Lake Tahoe West Science Symposium

Day 1: Tuesday May 19, 9:00 am – 2:00 pm

Day 2: Friday May 29, 9:00 am – 2:30 pm

Zoom Features

- Participants are in listen-only mode
- Click on the **Q&A icon** to submit questions
- Use the **Chat feature** if you need technical assistance – send messages to All Panelists
- Let us know who is online: please use the Chat feature to **introduce yourself**!
- We recommend joining through phone + computer if your audio or internet is poor

Symposium Goals and Audience

- Primary Goal: Present and discuss findings from the LTW modeling effort and how they inform future resilience of the Lake Tahoe basin landscape.
  - Additionally, highlight how modeling results informed the LTW Landscape Restoration Strategy and may inform future environmental analysis
- Diverse Audience

Symposium Format

- Each presentation will be followed by Q&A
- Participants submit questions using the Zoom Q&A feature
- Moderator will select questions for presenters and panelists
- Final panel will discuss overall take-homes

Morning agenda

Lake Tahoe West Science Symposium

TIME	AGENDA ITEM	PRESENTER
9:00 am	**Welcome, Zoom Overview, Agenda Review, Introductions**	**Sarah Di Vittorio,** National Forest Foundation
9:10 am	**Introduction to Today's Workshop** Orientation to today's talks and associated science products	**Pat Manley**, PSW **Jonathan Long**, PSW
9:20 am	**Effects of treatment in aspen-conifer stands on fire behavior and stand structure** 15-minute presentation followed by 5-minute Q&A	**Chad Hoffman** and **Justin Ziegler**, Colorado State University
9:40 am	**Effects of thinning on fuels and tree vigor** 15-minute presentation followed by 5-minute Q&A	**Brandon Collins**, University of California, Berkeley
10:00 am	**BREAK (15 minutes)**	
10:15 am	**Effects of forest thinning on snowpack and downstream hydrology** 25-minute presentation followed by 10-minute Q&A	**Adrian Harpold** and **Sebastian Krogh Navarro,** University of Nevada, Reno
10:50 am	**Water Quality** • Watershed Modeling of Disturbances (15 min) • Roads and Water Quality (15 min) • 10-minute Q&A	**Mariana Dobre**, University of Idaho **Jonathan Long**, PSW
11:30 am	**LUNCH (60 minutes)**	

LAKE TAHOE WEST RESTORATION PARTNERSHIP

Afternoon

Lake Tahoe West Science Symposium

TIME	AGENDA ITEM	PRESENTER
11:30 am	**LUNCH (60 minutes)**	
12:30 pm	**Smoke Impacts and Feasibility Indicators** 15-minute presentation followed by 5-minute Q&A	**Jonathan Long**, PSW
12:50 pm	**Indicators & Ecosystem Management Decision Support** • Overview of resilience indicators (10 min) and Q&A (5 min) • Results of analysis (20 min) and Q&A (10 min)	**Jonathan Long**, PSW **Eric Abelson**, PSW
1:35 pm	**BREAK (25 minutes)**	
2:00 pm	**Group Discussion: Take-homes for landscape-scale social ecological resilience and for management** 30 minutes **Pat Manley**, Moderator	**All Presenters** **LTW Staff:** **Jen Greenberg**, California Tahoe Conservancy **Brian Garrett**, LTBMU
2:30 pm	***ADJOURN***	

Introductions

Patricia Manley, Research Program Manager, U.S. Forest Service Pacific Southwest Research Station

LTW Science Team Co-Leader

Jonathan Long, Research Ecologist, U.S. Forest Service Pacific Southwest Research Station

LTW Science Team Co-Leader

Final Panel: Take-homes for landscape-scale social ecological resilience and for management

- Moderator: Pat Manley, PSW
- Jonathan Long, PSW
- Mariana Dobre, University of Idaho
- Eric Abelson, PSW
- Bill Elliot
- Jen Greenberg, California Tahoe Conservancy
- Brian Garrett, Forest Service LTBMU


