

An aerial photograph of a forested landscape. The foreground shows a dense forest of tall, thin trees, possibly pines or firs, with some areas appearing charred or dead. A winding road or path is visible on the left side. In the middle ground, a river flows through a valley. The background features rolling hills and mountains under a clear blue sky. The overall scene is a mix of green and brown, suggesting a transition or recovery from a fire event.

Strategies for Managing Future Fire Behavior and Effects Across the Landscape

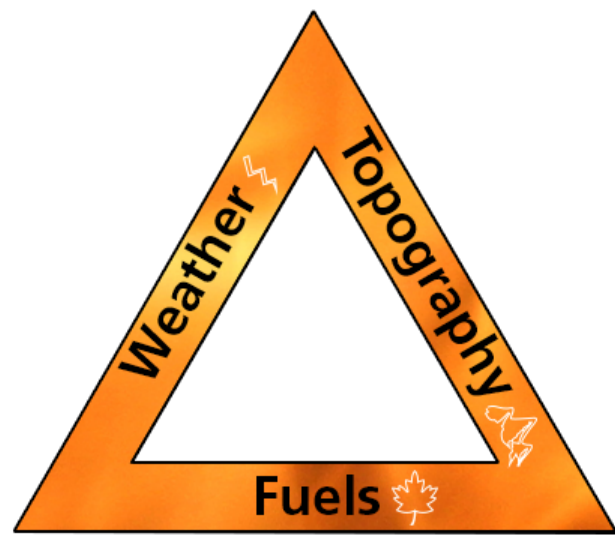
Matt Powers

College of Forestry, Oregon State University

Jane Kertis

Northwest Oregon Ecology Program (Semi-Retired)

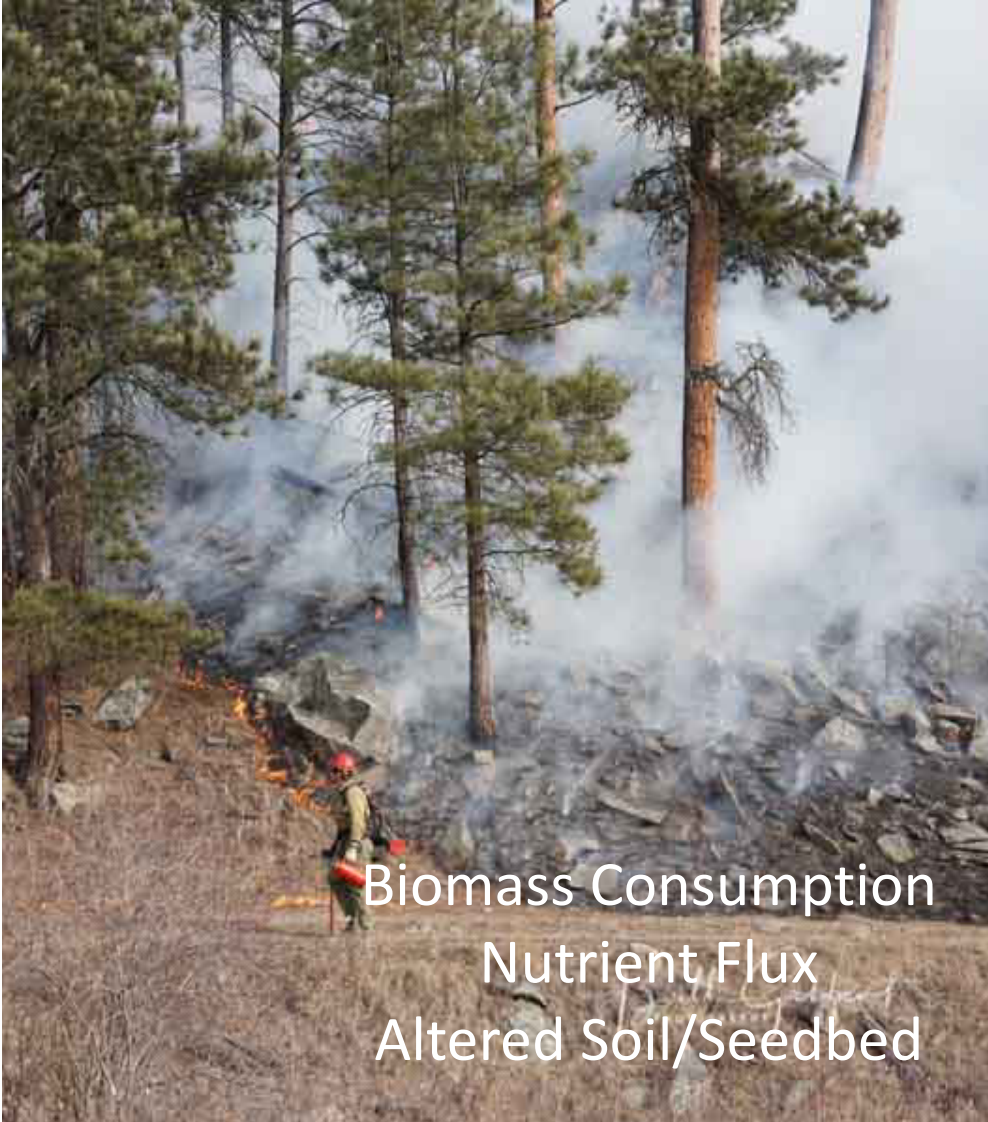
April 20, 2021



Fire Behavior Triangle

Fire behavior: the manner in which fire reacts to the influences of fuels, weather, and topography





Fire effects: the physical, biological, and ecological impacts of fire on the environment

How does forest management affect fire behavior and fire effects?

Alter fuel characteristics:

- Fuel loadings
- Fuel sizes
- Vertical and horizontal continuity
- Site and landscape scales

Species composition:

