscape level with important vegetation and biodiversity values

- energy dispursement in peak storm events reducing the potential for downstream flooding and infrastructure damage

Change in Riparian Vegetation: Fire Relationships

- Densification of forest from fire exclusion, particularly of smaller, shade tolerant trees may increase in some situations increasing fuel continuity and fire translation directly from uplands into riparian areas.

- Both peak flows in winter and overstory tree mortality in droughty conditions may contribute to unprecedented accumulations of large fuels with increased potential for long duration, high impact fire, adding to the increased potential for mass fire and highly unpredictable, erratic fire behavior.

- With drier conditions , the riparian network will not work as effectively as a firebreak that minimizes expansion of low to moderate severity fire, and may convert to higher severity fire more often. Drier riparian vegetation will add to an overall decrease in landscape level foliar moisture and reduce the effectiveness of this important mechanism of landscape level resistance to high severity fire.

- Projected increase in winds with climate change may align with topography and increase the likelihood of conversion to intense high severity fire more often in drainages and canyons (e.g. Almeda Fire)

- High severity stand replacement fire over large stretches may significantly reduce ecosystem services from the streams (shading, wildlife habitat, buffering capacity for water quality, etc), at least until vegetation grows back. However, the post high severity disturbance vegetation will likely be of a different type and composition, especially given the increased opportunity for establishment of invasives.

Riparian Areas and Local Fire Regimes

1. Burn like adjacent uplands **(much of Lower Watershed parcel above Ashland Creek)**

- Where similar upland-streamside vegetation, moisture conditions, terrain and topography occur (Small drainages, intermittent/ephemeral streams, headwaters, upper portions of narrow drainages)
- When large fires burning under severe fire weather exceed the influence of local topography and riparian-upland vegetation differences **(e.g. Almeda Fire)**

2. Burn less frequently and severely than adjacent uplands **(e.g. natural refugia: Winburn Unit 3)**

- Where riparian vegetation is distinctly different from uplands
- Where saturated soil, presence of riparian wetlands or hydrologic inputs from adjacent hillslopes influence fire behavior.
- At junctures of multiple intermittent/ephemeral drainages with increased cold/moist air drainage **(Unit LW-J)**

3. Burn more frequently and/or severely than adjacent uplands

- Where riparian areas serve as chimneys/corridors for severe fire; often in steep topography in upper portions of drainage network
- Where fuels and vegetation are higher than adjacent uplands due to natural or management conditions

4. Riparian areas serve as fuelbreaks **(Winburn riparian forest and adjacent Unit 3)**

- Where perennial stream valleys create breaks in fuel characteristics & continuity;
- Where saturated soil conditions, presence of riparian wetlands, or hydrologic inputs from hillslopes influence fire behavior **(Unit LW-J);**
- When fires burn with low intensity

Slide Source: adapted from Kate Dwire powerpoint: *Fire and Fuel Reduction Treatments in Riparian Areas: Management in the Context of Climate Change*

5. Riparian

Adaptation Options for Management

1. Use adaptive management and monitor thoroughly over time. The combination of projected drier extended summers and winters with larger storm events and higher peak flows presents a difficult conundrum for appropriate management responses in riparian areas. **(Change)**
2. Recognize that the riparian area below Reeder Reservoir will like continue to be an extremely altered riparian/aquatic environment with major concerns for potential flood stage impacts. Riparian management will likely have to continue to be considered within this unique context where limiting damage from floods in the highest priority. **(Persist)**
3. Thinning in riparian areas to increase tree size and function and improve tree vigor, especially in more upland areas higher in riparian network in intermittent and ephemeral portions. Promote more shade intolerant species. **(Persist, Change)**
4. Allow more frequent, low severity disturbance including from insects and disease such as occurring at Winburn with laminated root disease. Create low density stand conditions that may retard advancement of high severity fire within the riparian network while still retaining important riparian and aquatic function. **(Change)**
5. Break up fuel continuity in uplands close to major riparian areas (especially along Ashland Creek) to discourage opportunity for high severity disturbance advancing into riparian areas. Particularly target protection of important refugia to be retained at higher densities. **(Change)**
6. Develop a team of experts to specifically look at adaptation options for management in the riparian forestlands on the City of Ashland ownership. **(Change)**

6. Recreation

Climate Change Key Vulnerabilities

1. Increased population and expansion of outdoor recreational needs will impact natural areas and resource values and likely require increasing monitoring and oversight.

2. Extreme wildfire, projected to increase, may reduce recreational demand because of degraded site desirability, impaired air quality from smoke, and limited site access caused by fire management activities. Expect social and economic impacts

3. With longer summer season, increased days where minimum temperature encourage outdoor recreation use, particularly in shoulder seasons. Greater use and subsequent impacts on recreational facilities (e.g. trails) and higher maintenance costs to maintain the same level of ecological impact.

4. Larger peak storm events in winter – greater impact from trails, pirate trails, erosion and sedimentation, etc

5. Potentially greater impacts on cooler locations in summer, especially aquatic/riparian habitats (e.g. thermal refugia) , with impacts on water, wildlife, etc.

6. Impacts on wildlife generally- spatially complex relationships between wildlife and their habitats
   - -Alteration in complex spatial arrangement of habitat needs often subtle but important; impact is aggravated as vegetation changes with climate change
   - -Trails
   - -Dogs- anti-predator response, flight initiation distance, fragmentation
   - -More open forests, less hiding cover
   - -Decrease in landscape permeability
   - -Pacific fisher presence in lower watershed that has becomeincreasingly used for outdoor recreation

7. Increased potential for introduction of unwanted invasive species

8. Increased likelihood of outdoor recreationalists interaction with fire in a wildfire event. Evacuation?

Table 7.2—Participation in different recreational activities in Rogue River-Siskiyou and Umpqua National Forests in 2008a

	Visitors for whom this was their primary activity			
	Rogue River-Siskiyou National Forest		Umpqua National Forest	
	Percent	*Number*	*Percent*	*Number*
Warm-weather activities	**57.5**	**674,610**	**67.3**	**833,382**
Hiking/walking	19.6	230,442	20.9	259,578
Viewing natural features	24.3	284,769	26.1	323,334
Developed camping	4.0	47,163	7.7	95,128
Bicycling	0.5	5,970	2.0	24,288
Other non-motorized	2.2	26,268	2.6	32,384
Picnicking	0.1	597	0.1	1,012
Primitive camping	5.3	62,088	4.0	49,082
Backpacking	1.0	11,343	3.3	40,480
Winter activities	**12.9**	**151,638**	**1.3**	**16,192**
Downhill skiing	5.1	60,297	0.0	0
Snowmobiling	0.6	6,567	1.1	13,156
Cross-country skiing	7.2	84,774	0.2	3,036
Wildlife activities	**23.5**	**275,814**	**27.8**	**344,080**
Hunting	1.7	19,701	4.5	55,660
Fishing	8.5	99,699	9.1	113,344
Viewing wildlife	13.3	156,414	14.1	175,076
Gathering forest products	**2.3**	**27,462**	**1.6**	**20,240**
Water-based activities	**3.8**	**44,178**	**2.0**	**25,300**
Non-motorized activities	1.0	11,343	0.8	10,120
Motorized activities	2.8	32,835	1.2	15,180

Source: Halofsky et.al. 202x. Climate Change Vulnerability and Adaptation in Southwest Oregon.

“In recent years, Forest Service and City personnel, as well as casual trail users, have noticed a sharp increase in the number of visitors to the greater Ashland Watershed (USDA FS, 2014). This recent escalation has impacted user experiences, strained natural resources and created parking issues at trailheads on City lands”.

-Ashland Forest Plan 2016

Table 3-1: The total miles of trail on City lands by use type for each parcel.

Trail use by type in miles per parcel						
Forest Land Parcels	Use Type					
	Hike Only	Hiker/Equestrian Only	Multi Use	Bike Only	Hike/ Bike Only	Total trail length
Ashland Ponds	0.15		0.27			0.42
Alsing Reservoir						0
Burnson - Lawrence	0.11		0.19			0.30
Cottle - Phillips	0.22		0.01			0.23
Crowson Reservoir	0.09		0.04			0.13
Granite Street			0.43			0.43
Hitt Road	0.05		0.05			0.05
Hald - Strawberry			1.19			1.19
Liberty Street			0.09			0.09
Lower Watershed	0.75	2.49	0.40	1.04	1.48	6.32
Oredson Todd Woods	0.5		0.28			0.78
Siskiyou Mountain Park	2.37		2.37			4.74
Upper Lithia	1.71		0.39			2.10
Total trail length per user type	**5.90**	**2.49**	**5.71**	**1.20**	**1.48**	**16.78**

Trail Density Estimates- City of Ashland Ownership Examples

Location	Acres	Trail Miles	Trail Miles/Sq. Mile
COA- Lower Watershed	645	6.32[1]	**6.25**
Siskiyou Mtn. Park	271.5	4.74[1]	**11.2**
Upper Lithia Park	41	2.10[1]	**32.8**
COA- Lowest 140 acres	140	6.32[2]	**28.9**

[1]from Ashland Forest Plan, 2016, Table 3-1

[2]estimated- all or almost all trails in COA Lower Watershed in this area (BTI, Red Queen, Alice etc)

0.48 trail miles/square mile - Trail density on US Forest Service lands in the Ashland Creek Watershed, the highest amount of all watersheds analyzed (Page 3-43**,** Ashland Trails Project Environmental Assessment, December 2014)