Lake Tahoe West Science: Introduction

Jonathan Long, Research Ecologist

U.S. Pacific Southwest Research Station

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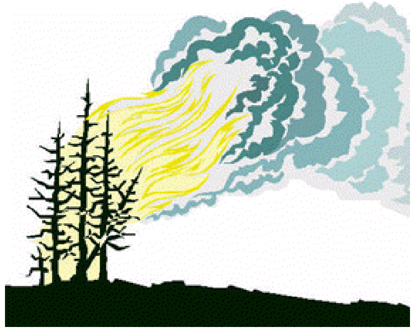
Patricia Manley, Research Program Manager

U.S. Pacific Southwest Research Station

pat.manley@usda.gov



Lake Tahoe West Science Team

- The science team embarked on a novel approach to modeling integrated resource responses to climate, management, and internal feedback mechanisms operating within socio-ecological systems
- Engaged researchers from multiple institutions
- Scientists represented multiple disciplines
    - Forest ecology, fire ecology, wildlife ecology, atmospheric science, soils, hydrology, economics

USDA Forest Service Research Stations:

- Jonathan Long & Pat Manley – PSW
- Angela White – PSW
- Keith Slauson – PSW
- Stacy Drury – PSW
- Eric Abelson - PSW
- Brandon Collins – UCB/PSW
- Keith Reynolds – PNW
- Bill Elliot and Sue Miller – RMRS

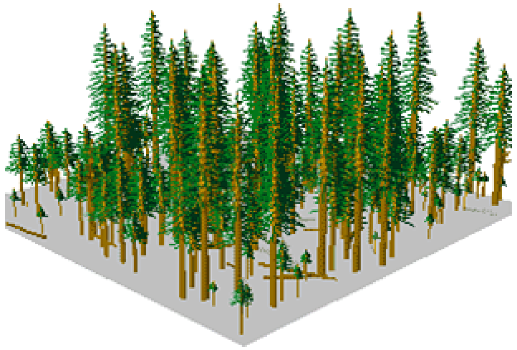
Research Universities:

- Rob Scheller & Charles Maxwell – NCSU
- Mariana Dobre & Erin Brooks – U Idaho
- Sam Evans, Tim Holland, & Matthew Potts – UCB
- Adrian Harpold and Sebastian Krogh Navarro – UNR
- John Mejia – DRI
- Chad Hoffman & Justin Ziegler – CSU