- Potential survival and regeneration after fire





Aerial Fuels

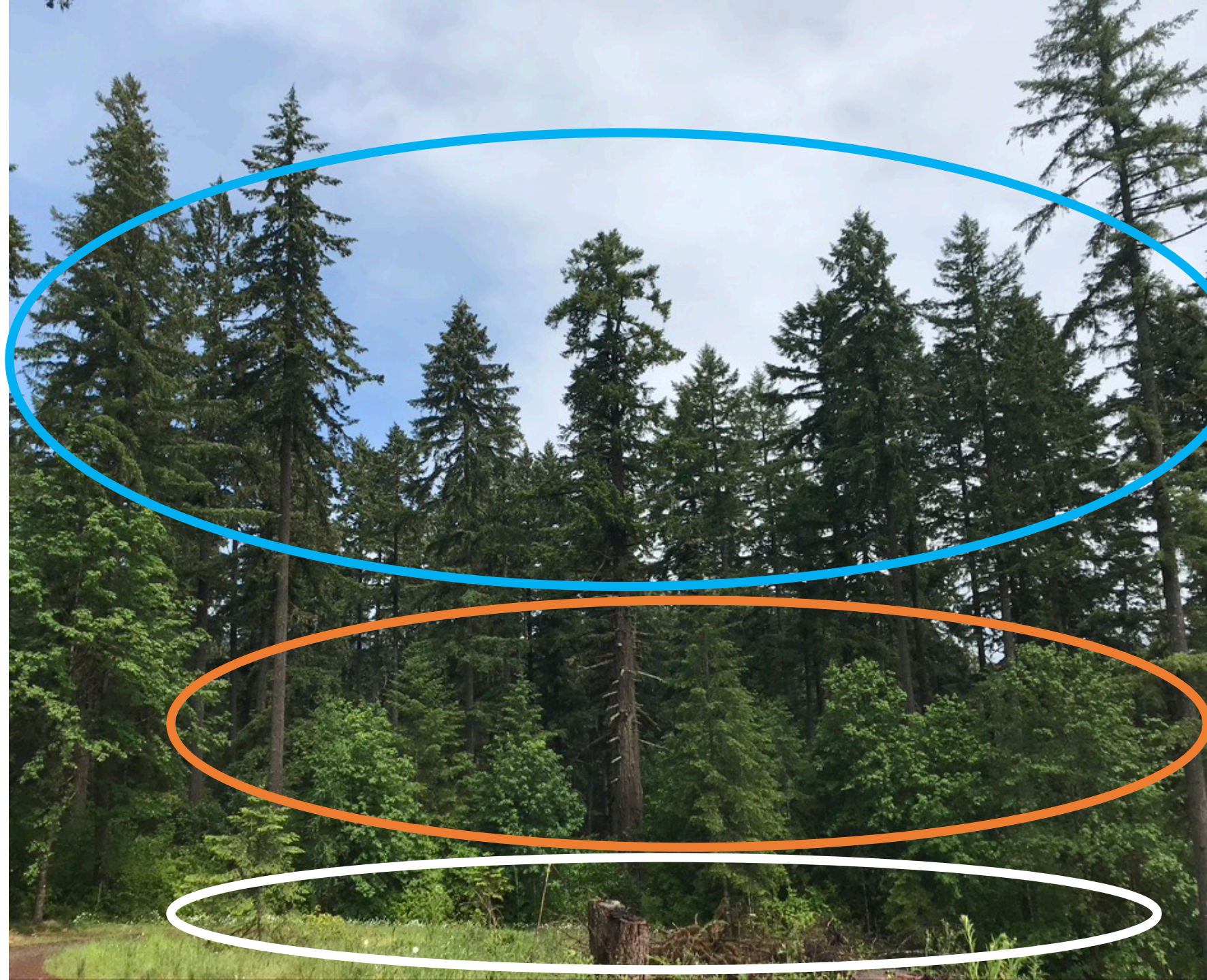
Live and dead combustable materials suspended well above the ground surface

Ladder Fuels

Material above the surface fuels that assists in the transfer of flames to the canopy

Surface Fuels

Living and dead biomass on or in close proximity to the soil surface



Principles of Fuel Reduction (Agee & Skinner 2005)

Principle	Fire Behavior Effect	Management Outcomes
Reduce surface fuels	Reduces fireline intensity/flame length	Reduces torching, reduced heat to vegetation, facilitates firefighting activities
Increase height to live crown	Requires longer flame lengths to initiate torching	Less torching, reduced overstory mortality, reduced potential for active crown fire
Decrease crown density	Reduces probability of tree-to-tree crown fire	Reduces potential for active crown fires, reduces mortality
Promote/retain large-diameter trees of fire-resistant species	Reduces mortality at a given fire intensity	Reduces likelihood of high-severity fire; increases ecosystem resilience (more post-fire seed sources)

Principles of Fuel Reduction (Agee & Skinner 2005)

Principle	Effect	Management Outcomes
Reduce surface fuels	Reduces fireline intensity/flame length	Reduces torching, reduced heat to vegetation, facilitates firefighting activities
Increase height to live crown	Requires longer flame lengths to initiate torching	Less torching, reduced overstory mortality, reduced potential for active crown fire
Decrease crown density	Reduces probability of tree-to-tree crown fire	Reduces potential for active crown fires, reduces mortality
Promote/retain large-diameter trees of fire-resistant species	Reduces mortality at a given fire intensity	Reduces likelihood of high-severity fire; increases ecosystem resilience (e.g., more post-fire seed sources)

Principles of Fuel Reduction (Agee & Skinner 2005)

Principle	Effect	Management Outcomes
Reduce surface fuels	Reduces fireline intensity/flame length	Reduces torching, reduced heat to vegetation, facilitates firefighting activities
Increase height to live crown	Requires longer flame lengths to initiate torching	Less torching, reduced overstory mortality, reduced potential for active crown fire
Decrease crown density	Reduces probability of tree-to-tree crown fire	Reduces potential for active crown fires, reduced mortality
Promote/retain large-diameter trees of fire-resistant species	Reduces mortality at a given fire intensity	Reduces likelihood of high-severity fire; increases ecosystem resilience (e.g. more post-fire seed sources)

Principles of Fuel Reduction (Agee & Skinner 2005)

Principle	Effect	Management Outcomes
Reduce surface fuels	Reduces fireline intensity/flame length	Reduces torching, reduced heat to vegetation, facilitates firefighting activities
Increase height to live crown	Requires longer flame lengths to initiate torching	Less torching, reduced overstory mortality, reduced potential for active crown fire
Decrease crown density	Reduces probability of tree-to-tree crown fire	Reduces potential for active crown fires, reduces mortality
Promote/retain large-diameter trees of fire-resistant species	Reduces mortality at a given fire intensity	Reduces likelihood of high-severity fire; increases ecosystem resilience (e.g., more post-fire seed sources)



Mechanical Density Reductions (i.e., Thinning)