Trails- Estimates of Disturbance to Wildlife

"Each alternative considered in this EA is expected to result in some degree of disturbance to wildlife in the action area, particularly species that are dependent on late-successional habitat. The following analysis assumes that disturbance would occur **within 100 meters** of existing roads, System Trails, historic trails, and unapproved trails in the action area"

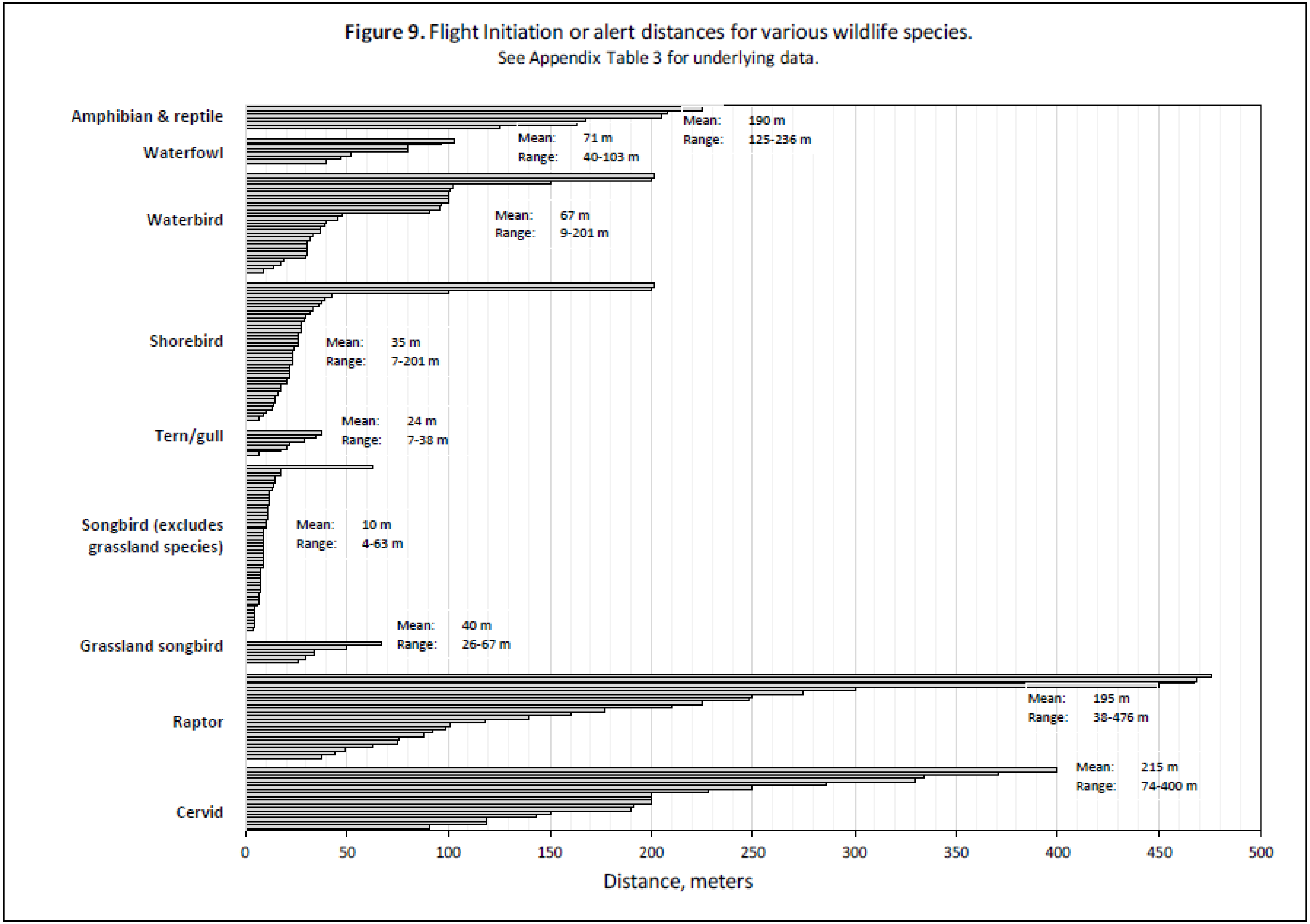
- Pg. 3-47, Ashland Trails Project Environmental Assessment, December 2014

Disturbance to Wildlife per Mile of Trail (with 100 meter buffers)

1) Acreage Amount- 79.5 acres
2) Fragmentation of Habitat

Figure 1. Conceptual illustration of the relative impacts on wildlife due to people without and with dogs.

Source: Hennings. 2017. The impacts of dogs on wildlife and water quality: A *literature* review. *In: Hiking, mountain biking and equestrian use in natural areas: A recreation ecology literature overview.*



Source: Hennings. 2017. Hiking, mountain biking and equestrian use in natural areas: A recreation ecology literature overview.

6. Recreation

Adaptation Options for Management

1. **Recreational use in wildlands is different than in more urban or semi-urban City parks and requires a different set of constraints and oversight. Identify current and future impacts on ecological values and forest resources on City forestlands from expected expanding human recreational use. Consider individual categories of use/impacts and tools for managing those impacts. Determine a recreational carrying capacity while looking at all impacts and values by location and vegetation/habitat type. (Change)**

2. **Plan for increased demand for recreational use of City lands in the future with temperature increases, especially cooler locations along riparian networks. Spatially arrange for that use, avoiding areas through recreation engineering that have other important values that may be in conflict with increasing recreational use (e.g. refugia important from a wildlife perspective, etc). In particular, consider habitat connectivity to facilitate animal movement and range shifts with climate change, especially along riparian corridors. (Change)**

3. **Plan for increased maintenance of trail, parking and other recreational infrastructure, both from increased shoulder-season use and greater storm-related impacts in winter. Consider a more regulated plan for trail use including evacuation of trail users in an emerging wildfire event. (Change)**

4. **Separate considerations for and importance of human from pet use of recreational facilities. (Change)**

5. **Closely monitor and remove (if possible) unwanted invasive species (Persist, Change e.g. more monitoring and removal along all trails (including “pirate” trails) or other high use areas).**

Recreational Carrying Capacity

Recreational carrying capacity refers to the amount of recreational use a trail or site can support beyond which excessive environmental/biological damage, social and managerial issues, or decreased visitor experience may occur. The idea is to identify social (recreationist) or ecological thresholds based on a predetermined set of standards which when exceeded, trigger specific management actions to reduce impacts.

Source: Hennings 2017. "Hiking, mountain biking and equestrian use in natural areas: A recreation ecology literature review".

TOOLS TO HELP MANAGE NEGATIVE EFFECTS:

Most Common Categories

1. **TRAIL DESIGN AND CONSTRUCTION RESOURCES**
2. **RECREATIONAL CARRYING CAPACITY AND VISITOR USE FRAMEWORKS**
3. **MONITORING APPROACHES**
4. **ADDRESSING UNAUTHORIZED TRAILS**
5. **PROTECTING RIPARIAN HABITAT AND WATER QUALITY**
6. **MINIMIZING FRAGMENTATION AND EDGE EFFECTS**
7. **MINIMIZING EFFECTS OF RECREATIONAL USE ON WILDLIFE**

Source: Hennings 2017. "Hiking, mountain biking and equestrian use in natural areas: A recreation ecology literature review".

Each of these 7 categories should be considered separately for its relevance on the City of Ashland ownership, particularly considering that each is likely to become more important with developing climate change.

THIS IS *NOT* AN OFF-LEASH AREA

And here's why:

We love your dog. We have dogs, too.

BUT HERE'S THE THING: No matter how well-behaved some dogs may be, they have exceptional noses, and they are curious about a big world that people can't see. And without a leash, dogs can cover a lot of ground in a short time. Whether their explorations lead them to accidentally step into an active bird nest, or to follow an irresistible scent into an animal's hiding spot, it doesn't take long for the sweetest or most well-behaved dog to inflict lasting damage to a local ecosystem.

Some wildlife will flee and never return after experiencing just one single threat to their home.

AND YES, POOP IS A PROBLEM! It carries bacteria that can make animals sick—and it broadcasts a clear signal to local wildlife that a new predator has discovered their sanctuary. Natural ecosystems can handle wild-animal poop, but not dog doo. That's why it's important to SCOOP it!

You may be one of those dog owners who can let your pet off its leash, knowing that he or she will never leave your side. We envy you, and other dog owners will, too. Your unleashed pet will embolden others to remove the leash from their less well-behaved companions. One dog can cause significant damage; many dogs, over time, can cause catastrophic changes to this place that we all love and share.

This is a nature preserve. It has been protected for the plants and animals that live here.
People—and our pets—are welcome but temporary visitors.

Thanks to our members, this is one of the few remaining places in the San Juan Islands where nature really does come first.

DOGS ENRICH OUR LIVES. And in this beautiful and sensitive place, they also belong on their leash!

From your dog-loving friends at

the SAN JUAN
PRESERVATION
TRUST

360.378.2461 sjpt.org

7. Carbon

Carbon sequestration is the long-term process of removing carbon from the atmosphere through photosynthesis and storing it in forest biomass and soils

Carbon storage is the actual amount of carbon stored in forest and in the products produced by forests.

Carbon cycles through forest ecosystems in an ever evolving process: 1) Uptake through photosynthesis and subsequent growth; 2) Release through respiration , decomposition and forest disturbances.