Multiple Scales of Modeling

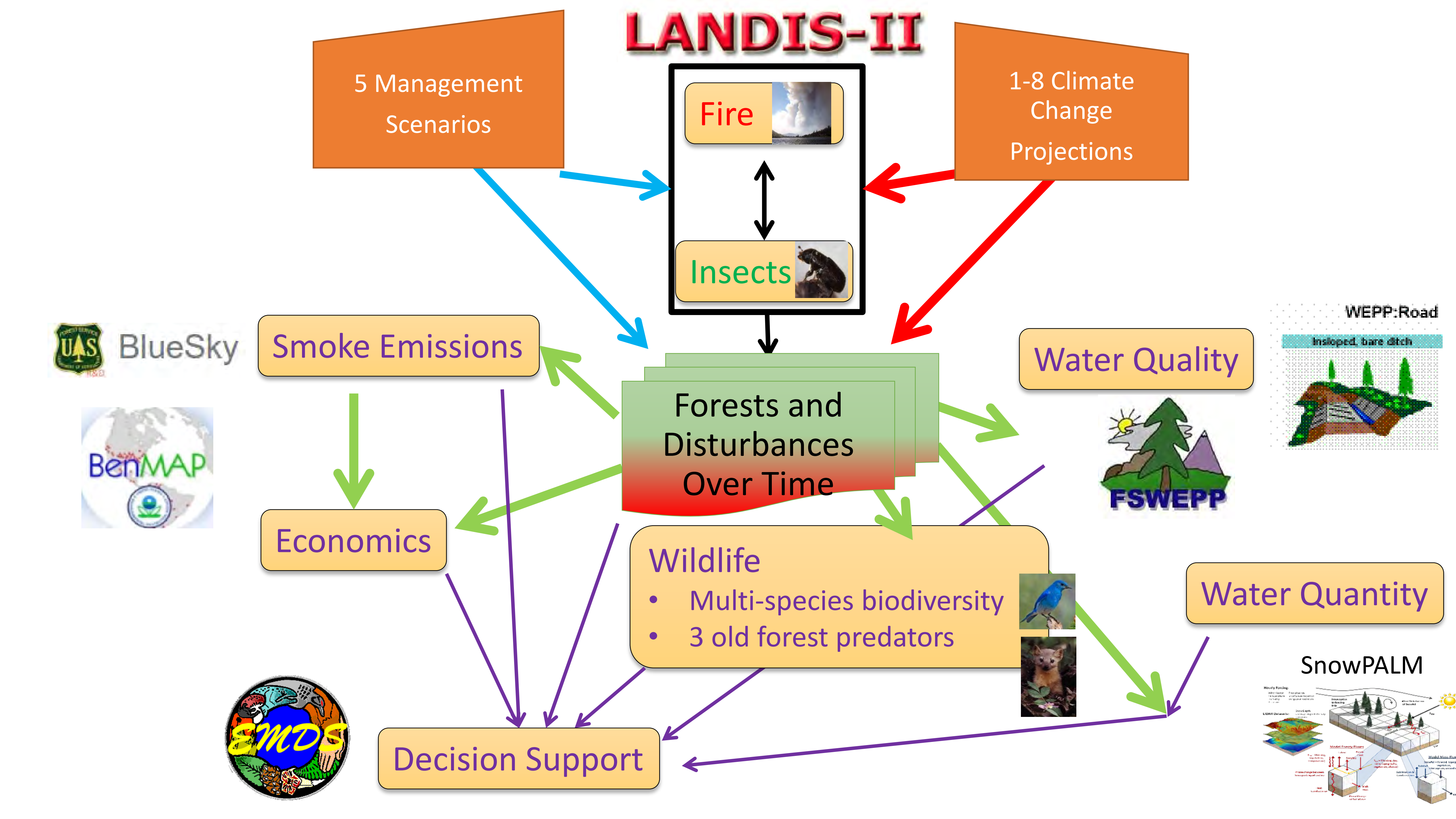
Short-term "Event" Modeling

Long-term "Regime" Modeling



- Landscape fire outcomes
- Carbon sequestration
- Vegetation communities
- **Wildlife habitat**
- **Air quality**
- **Potential water yield**
- **Water quality**
- Economics

- **Fire behavior in aspen stands**
- **Smoke impacts of fire events**
- **Hydrologic effects of thinning**
- **Water quality effects of disturbances**


LANDIS-II
5 Management Scenarios
1-8 Climate Change Projections
Fire
Insects
Forests and Disturbances Over Time
Smoke Emissions
BlueSky
BenMAP
Economics
Wildlife
• Multi-species biodiversity
• 3 old forest predators
Water Quality
WEPP:Road
Insloped, bare ditch
FSWEPP
Water Quantity
SnowPALM
EMDS
Decision Support

Schedule

May 19th

- Landscape disturbance and vegetation dynamics
- Wildlife habitat
- Economics

May 29th

- Monitoring of forest growth and vigor
- Treatments in aspen-conifer stands
- Hydrology/snow
- Water quality (watersheds and roads)
- Smoke and feasibility
- Decision support

Long-term Dynamics: Response to management regimes over 100 years of changing climate

- Modeled forest growth, fire, and beetle kill dynamics over 100 years
- Evaluated 5 management scenarios and multiple climate projections
- Used outputs from forest dynamic modeling as inputs to other models, such as wildlife, smoke, water quality and economics

Management Scenarios

Amount of Active Treatment

None

1) **Suppression-Only**: No land management actions except fire suppression in all management zones.

2) Wildland Urban Interface (WUI): Forest thinning in the WUI only (most like recent treatment).