Surface Fuel Reductions





USDA Forest Service



Agee and Lehmkuhl 2009

Thin & Burn Treatments

Fuel Treatment Impacts on Fuel Characteristics

Treatment Type	Impacts on Surface Fuels	Impacts Crown Base Ht	Impacts on Crown Density	Impacts on Tree Species and Size Distributions
Thinning	<ul style="list-style-type: none"> • More slash (ST-MT) • Less veg (ST) • More veg (MT-LT) 	<ul style="list-style-type: none"> • Depends on thinning method • Raised w/thin from below 	<ul style="list-style-type: none"> • Reduced; degree varies with intensity and method) 	<ul style="list-style-type: none"> • Depends on method, intensity and marking • Inc. tree growth
Burning	<ul style="list-style-type: none"> • Reduced (ST-MT) • Small tree inputs? • Veg recovery (MT-LT) 	<ul style="list-style-type: none"> • Raised if small trees are killed • Limited if only crown scorch 	<ul style="list-style-type: none"> • Depends on fire severity • Little to no impact for most Rx burns 	<ul style="list-style-type: none"> • Kills fire-sensitive species • Little impact on tree growth
Thinning & Burning	<ul style="list-style-type: none"> • Reduced (ST-MT) • Veg recovery (MT-LT) 	<ul style="list-style-type: none"> • Typically raised • Degree depends on thin method and fire intensity 	<ul style="list-style-type: none"> • Reduced; degree varies with thin intensity and method 	<ul style="list-style-type: none"> • Burn kills fire sensitive species • Thinning approach impacts size dist

Fuel Treatment Impacts on Fuel Characteristics

Treatment Type	Impacts on Surface Fuels	Impacts Crown Base Ht	Impacts on Crown Density	Impacts on Tree Species and Size Distributions
Thinning	<ul style="list-style-type: none"> • More slash (ST-MT) • Less veg (ST) • More veg (MT-LT) 	<ul style="list-style-type: none"> • Depends on thinning method • Raised w/thin from below 	<ul style="list-style-type: none"> • Reduced; degree varies with intensity and method) 	<ul style="list-style-type: none"> • Depends on method, intensity and marking • Inc. tree growth
Burning	<ul style="list-style-type: none"> • Reduced (ST-MT) • Small tree inputs? • Veg recovery (MT-LT) 	<ul style="list-style-type: none"> • Raised if small trees are killed • Limited if only crown scorch 	<ul style="list-style-type: none"> • Depends on fire severity • Little to no impact for most Rx burns 	<ul style="list-style-type: none"> • Kills fire-sensitive species • Little impact on tree growth
Thinning & Burning	<ul style="list-style-type: none"> • Reduced (ST-MT) • Veg recovery (MT-LT) 	<ul style="list-style-type: none"> • Typically raised • Degree depends on thin method and fire intensity 	<ul style="list-style-type: none"> • Reduced; degree varies with thin intensity and method 	<ul style="list-style-type: none"> • Burn kills fire sensitive species • Thinning approach impacts size dist

Fuel Treatment Impacts on Fuel Characteristics

Treatment Type	Impacts on Surface Fuels	Impacts Crown Base Ht	Impacts on Crown Density	Impacts on Tree Species and Size Distributions
Thinning	<ul style="list-style-type: none"> • More slash (ST-MT) • Less veg (ST) • More veg (MT-LT) 	<ul style="list-style-type: none"> • Depends on thinning method • Raised w/thin from below 	<ul style="list-style-type: none"> • Reduced; degree varies with intensity and method) 	<ul style="list-style-type: none"> • Depends on method, intensity and marking • Inc. tree growth
Burning	<ul style="list-style-type: none"> • Reduced (ST-MT) • Small tree inputs? • Veg recovery (MT-LT) 	<ul style="list-style-type: none"> • Raised if small trees are killed • Limited if only crown scorch 	<ul style="list-style-type: none"> • Depends on fire severity • Little to no impact for most Rx burns 	<ul style="list-style-type: none"> • Kills fire-sensitive species • Little impact on tree growth
Thinning & Burning	<ul style="list-style-type: none"> • Reduced (ST-MT) • Veg recovery (MT-LT) 	<ul style="list-style-type: none"> • Typically raised • Degree depends on thin method and fire intensity 	<ul style="list-style-type: none"> • Reduced; degree varies with thin intensity and method 	<ul style="list-style-type: none"> • Burn kills fire sensitive species • Thinning approach impacts size dist

Stand Structure Impacts on Fire Severity

Drier, Mixed-Conifer Forests

- Higher basal area or biomass is often associated with more high severity fire
- Dense overstories and multi-layered canopies contribute to greater risk of crown fire
- Shrub-dominated systems tend to burn at higher severities