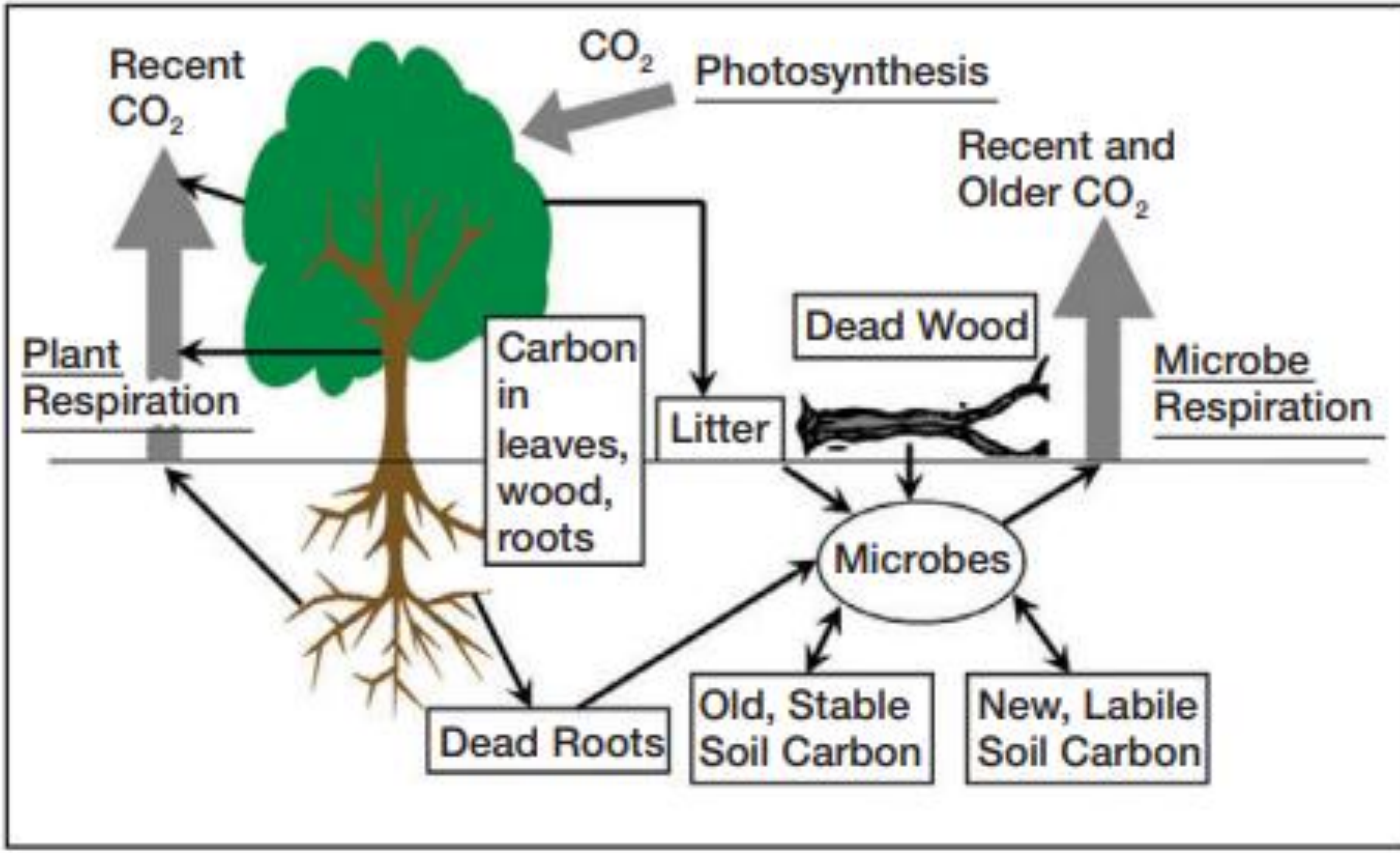
Forests in the United States are currently a carbon sink, sequestering and storing more carbon than they are releasing, although there are large differences amongst regions. This is an important ecosystem service.

Carbon taken up by forests is approximately 12-19% of total carbon dioxide emissions (Ryan et.al 2010) . They are the largest terrestrial carbon sink in the nation.

Carbon is stored in different amounts in different reservoirs in the forest – above ground, below ground, understory, standing dead, downed dead, forest floor, soil organic carbon .

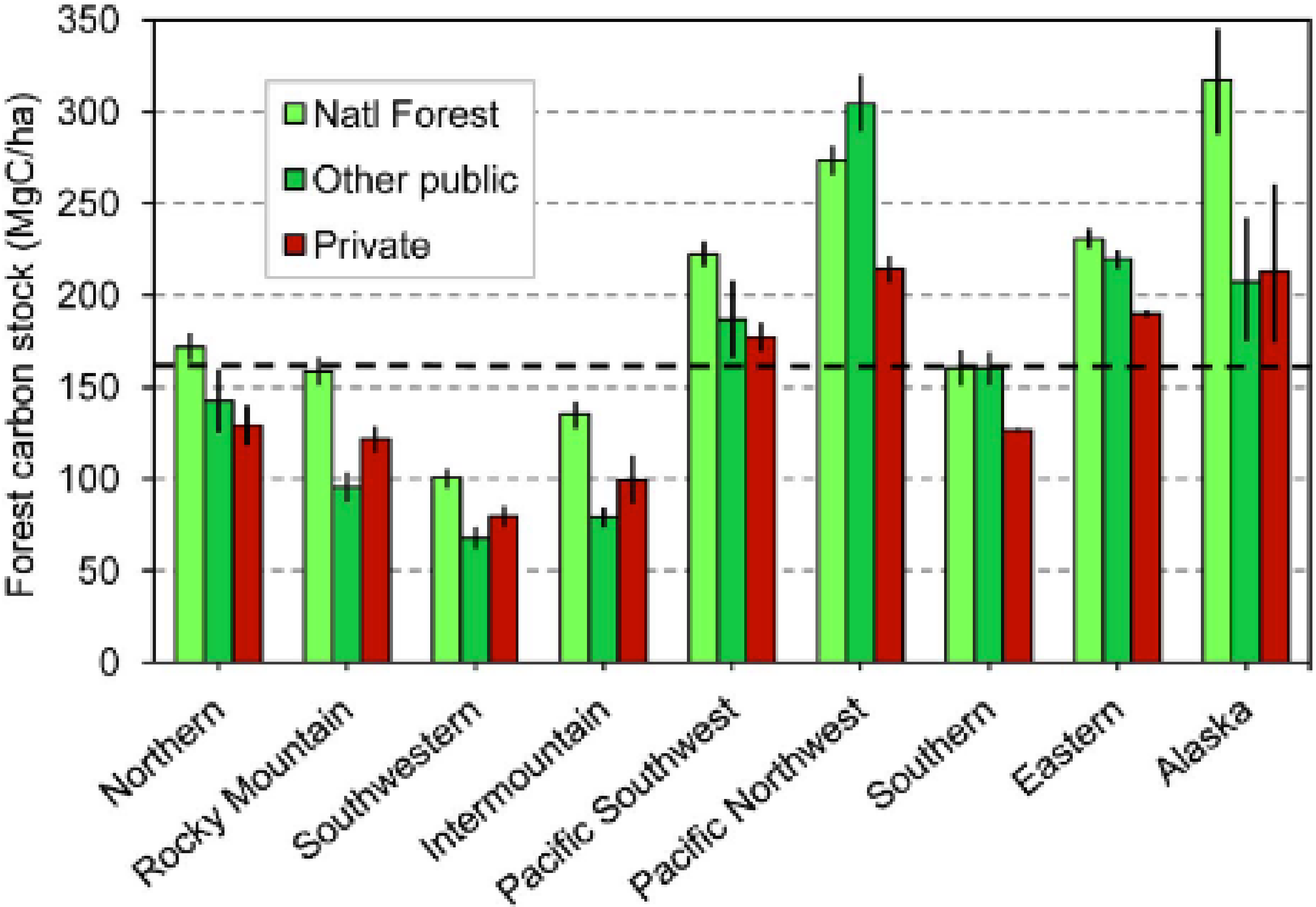
The actual numbers in each of these important metrics can vary considerably in the published literature (i.e. the devil is in the details, in the assumptions and in the inherent amount of uncertainty in the subject in general).