~1000 acres annually

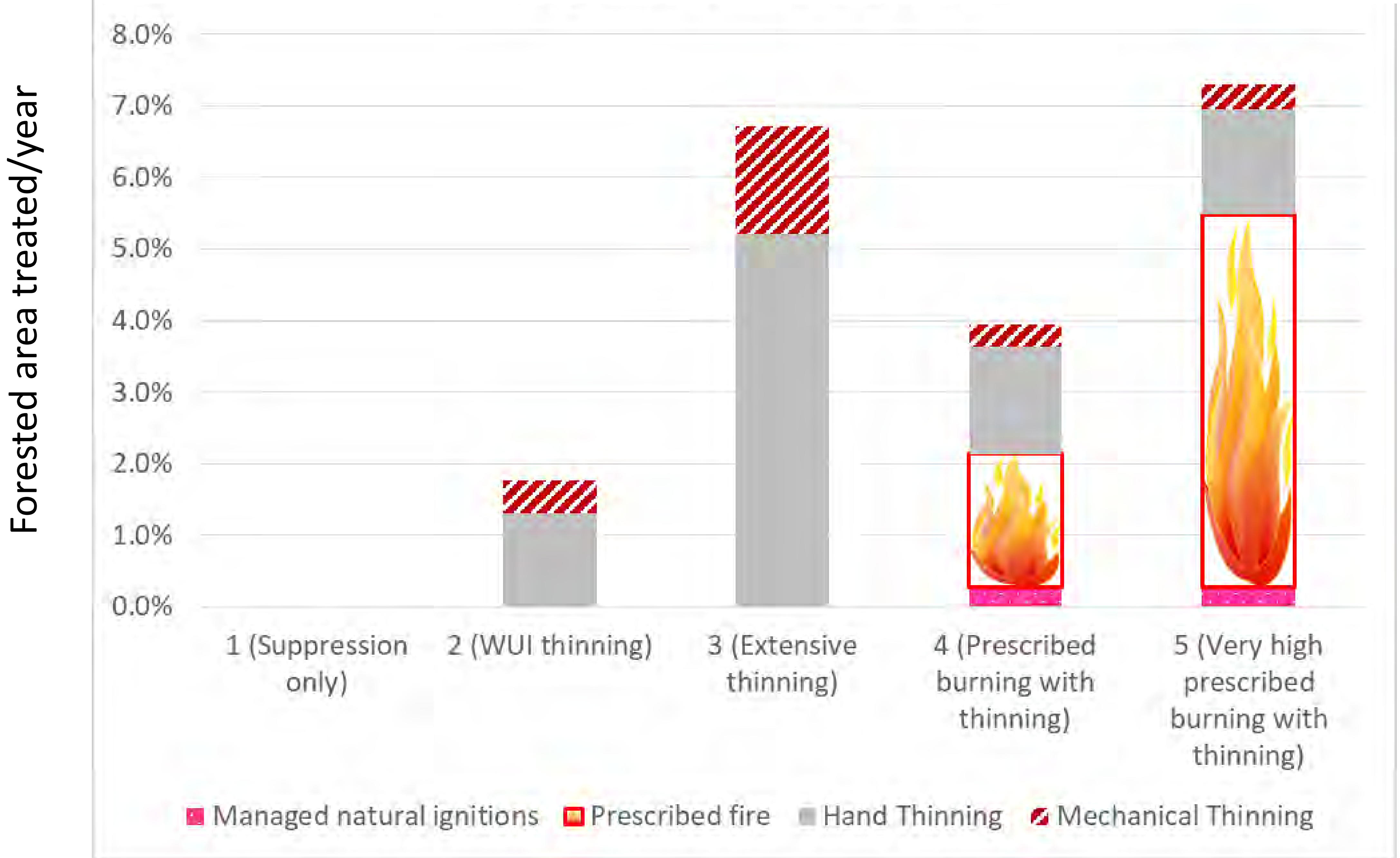
4) Fire-Focused (moderate prescribed burning): Modest forest thinning in the WUI, moderate levels of prescribed fire, and some wildfire managed for resource objectives outside of the WUI.

3) Thinning-Focused: High levels of forest thinning in the WUI, General Forest, and Wilderness.

5) Fire-Focused (high prescribed burning): Modest forest thinning in the WUI, high levels of prescribed fire, and some wildfire managed for resource objectives outside of the WUI.