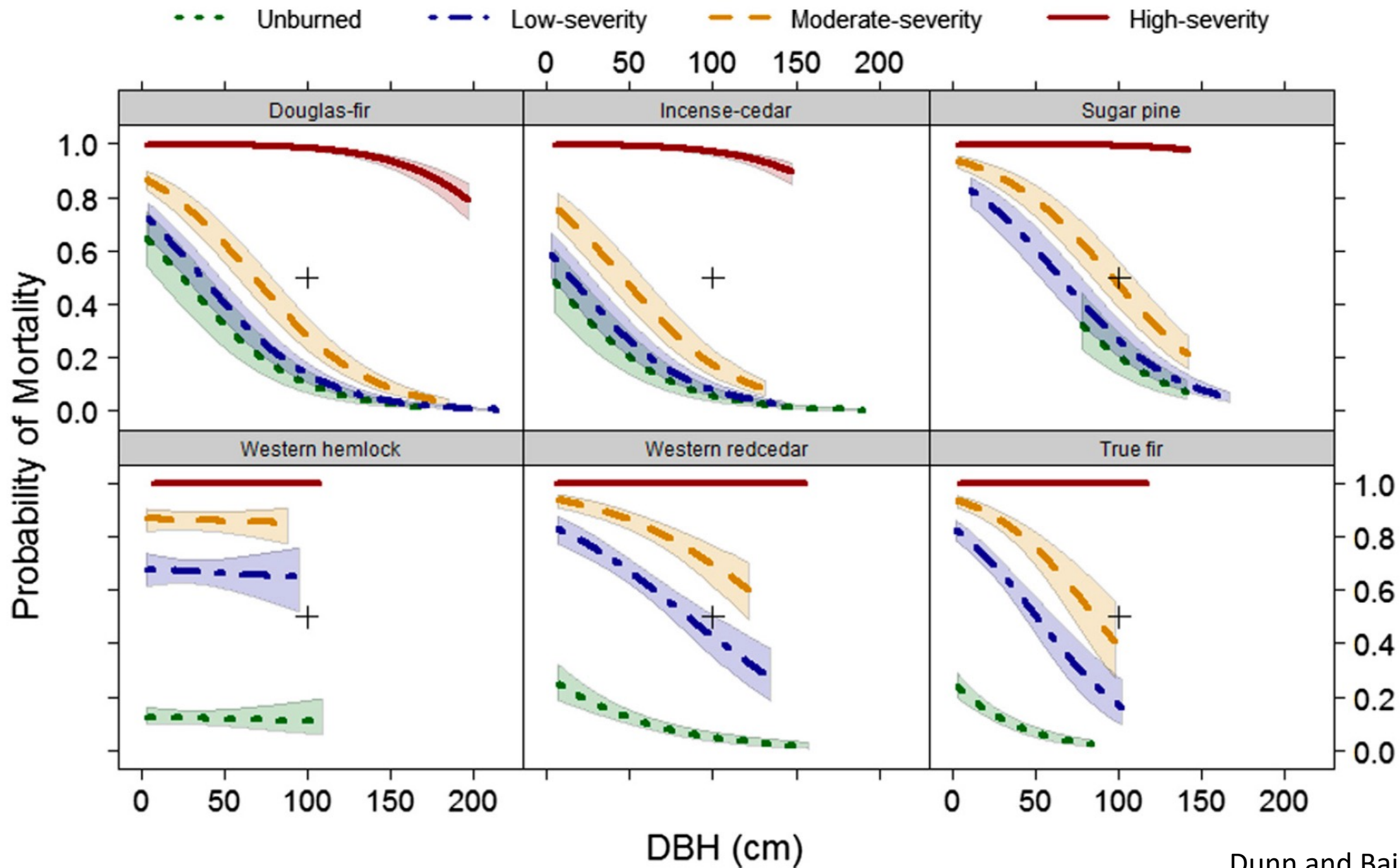




Contrasts in Douglas-fir Forests of SW Oregon/NW California and the west-central Cascades

- Dense, young stands are very susceptible to high-severity fire
- Mature and older stands with high levels of large tree cover have proportionally less severe fire
- Tree size and species composition heavily influences risk of tree mortality





Stand-Scale Effects of Fuel Reduction Treatments

Impacts on Fire Severity

- Thin and burn treatments have consistently resulted in reduced wildfire severity compared to untreated areas and thin-only areas
- Thin-only treatments have been shown to reduce fire severity in some studies, and to increase fire severity in others
- Rx burning and past wildfire have generally been shown to reduce fire severity
- Treatment effectiveness is reduced, but not eliminated, under more extreme fire weather conditions

Stand-Scale Effects of Fuel Reduction Treatments

Impacts on Fire Behavior

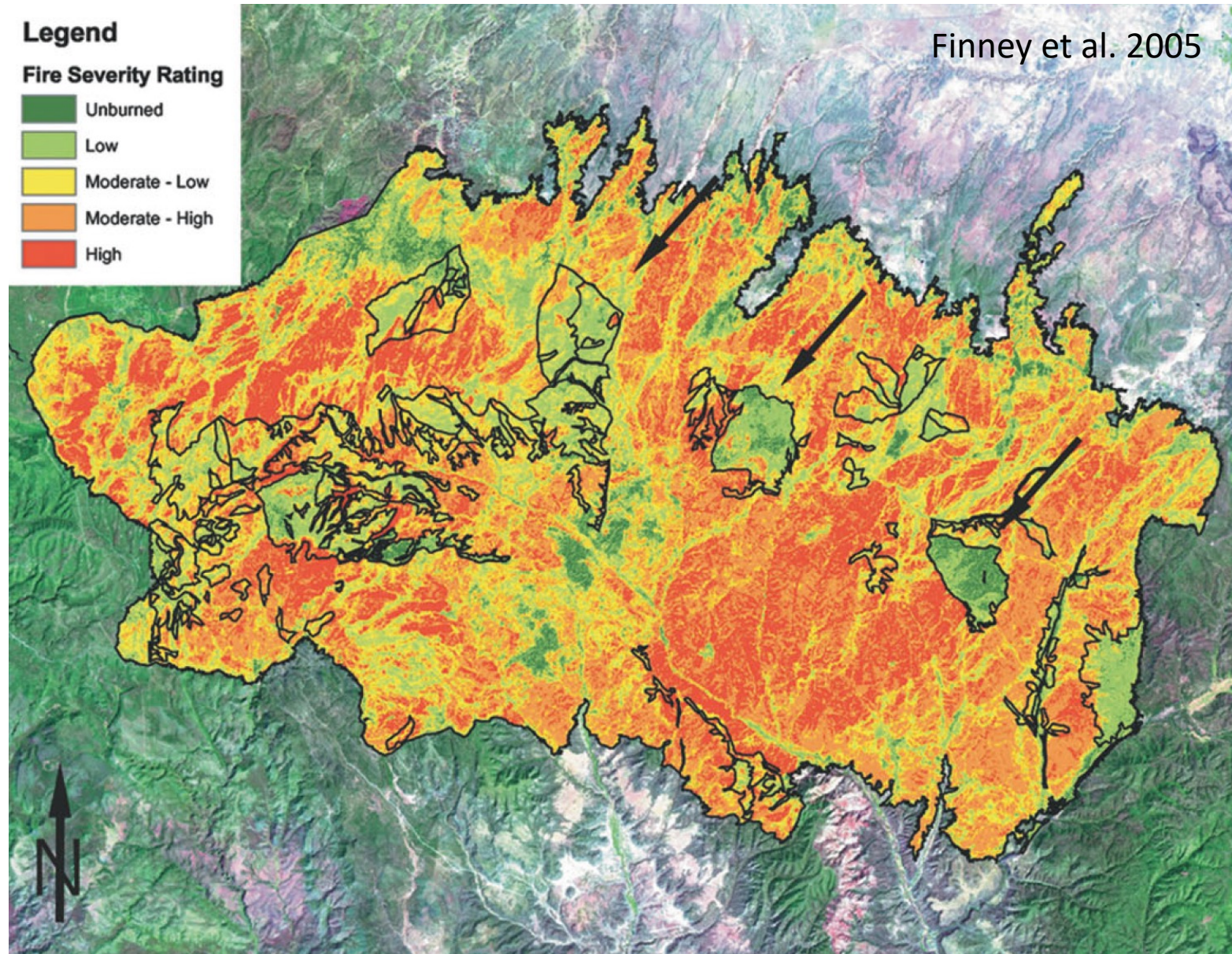
- Treatments involving surface fuel reductions, particularly when combined with thinning are most effective at reducing fire intensity.
- Thin and burn treatments promote a shift from crown fire behavior in untreated areas to lower intensity, surface fire in treated areas.
- Fuel treatments involving "skips" typically have a weaker effects on fire behavior and severity than more uniform density reductions