Carbon in Forests

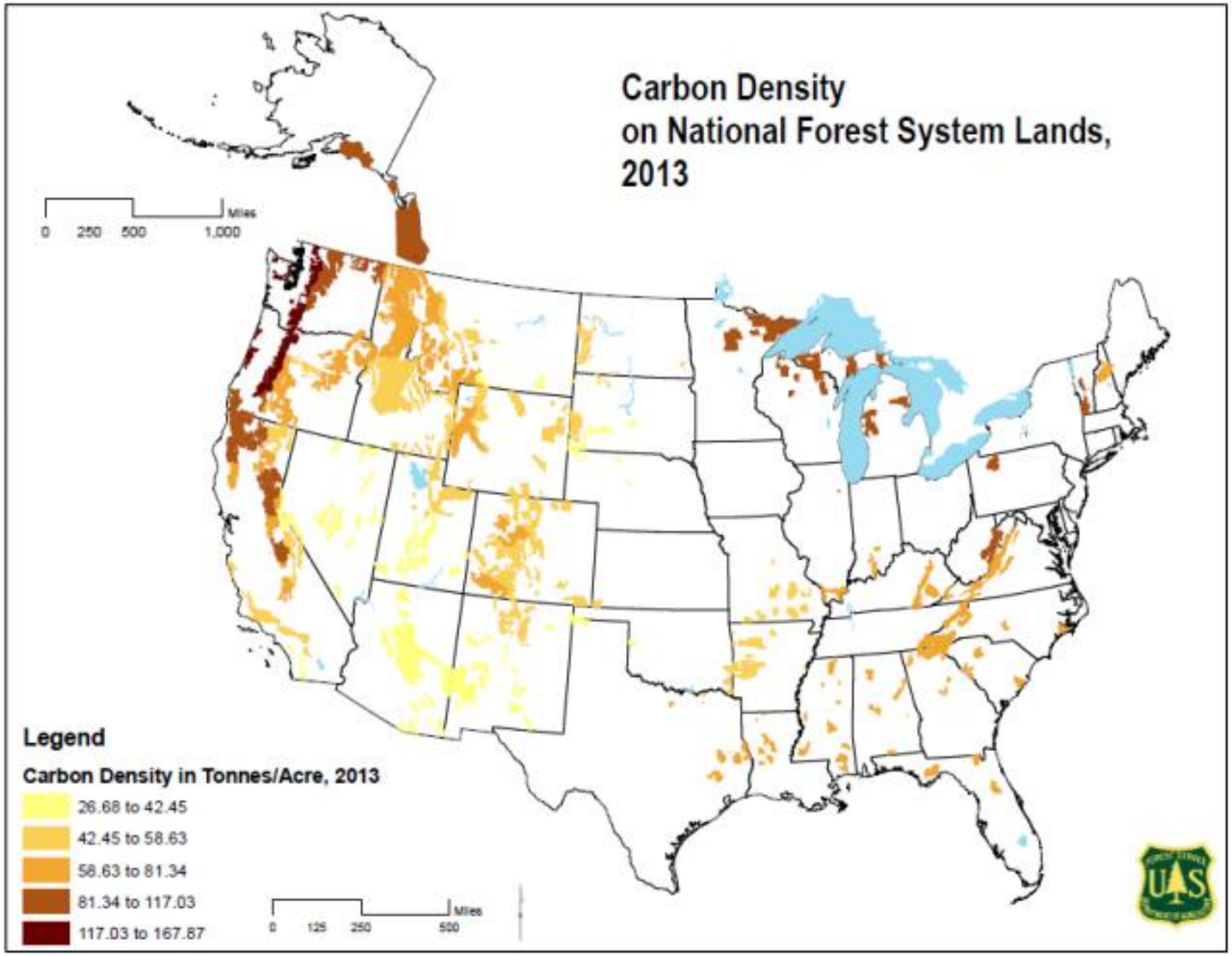


Slide Source: Ryan et.al. 2010. A Synthesis of the Science on Forests and Carbon for U.S. Forests

The Pacific Northwest has some of the highest carbon density forests in the world

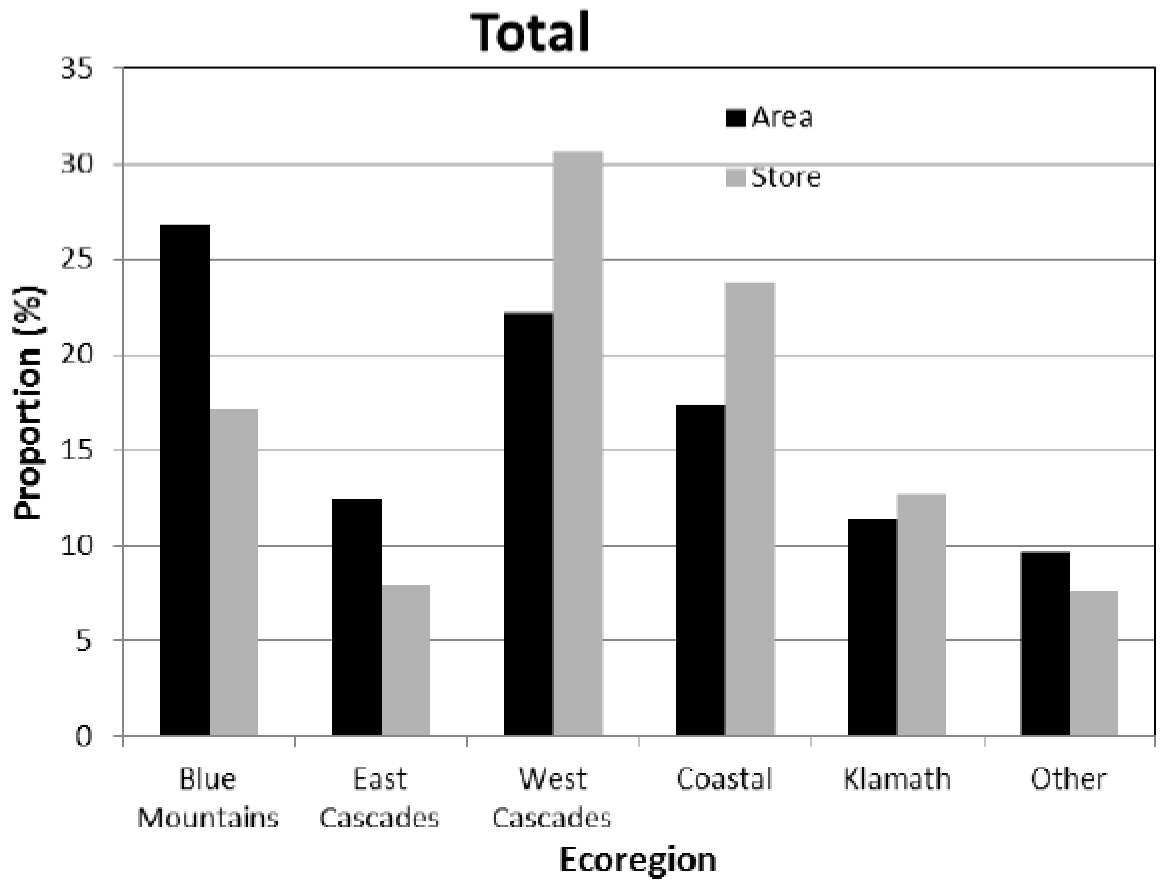


Heath et.al. 2011. Carbon stocks on forestland of the United States, with emphasis on USDA Forest Service ownership.



Source:USDA Forest Service. 2015. Baseline Estimates of Carbon Stocks in Forests and Harvested Wood Products for National Forest System Units; Pacific Northwest Region. 48 pp. Whitepaper. http://www.fs.fed.us/climatechange/documents/PacificNorthwestRegionCarbonAssessment.pdf

Figure 1. Proportional distribution of area and total carbon stores by forested area within each ecoregion.



Source: Oregon Global Warming Commission: Forest Carbon Accounting Project Report, 2018