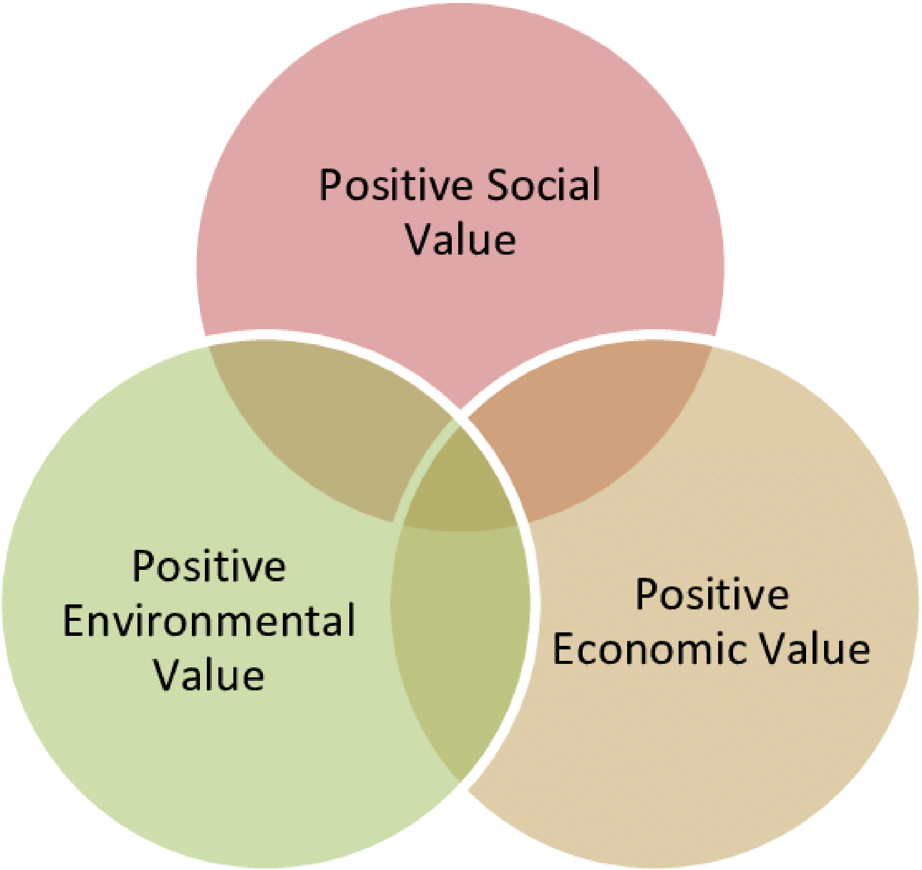
~4000 acres annually

Management Scenarios: Amount and Type of Treatment per Year



Integrated Evaluation of Social and Ecological Values

- Evaluated the potential net benefits of different courses of action and which values are most important
- Economic analysis of social values – May 19
  - Management costs
  - Carbon accounting
  - Property risk
- Decision support tool-based comparison of social and ecological values - May 29
  - Overall scenario performance across multiple social and ecological benefits



Effects of forest thinning on snowpack and downstream hydrology

Adrian A. Harpold, **Sebastian Krogh**, University of Nevada, Reno
Patrick Broxton, University of Arizona
Seshadri Rajagopal, Desert Research Institute

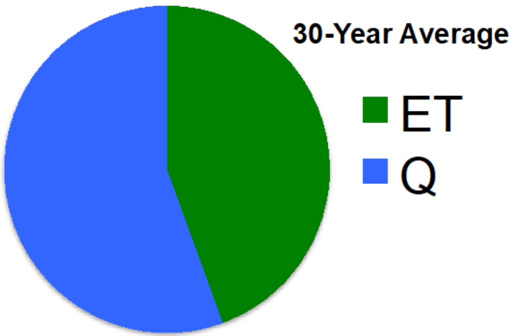
sagehen.blogspot

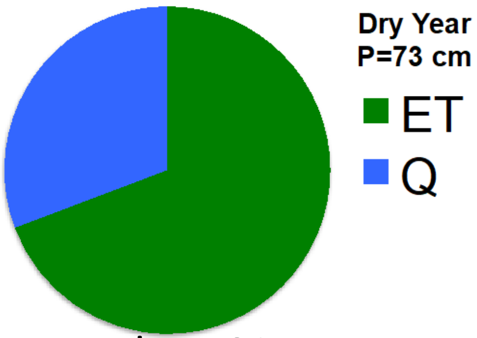
Presentation Outline

- Motivation for forest thinning for hydrology
  – Importance of snow and evapotranspiration
  – A primer in snow vegetation interactions
- ‘Virtual thinning’ to estimate snow changes
  – Verification of model with a proof of concept
  – Decision support tool results
- Continued research efforts
  – Effects on downstream hydrology
  – Verifying and extrapolating these results