Landscape-Scale Impacts of Fuel Treatments

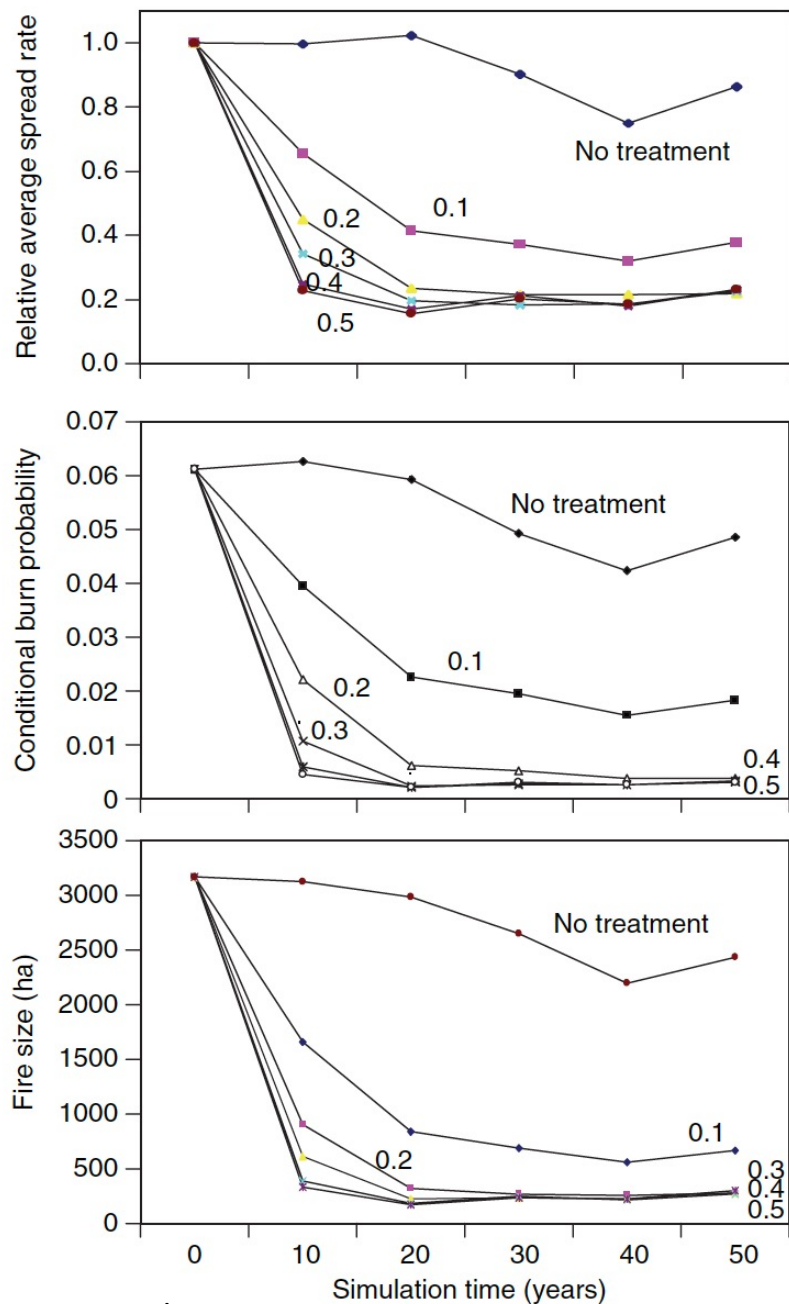
Fires transition from head fires to flanking and backing fires on the leeward side of treated areas.

This reduces fireline intensities and spread rates around the treated areas.

Reduced spread rates can contribute to reduced fire sizes.



Landscape-Scale Impacts of Fuel Reduction Treatments



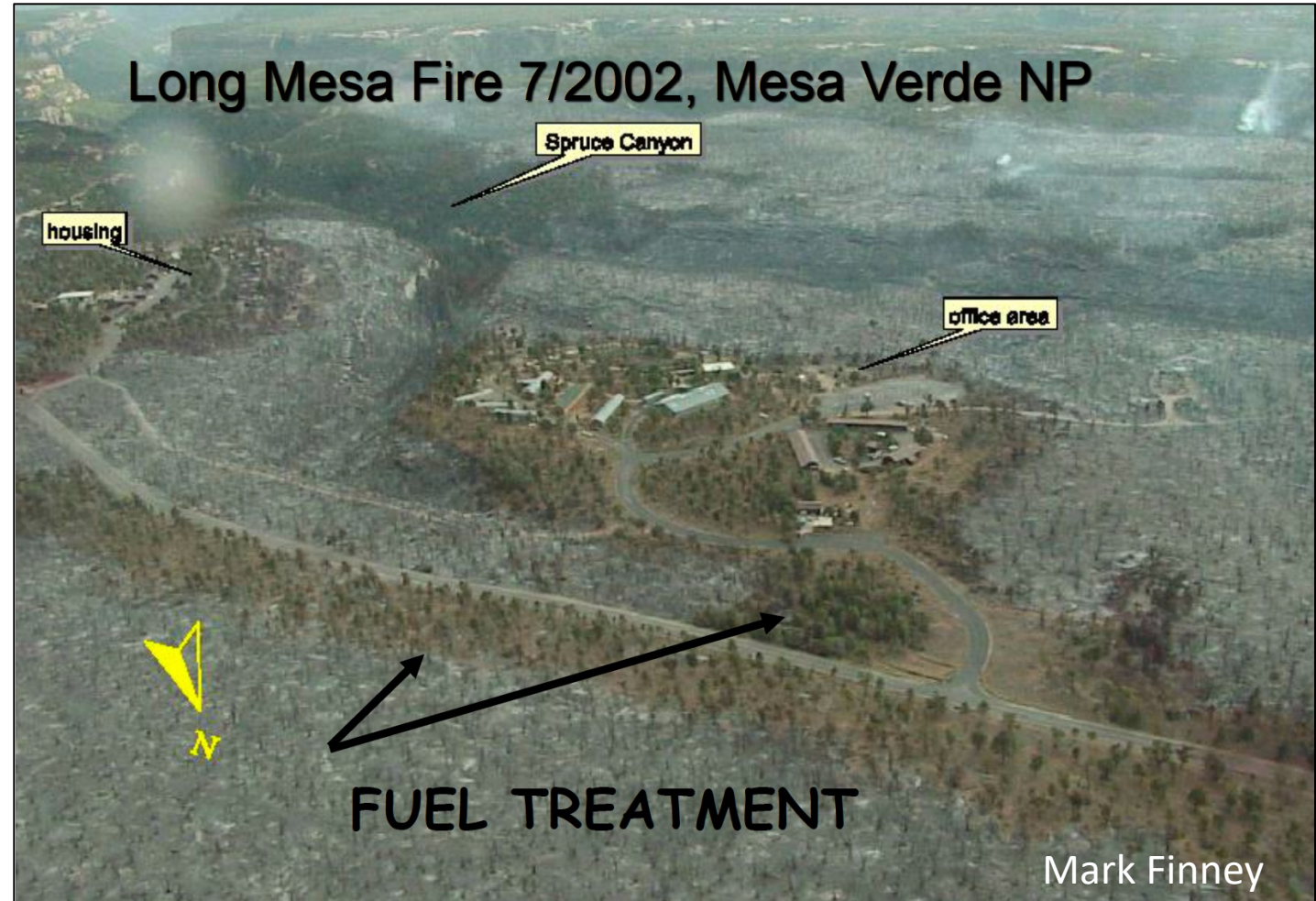
- Fuel treatment application reduces mean fire size, burn probabilities, and spread rates
- Increasing rates of fuel treatment result in improved reductions in fire size, burn probability, and spread rates
- Treating more than about 20% of the landscape per decade produces diminishing returns
- Even modest treatment rates (5-10% pe decade) have been shown to moderate landscape-scale fire behavior across entire RDs and NFs