Carbon Amounts on City of Ashland Forestlands

COA Lower Watershed Carbon Storage From FVS in tons/acre

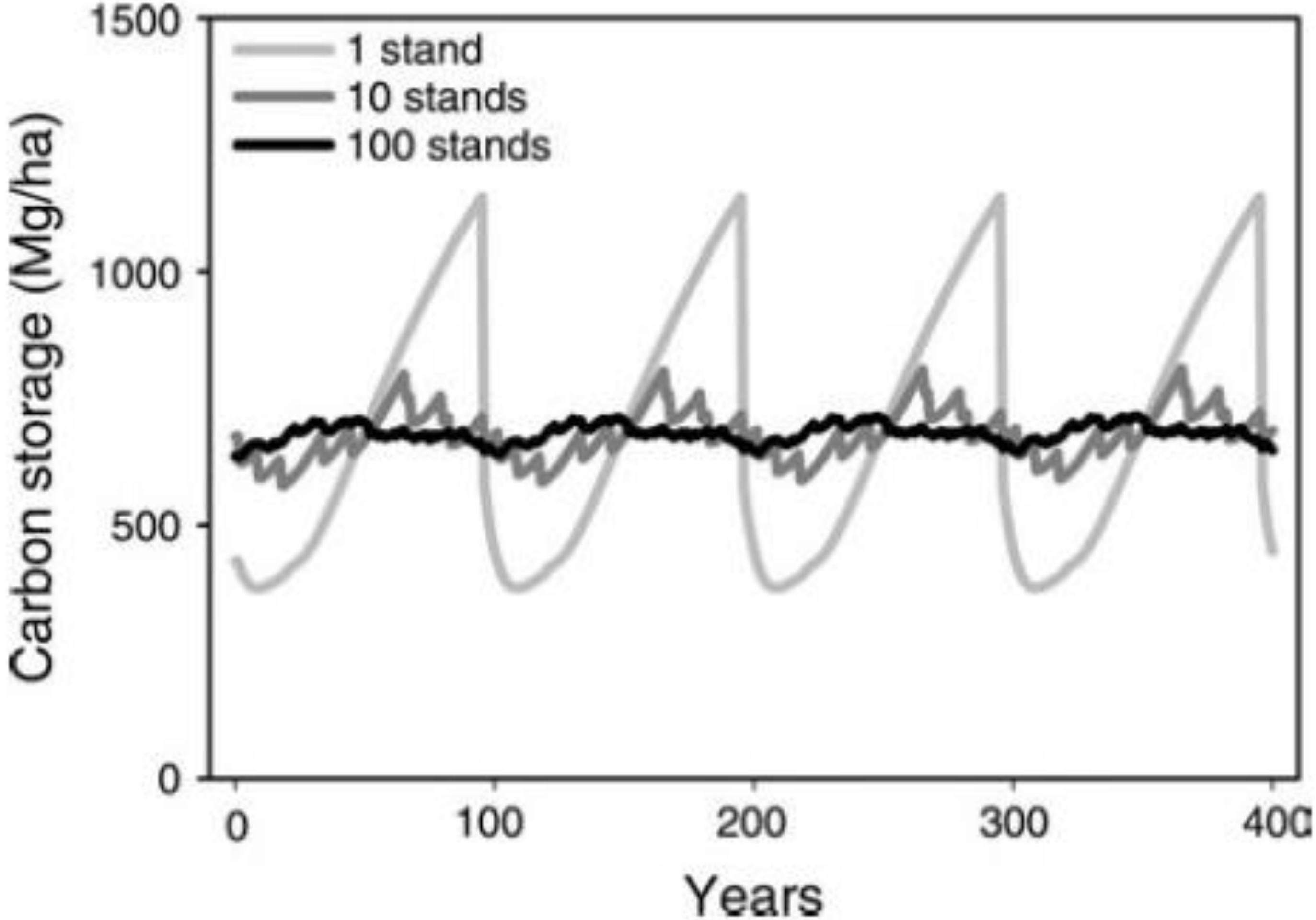
Unit	Aboveground Live		Belowground Live		Standing Dead	Forest			Total Stand Carbon
	Total	Merch	Live	Dead		DDW	Floor	Shb/Hrb	
A1	31.3	21.3	6.6	0.6	0.5	4.3	3.3	0.5	47.5
B	39.0	27.4	8.2	0.9	1.7	4.6	3.5	0.4	58.3
C	19.4	11.1	4.5	0.6	2.1	5.7	3.8	0.5	36.6
D	26.7	17.9	6.5	0.5	2.1	4.2	3.2	0.5	43.7
E	25.1	17.3	5.9	1.0	3.3	4.8	3.4	0.6	44.0
F	39.1	25.9	8.7	0.5	1.7	5.0	3.8	0.3	59.1
G	34.1	16.1	7.0	0.3	1.4	5.2	3.9	0.2	52.2
H	38.8	28.6	9.1	0.5	1.6	4.4	3.4	0.5	58.3
J	77.6	62.3	15.9	0.5	2.7	4.5	3.4	0.4	105.1
K	57.1	40.5	12.1	1.4	4.8	5.2	3.9	0.2	84.7
L	60.8	45.6	12.3	0.5	1.3	5.0	3.8	0.3	83.9
M1	69.8	52.9	14.7	0.2	0.3	6.6	4.6	0.2	96.4
M2	95.7	72.2	19.6	1.7	7.8	5.2	3.9	0.2	134.0
N	97.7	76.3	18.2	0.9	4.7	5.2	3.9	0.2	130.7
P	59.2	45.9	12.8	0.7	3.0	5.2	3.7	0.5	85.0
Q	85.4	66.1	17.2	0.4	0.9	5.2	3.9	0.2	113.1
R	59.3	40.9	12.2	1.8	2.4	5.2	3.9	0.2	85.0
S	58.5	45.9	11.5	1.3	6.5	4.7	3.5	0.4	86.4
W1	58.4	43.7	12.3	0.2	0.7	5.0	3.8	0.3	80.7
W2	83.6	66.9	16.3	1.6	4.8	4.8	3.7	0.3	115.1
Total	**54.1**	**39.3**	**11.2**	**0.8**	**2.8**	**5.0**	**3.8**	**0.3**	**78.0**

COA Winburn Carbon Storage From FVS in tons/acre

Unit	Aboveground Live		Belowground Live		Standing Dead	Forest			Total Stand Carbon
	Total	Merch	Live	Dead		DDW	Floor	Shb/Hrb	
1	71.4	54.7	14.6	1.3	4.3	5.7	4.1	0.3	101.8
2	57.6	43.9	11.2	1.4	3.0	4.9	3.7	0.3	82.2
3	123.2	101.0	22.9	0.7	2.0	5.6	4.4	0.2	159.0
4	124.4	104.4	23.3	1.0	3.4	4.9	3.9	0.4	161.3
5	85.4	66.6	17.6	2.4	6.2	5.9	5.0	0.3	122.8
6	60.2	45.2	12.6	2.0	9.0	5.7	4.6	0.2	94.4
Total	**79.0**	**61.7**	**15.8**	**1.5**	**4.6**	**5.6**	**4.6**	**0.2**	**111.4**

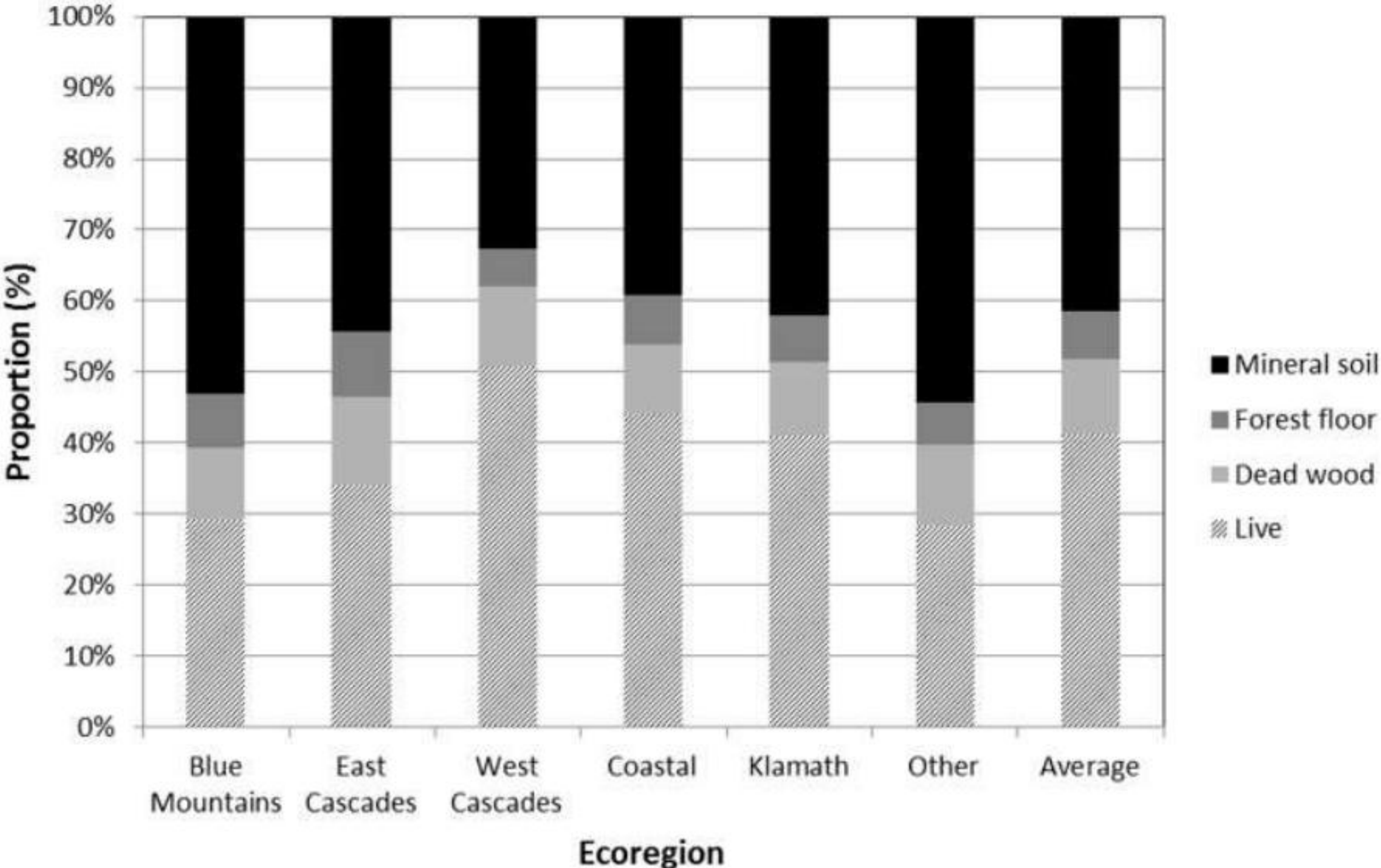
Source: Main 2018. City of Ashland Forestlands: Inventory Analysis and Recommendations

Importance of Time and Scale in Measuring Carbon Storage



Source: McKinley et. al. 2011. A synthesis of current knowledge on forests and carbon storage in the United States.