Tahoe West Project highlights importance of water

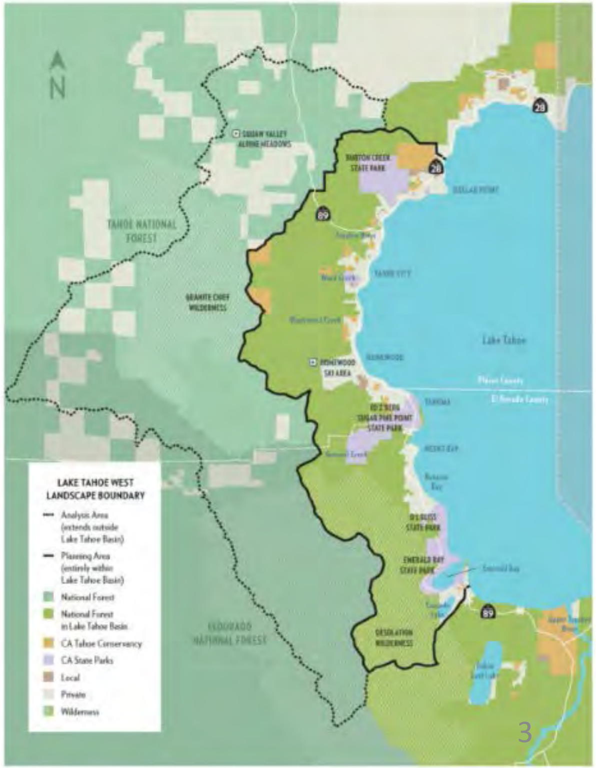
- Semi-arid, snow dominated montane forests
  - Most water from snowmelt (little summer rain)
  - Critical downstream water supply
  - Much of the water budget is lost at ET
  - High natural fire risk – snow mediated
  - Critical aquatic habitat mediated by groundwater
  - Competing uses, including snow recreation