Landscape-Scale Impacts of Fuel Treatments

Fuel treatments alter fire behavior, but they are not designed to stop fire!

Treatment layout planning should consider:

- Resource values & risk
- Likely fire weather
- Landscape conditions
- Knowledge of fire regimes
- Interactions among current and past treatments



Treatment Lifetimes

You should consider:

- Vegetation type
- Ecosystem productivity
- Topography
- Treatment type
 - 5-15 years for Rx burning
 - 10-25 years for thin and burn treatments
- Fire weather conditions



Treatment Placement

Optimization algorithms

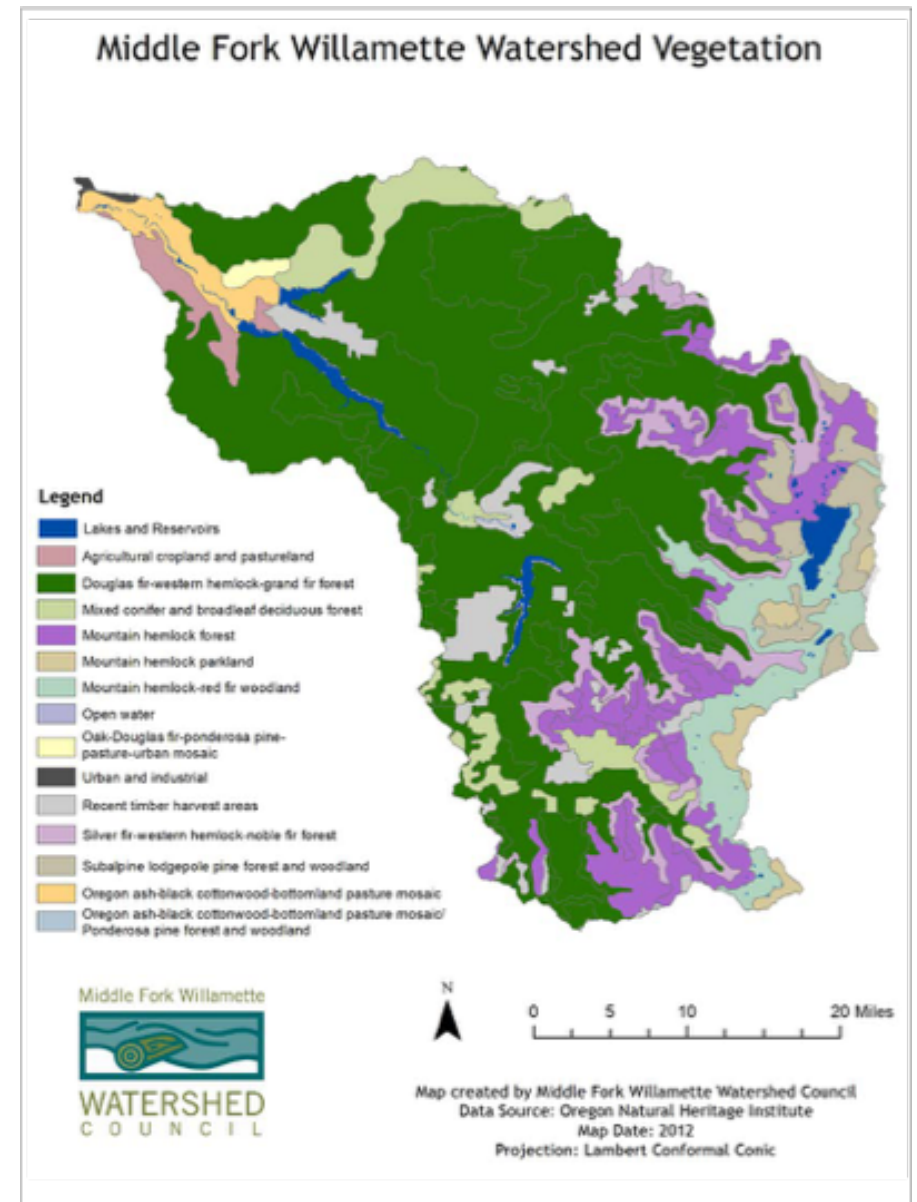
- Place treatments in areas w/high fire risk
- Least burn area and high intensity fire

Resource value-based placement

- Best at reducing risk to WUI communities
- Less effective at reducing mean fire sizes and area burned at high intensities