Total Carbon Stores by Pool for Each Oregon Ecoregion



Source: Oregon Global Warming Commission: Forest Carbon Accounting Project Report. 2018

Carbon Accounting for the Pacific Northwest

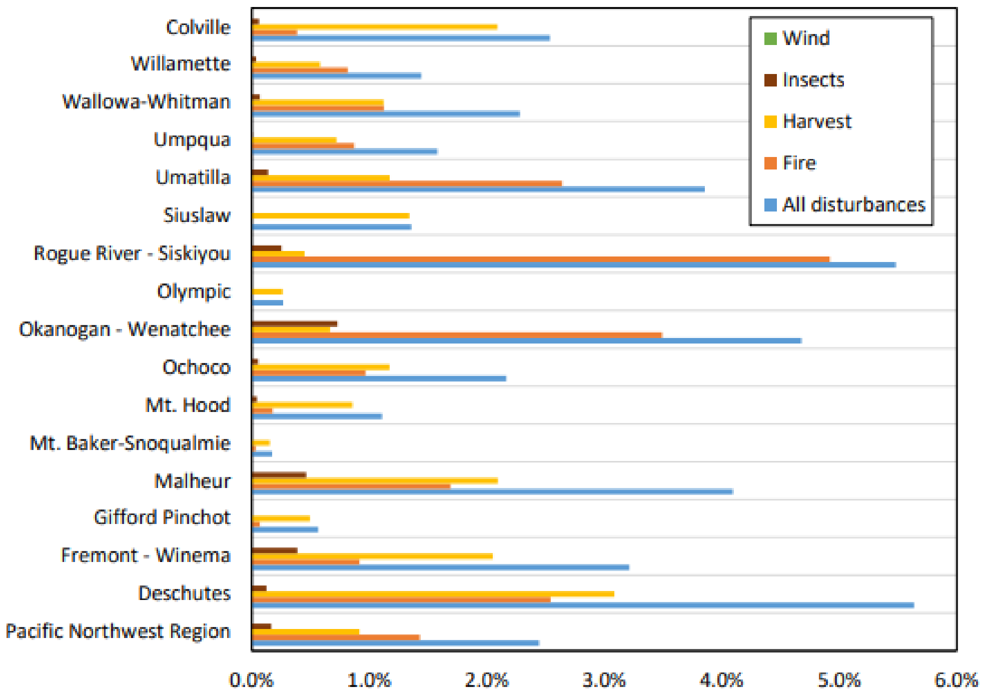
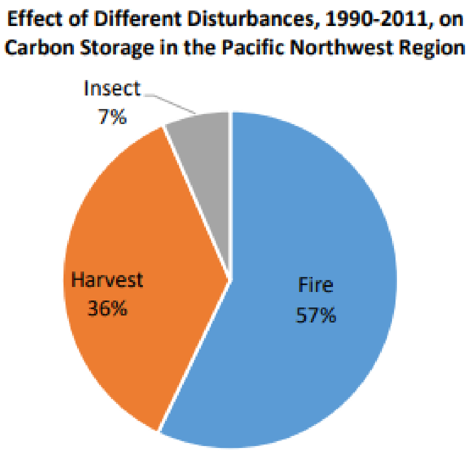
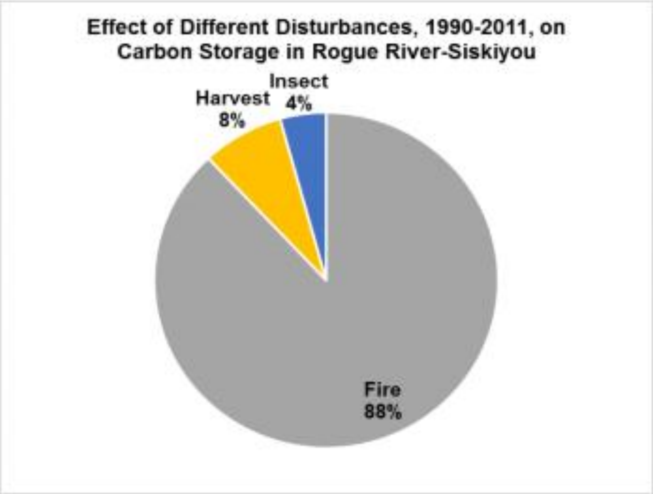


Figure 55. Carbon stock reduction in 2011 due to disturbances occurring from 1990 through 2011, by each national forest and for all national forests combined in the Pacific Northwest Region. Percent reduction represents how much nonsoil carbon was lost from the baseline forest inventory carbon stock estimates.





Source: Birdsey, Richard A.; Dugan, Alexa J.; Healey, Sean P.; Dante-Wood, Karen; Zhang, Fangmin; Mo, Gang; Chen, Jing M.; Hernandez, Alexander J.; Raymond, Crystal L.; McCarter, James. 2019. Assessment of the influence of disturbance, management activities, and environmental factors on carbon stocks of U.S. national forests. Gen. Tech. Rep. RMRS-GTR-402. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

Carbon emissions for one large wildfire with a high amount of high severity fire, the 2002 Biscuit fire, equaled one third of that years total fossil fuel carbon emissions for the state of Oregon.

Source: Campbell et al. 2007. Pyrogenic carbon emission from a large wildfire in Oregon, United States.

7. Carbon

Climate Change Key Vulnerabilities

1. Loss of forest in general from high severity disturbance and/or climate change over time- potential loss of both stored carbon and potential for ongoing sequestration; shift to alternate vegetation types that don't store or sequester as much carbon.

2. Loss of carbon storage in older forests and large trees as they decline

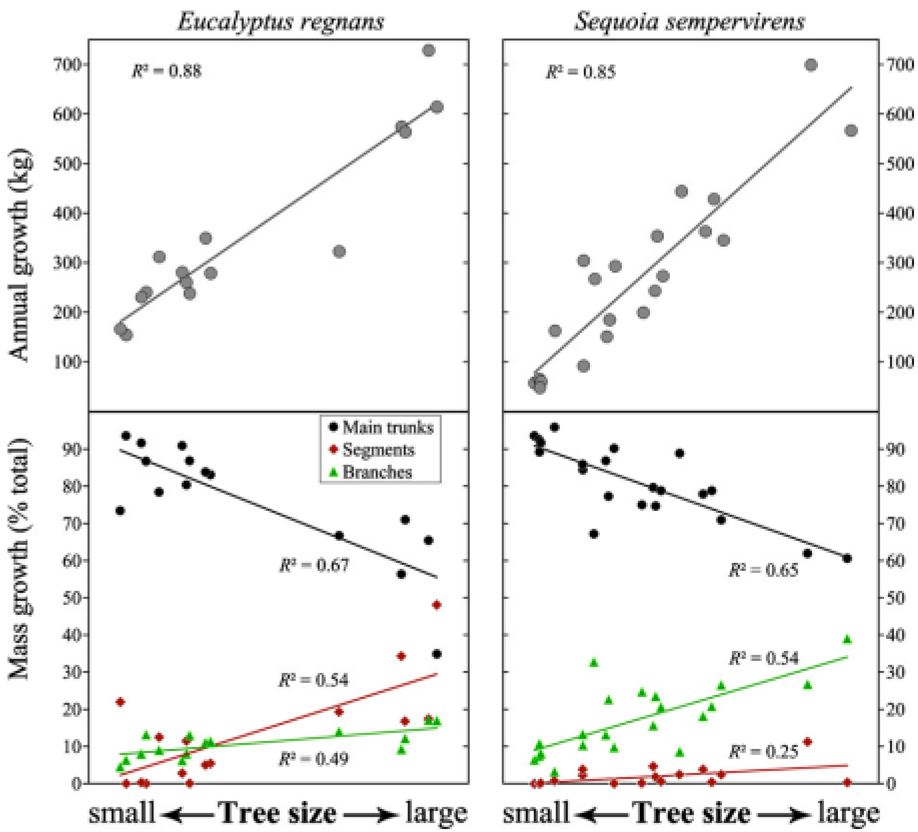
3. Declining vigor in future forest from climate change will reduce vegetation growth and carbon sequestration

4. Potential impacts to carbon stored in forest soils from high severity fire or poor land management practices

“While high severity disturbances can change forests from net carbon accumulators to net carbon emitters for long periods (Cohen et al., 1996; Kashian et al., 2006; Dore et al., 2010), our results imply that low to moderate severity disturbances have milder effects on live biomass, likely stabilizing in a relatively short period of time (likely less than 10 years) “also see Hurteau and North, 2010; Webster and Halpern, 2010).

Source: Halofsky et.al 202x. Climate Change Vulnerability and Adaptation in Southwest Oregon

Importance of Large Trees for Carbon Sequestration and Storage



Source: Sillett et.al 2010.Increasing wood production through old age in tall trees.

"Pooled across the five dominant species, large trees accounted for 3% of the 636,520 trees occurring on the inventory plots but stored 42% of the total aboveground carbon storage. "

Source: Mildrexler et.al. 2020. Large Trees Dominate Carbon Storage in Forests East of the Cascade Crest in the United States Pacific Northwest

"In our western USA old-growth forest plots, trees >100 cm in diameter comprised 6% of trees, yet contributed 33% of the annual forest mass growth."

Source: Stephenson et.al 2014. Rate of tree carbon accumulation increases continuously with tree size.