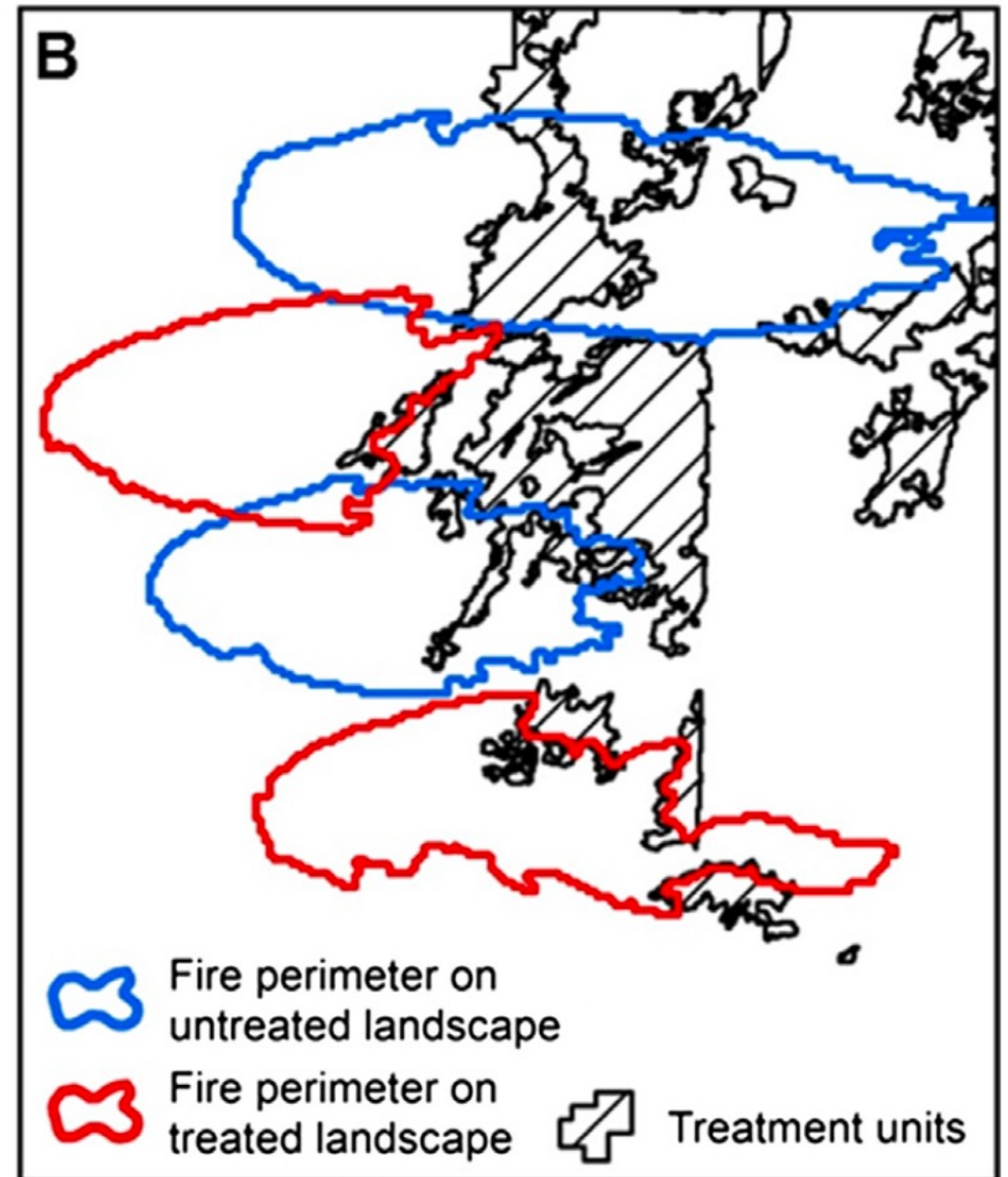
Random placement

- Least effective option



Other Considerations

- Spatial restrictions on fuel treatment placement reduce landscape-scale effectiveness.
- Overlapping fuel treatments can be more effective than scattered treatments.
- Larger treatments are more effective on a local scale, but the treatment unit size effect is weak at landscape scales.
- Past wildfires often have moderating effects similar to prescribed burning



PODs and Fuel Management

What are PODs?

Spatial units designed to facilitate wildfire management planning & analysis.


Utility for fuel treatment planning:

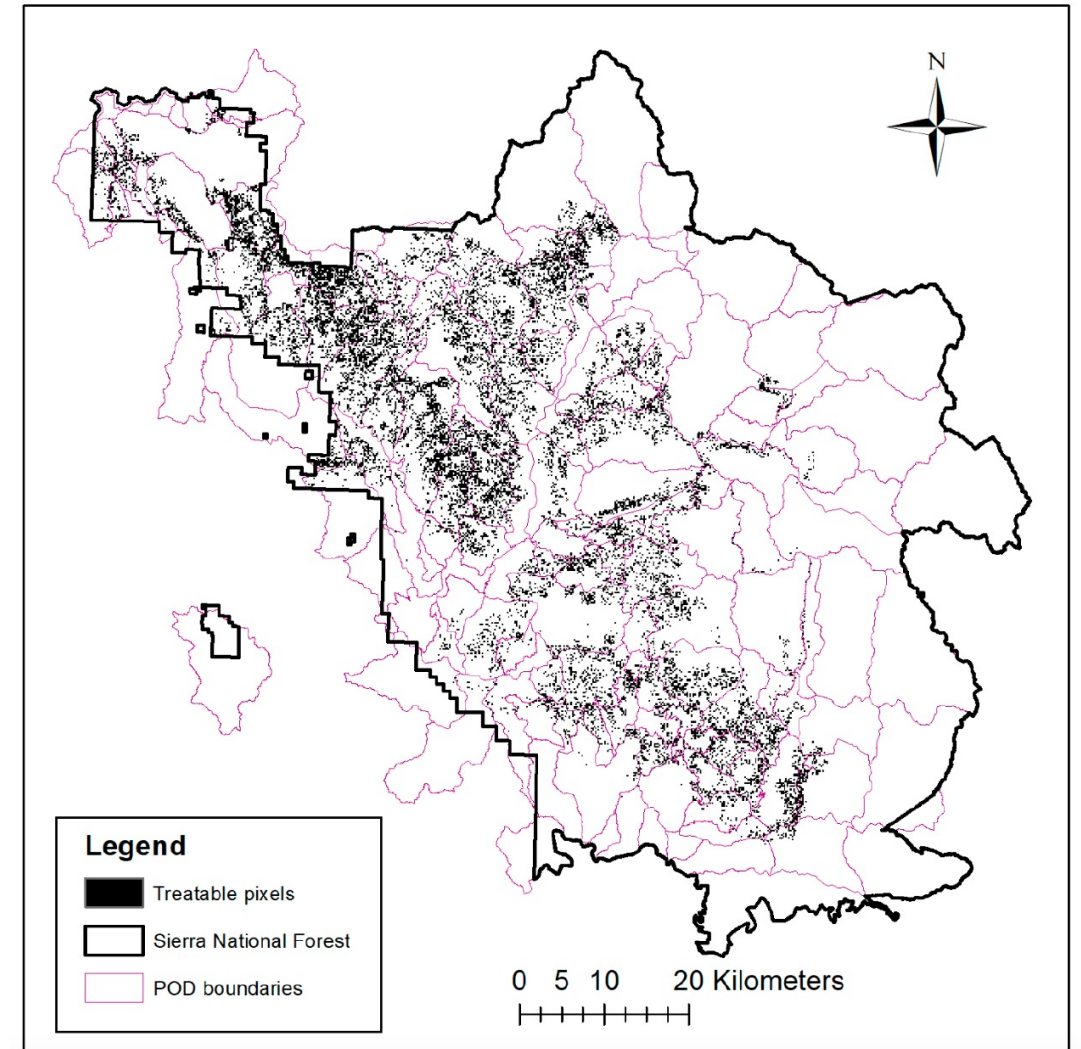
PODs already consider HVRAs, potential fire behavior and fire effects.

- Protect
- Restore
- Maintain

Article

Modeling Fuel Treatment Leverage: Encounter Rates, Risk Reduction, and Suppression Cost Impacts

Matthew P. Thompson ^{1,*}, Karin L. Riley ² , Dan Loeffler ³ and Jessica R. Haas ²



Landscape-Scale Impacts of Fuel Treatments

Important Caveats

- Some areas will experience increased fire behavior due to altered fire progression pathways
- Areas where treatments are not permitted experience less benefit than the landscape average
- Burn probability and rate of spread are typically reduced by larger percentages than flame lengths
- Treatments involving fire are typically much more effective during extreme fire weather events than mechanical-only treatments

Broad Conclusions

- Fuel treatment principles are applicable across a wide range of systems.
- Thin and burn treatments are best.
- Extreme fire weather will likely lessen, but not eliminate treatment effects.
- Consider landscape context in planning and implementation.
- Consider tradeoffs between landscape-scale and individual resource benefits.
- **Keep expectations realistic!**

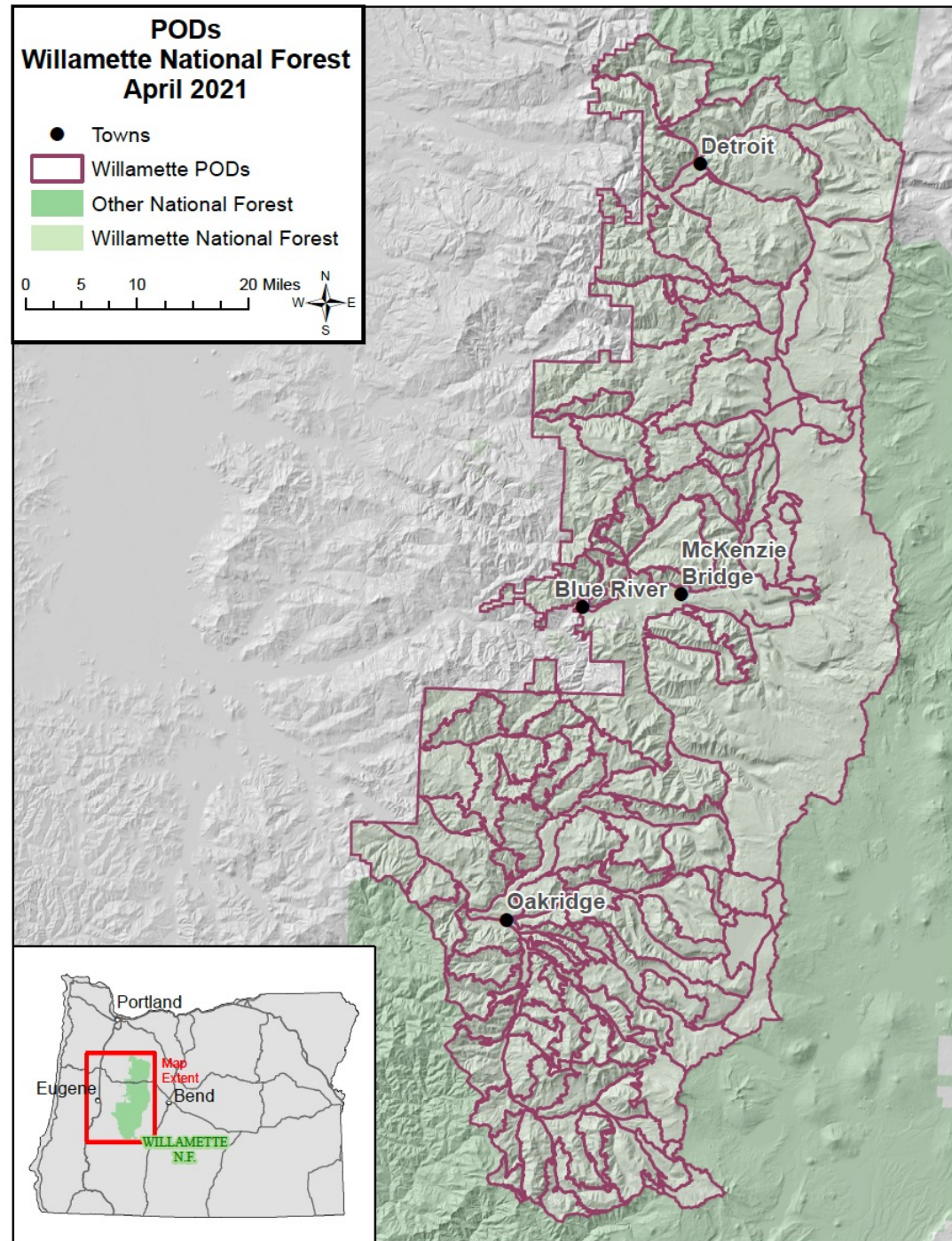


Questions Moving Forward

How and when do we apply fuel reduction principles in westside forests?

- Reduce surface fuels
- Raise crown base heights
- Decrease crown density
- Promote fire-resistant and resilient stands and landscapes

How do we leverage existing resources to optimize fuel treatment planning and implementation at landscape-scales?



Silvicultural Treatment Impacts on Fuels and Wildfire Behavior in Moist, Westside Pacific Northwest Forests: A Summary of Relevant Literature



Prepared by:
Matthew D Powers
Department of Forest Engineering Resources and Management
Oregon State University
August 31, 2020

Fuel Treatment Impacts on Landscape-Scale Wildfire Behavior in Moist, Westside Pacific Northwest Forests: A Summary of Relevant Literature

**Coming
Soon!**

A report for the Willamette National Forest prepared by:
Matthew D Powers
Department of Forest Engineering Resources and Management
Oregon State University
and
Jane Kertis
Northwest Oregon Ecology Program
USDA Forest Service (retired)
March XX, 2021

A photograph of a forest landscape. In the foreground, a path of dark, mossy rocks leads through dense green ferns and other vegetation. Several dead, charred tree trunks stand prominently in the middle ground, contrasting with the surrounding living forest. The background shows a dense forest of tall, thin trees under a clear blue sky.

Thank you!