7. Carbon

Adaptation Options for Management

1. Emphasize ecosystem function and resilience, with carbon one of multiple ecosystem services and values to be integrated into forest management decisionmaking. (**Persist)**

2. Utilize full-cost carbon accounting that recognizes the value of management actions that reduce the risk of carbon loss through stand replacing fire. **(Persist)**

3. Continue to utilize fuel treatments to minimize scale and severity of disturbance; avoid high severity disturbance that impacts so many important ecosystem services and values in this situation. Utilize prescribed underburning recognizing the trade-off: while prescribed fires obviously release carbon into the atmosphere, it is at significantly lower levels than that released during higher severity wildfires (Hurteau and North 2009) . Manual thinning and slash treatment to achieve fire management objectives releases even less carbon into the atmosphere. KEEP GREEN FORESTS THAT BOTH STORE AND SEQUESTER CARBON! **(Persist)**

4. Strive to maintain large trees and older forests for as long as possible **(Persist)**

5. Manage for less intensive harvests and longer rotations, which can be common outgrowths of implementation of frequent, low severity "planned disturbances" and multi-cohort, multi-species management. (**Persist)**

6. Tree mortality management. Maintain stand densities, structures and species compositions that minimize the likelihood of outbreak levels of mortality, and adjust over time to respond to expected changes in climate variables Carefully evaluate tree mortality and strive for improved ways to measure tree vigor. Determine appropriate levels of snags, downed wood and fuels that can be maintained to provide important ecosystem services while continuing to maintain an acceptable risk from a fire management perspective. **(Persist)**

7. Use best management practices to avoid soil impacts and protect forest soil carbon. Continue to use helicopters when necessary to avoid soil impacts. If using ground-based harvest systems, best management practices are very important to minimize soils impacts **(Persist)**

Forest Carbon Principles

Forest carbon management (carbon stewardship) may best be articulated through the following principles and guidelines. They are intended to provide considerations for integrating carbon management with planning and implementation processes and with efforts to adapt forests to the impacts of a changing climate. These are preliminary guiding principles intended to be refined, updated and formally approved based on field experience, emerging science and higher level policy revisions and interpretation across the full range of Forest Service programs and authorities, not just NFS.

1. **Emphasize ecosystem function and resilience.** Carbon sequestration capacity depends on sustaining and enhancing ecosystem function to maintain resilient forests adapted to changing climate and other conditions.
2. **Recognize carbon sequestration as one of many ecosystem services.** Carbon sequestration is one of many benefits provided by forests, grasslands, and forest products, now and in the future. Carbon sequestration should be considered in context with other ecosystem services.
3. **Support diversity of approaches in carbon exchange and markets.** Recognize that decisions about carbon in America's forests are influenced by ownership goals, policy, ecology, geography, socioeconomic concerns, and other factors that vary widely.
4. **Consider system dynamics and scale in decision making.** Evaluate carbon sequestration and cycling at landscape scales over long time frames. Explicitly consider uncertainties and assumptions in evaluating carbon sequestration consequences of forest and grassland management options.
5. **Use the best information and methods to make decisions about carbon management.** Base forest management and policy decisions on the best available science-based knowledge and information about system response and carbon cycling in forests, grasslands, and wood products. Use this information wisely by dealing directly with uncertainties, risks, opportunities, and tradeoffs through sound and transparent risk management practices.
6. **Strive for program integration and balance.** Carbon management is part of a balanced and comprehensive program of sustainable forest management and climate change response. As such, forest carbon strategies have ecological, economic, and social implications and interactions with other Forest Service programs and strategies, such as those for energy and water.

"Note: These principles are not meant to imply that maximizing forest carbon storage should be the objective of any forest plan or that carbon should be the most important or overriding purpose of forest plans or project actions. This information is provided to help forests and their stakeholders determine the state of the carbon resource, and how carbon stewardship might be blended with other ecosystem service goals in planning and management."

Source: USDA Forest Service 2015. Baseline Estimates of Carbon Stocks in Forests and Harvested Wood Products for National Forest System Units- Pacific Northwest Region

Full-cost carbon accounting is important for land managers

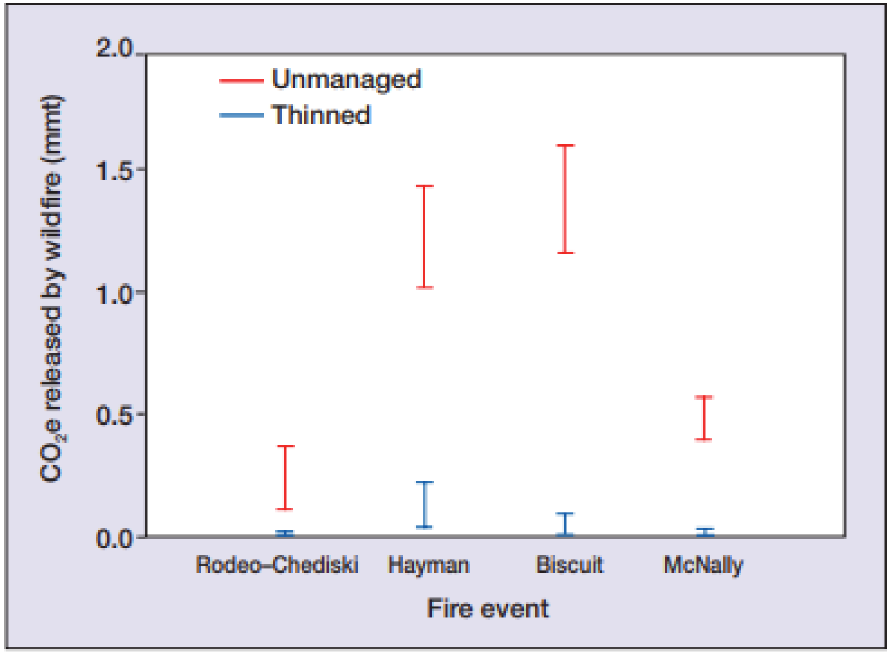


Figure 2. *Millions of metric tons of CO_2 equivalent released from wildfire. Red bars show the range of CO_2 released in each fire event in high-severity burn areas using the two different combustion efficiencies. Blue bars show the range of CO_2 that would have been released had the areas been thinned before wildfire, again assuming the two different combustion efficiencies.*

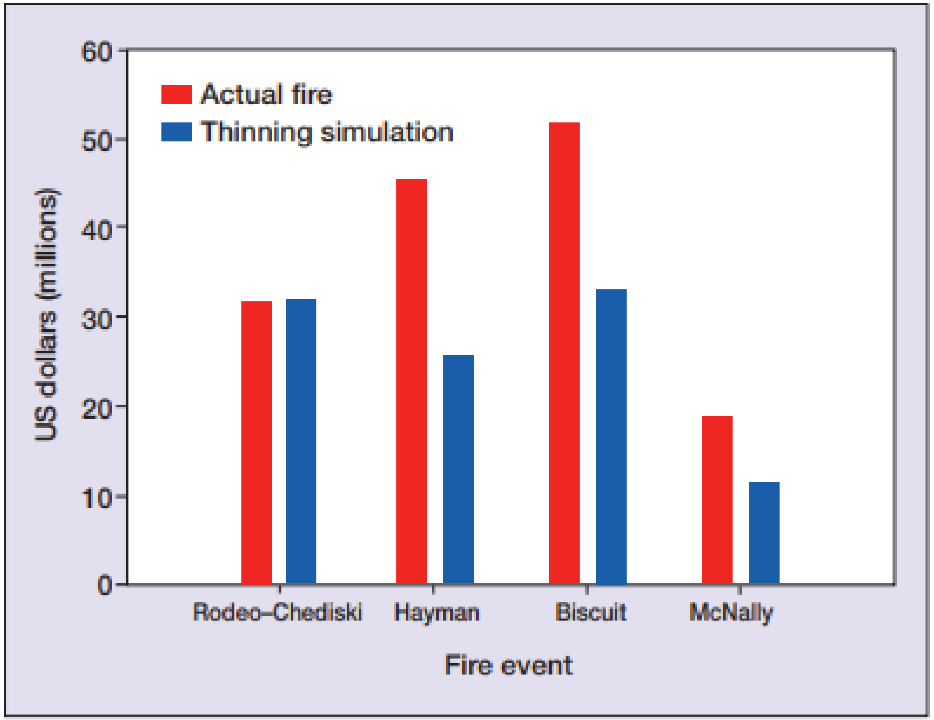


Figure 3. *Total estimated cost of each fire event plus the cost of offsetting the CO_2 release (red) and total cost of thinning the same land area minus the market value of the offsets gained from protecting the carbon stock (blue).*

"Carbon accounting should recognize the value of management actions that reduce the risk of carbon loss through stand replacing fire"

Source: Hurteau et.al. 2008

Figure 5. *Stand conditions following the 2002 Cone fire at the Blacks Mountain Experimental Forest. The white line approximates the border between the treated and untreated areas prior to the wildfire. The area in the upper left was left untreated and the remaining area was thinned and prescribe-burned prior to the Cone fire.*

Source: Hurteau et.al. 2008. Carbon protection and fire risk reduction: toward a full accounting of forest carbon offsets

High severity versus low to moderate severity fire and effects on carbon

"While high severity disturbances can change forests from net carbon accumulators to net carbon emitters for long periods (Cohen et al., 1996; Kashian et al., 2006; Dore et al., 2010), our results imply that low to moderate severity disturbances have milder effects on live biomass, likely stabilizing in a relatively short period of time (likely less than 10 years) (also see Hurteau and North, 2010; Webster and Halpern, 2010). Moreover, reductions in forest density following prescribed fire are expected to decrease risks of crown fires (Stephens et al., 2009), potentially reducing the likelihood of massive carbon losses from future wildfires (Hurteau and North, 2009; North et al., 2009)."

Source: Van Mantgem et.al. 2011. Long-term effects of prescribed fire on mixed conifer forest structure in the Sierra Nevada, California.

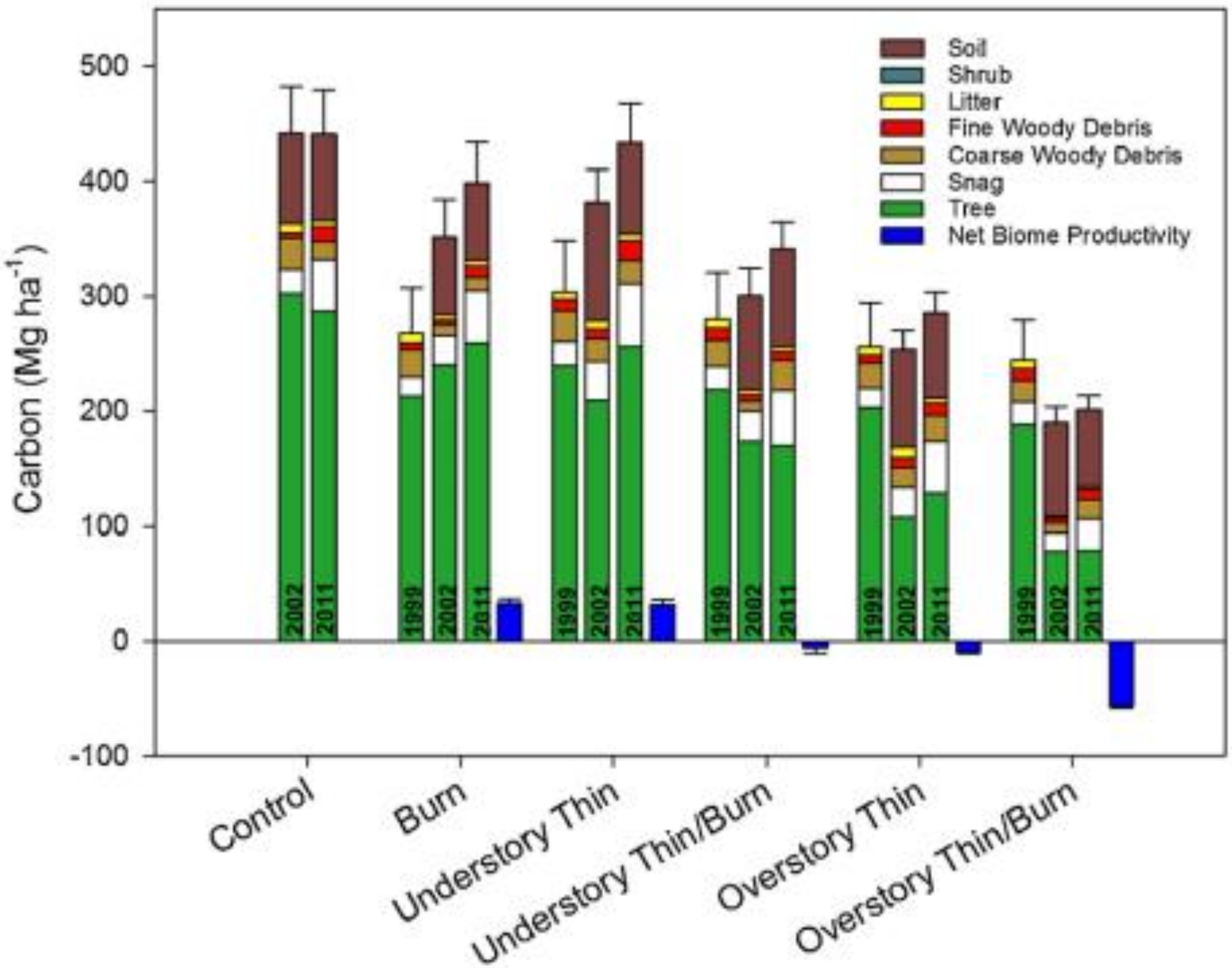
"Long term modeling suggests that intact disturbance regimes have little long-term effect on terrestrial carbon stocks, as biomass losses are replaced by forest recovery (Hurteau and Brooks 2011). In contrast, disruptions to disturbance regimes can durably alter carbon stocks by driving type conversion of forests to other ecosystems (Kashian et al. 2006, Landry and Matthews 2016). Disruption to the disturbance regime (and the impact of these disruptions on carbon storage) is a pressing issue in the extensive frequent fire forests of the American west." (Fule et al. 2012, Hessburg et al. 2016).

Source: Foster et.al. 2020. Potential wildfire and carbon stability in frequent-fire forests in the Sierra Nevada: trade-offs from a long-term study

Carbon emissions for mechanical treatments and controlled fire are significant and some argue that these carbon costs are not offset by reduced carbon emissions in the event of subsequent wildfire (Harmon et al. 1990, Harmon et al. 2009, Finkral & Evans 2008, Hudiburg et al. 2011). Other researchers have shown that fuels treatments are justified by reduced carbon emissions due to wildfire (Dore et al. 2010, Hurteau & North 2008, Finkral & Evans 2008, Wiedinmyer & Hurteau 2010, North & Hurteau 2011, Stephens et al. 2012). In part, this dichotomy exists because likelihood of wildfire must be considered when determining the effectiveness of fuel reduction treatments at mitigating carbon release (Mitchell et al. 2009, Ager et al. 2010, Campbell et al. 2011). In dry, frequent fire forests of the west many authors make the case that with 100 years of fire exclusion and a lengthening fire season due to climate change these forests are so flammable the majority of the landscape will receive wildfire, thereby justifying the assumption that fuel treatments will be a net carbon benefit (e.g. Dore et al. 2010, Hurteau & North 2008, Finkral & Evans 2008, North et al. 2009, Wiedinmyer & Hurteau 2010, Stephens et al. 2012). Further, targeting treatments to remove small diameter trees and tree species that are sensitive to fire – actively promoting large, fire tolerant trees – may over the long run increase stable carbon stocks as found in historically open frequent fire forests (North et al. 2009) . Even in absence of future fire some authors have found increased carbon sequestration in thinned forests, particularly in regard to future climate (e.g. Cathcart et al. 2007, North et al. 2009, Dore et al. 2010), others find thinning forests simply releases carbon with no long-term carbon storage benefit (e.g. Campbell et al. 2009, Hudiburg et al. 2009, Amiro et al. 2010, Hudiburg et al. 2011, Law et al.). Fortunately, fuels treatments and forest restoration are justified for non-carbon reasons as well, further justifying use of mechanical treatments and fire to promote natural processes and resilience to facilitate forest adaptation to a changing climate while minimizing undesirable state changes (McKinley et al. 2011, Peterson et al. 2011, Vose et al. 2012)

Source: Myer et.al 2013. The Rogue Basin Action Plan for Resilient Watersheds and Forests in a Changing Climate.

Carbon pool amounts pre-treatment, immediately post-treatment and 10 years post-treatment for 5 different treatments and one control



Wiechmann et.al. 2015. The carbon balance of reducing wildfire risk and restoring process: an analysis of 10-year post-treatment carbon dynamics in a mixed-conifer forest

‘Forests are viewed as a potential sink for carbon (C) that might otherwise contribute to climate change. It is unclear, however, how to manage forests with frequent fire regimes to maximize C storage while reducing C emissions from prescribed burns or wildfire. We modeled the effects of eight different fuel treatments on treebased C storage and release over a century, with and without wildfire. Model runs show that, after a century of growth without wildfire, the control stored the most C. However, when wildfire was included in the model, the control had the largest total C emission and largest reduction in live-tree-based C stocks. In model runs including wildfire, the final amount of tree-based C sequestered was most affected by the stand structure initially produced by the different fuel treatments. In wildfire-prone forests, tree-based C stocks were best protected by fuel treatments that produced a low-density stand structure dominated by large, fire-resistant pines.”

Hurteau and North 2009

Summary of Carbon Adaptation Strategies

1. Major disruptions to intact disturbance regimes (e.g. high severity fire, clearcutting) can cause significantly alter carbon stocks, particularly if they ultimately produce type conversions accelerated by climate change.

2. Treatments such as thinning and prescribed underburning may produce short-term carbon losses but can be quickly regained by forest recovery in healthy forests. Frequent, low to moderate severity disturbance can be employed without major carbon losses over time, with extended rotations well-recognized as a plus for carbon retention. The City of Ashland is in the somewhat unique position to already have employed frequent low severity planned disturbance for 25+ years in it's dry forests.

3. Treatments may result in short-term carbon losses but significant other co-benefits related to carbon storage and sequestration may occur in the immediate years to come:

- increased growth and vigor of retained trees
- increased retention and vigor of big trees and older forests that store the most carbon
- reduced likelihood of high severity wildfire with high emissions, loss of ecosystem services and potential for type conversions
- long-term carbon storage can occur in wood products if utilized

4. Treatments to reduce fire danger in dry forests that have evolved with frequent, low to moderate severity forests for millenia, such as on the City of Ashland forestlands, are much more important to consider when analyzing strategies for carbon retention and management.

There is likely nowhere in southern Oregon where the ecosystem values and services are higher than in the Ashland Watershed. There is also already a very high carbon density and considerable carbon storage in the Ashland Watershed that is threatened by potential high severity disturbance- a potential which will only increase with climate change. Given these realities, management designed to protect and maintain these values/services and the ecological functions that have produced these values/services over time is especially prudent, although this does not maximize carbon accounting in the short term.

<u>Persist</u> in appropriate management to reduce the potential for large scale, high severity fire. The expected increases in that potential with climate change suggests an even greater urgency to continue, if not accelerate, that management.

If not now, when?

If not here, where?