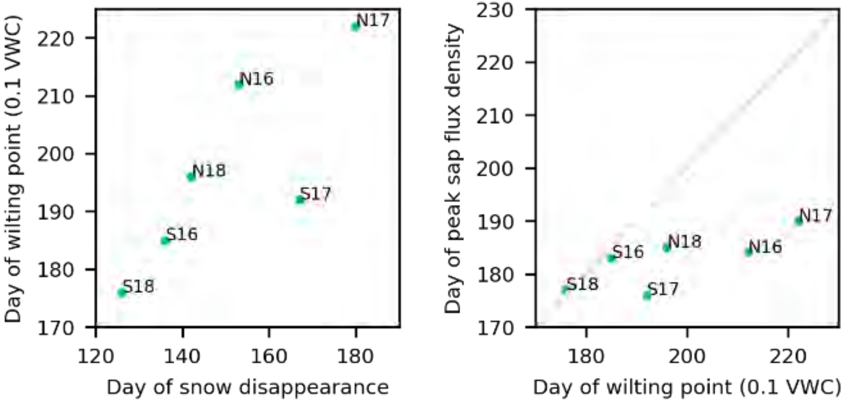
Water Budget of Upper Truckee, CA

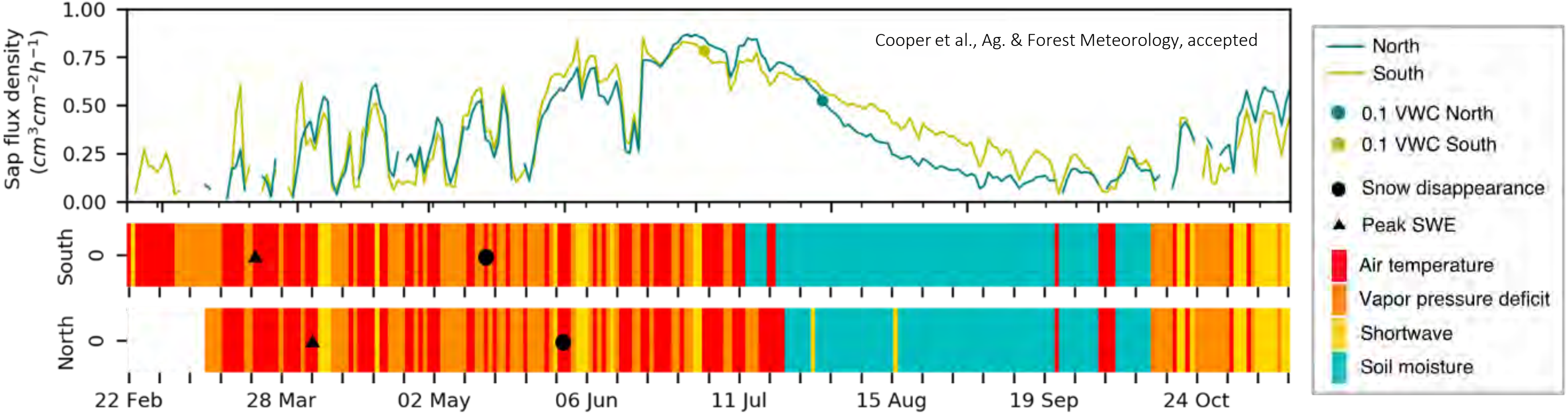
Tahoe West Project



Importance of snow in forest hydrology

- Snow disappearance controls dry down of soil and ground fuel moisture
  - Less snow retention = more water stress and bigger fires
- Snow disappearance mediated soil moisture controls the timing of water limitations in Sierra Nevada conifer forests
- Snowmelt is the primary (only) hydrological event that can drive water deep into the subsurface and recharge groundwater

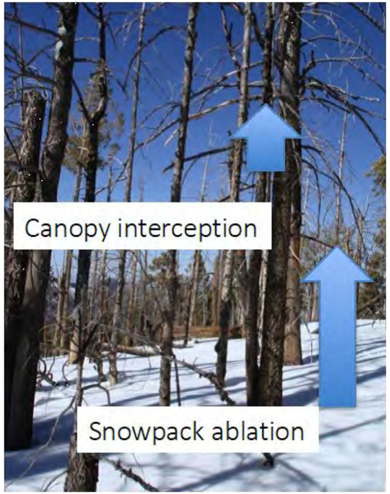


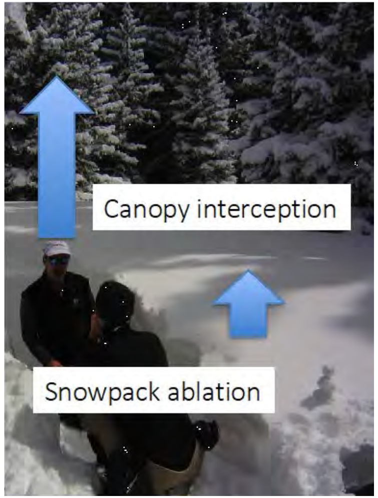


Cooper et al., Ag. & Forest Meteorology, accepted

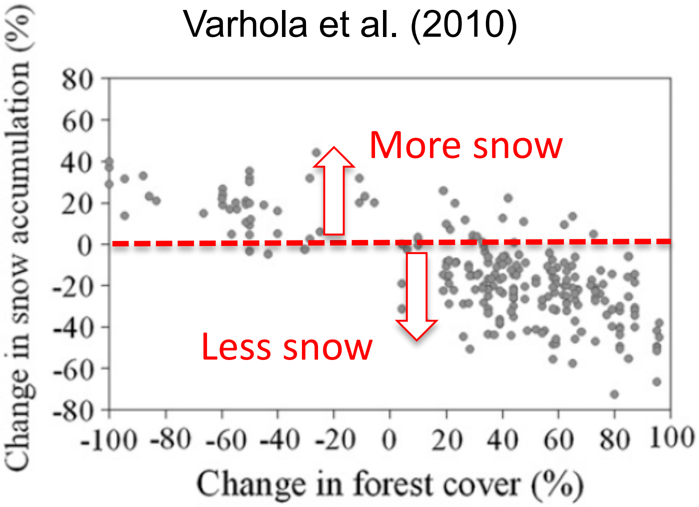
Manipulating the forest canopy is one of the only 'nobs' we have to manage hydrology

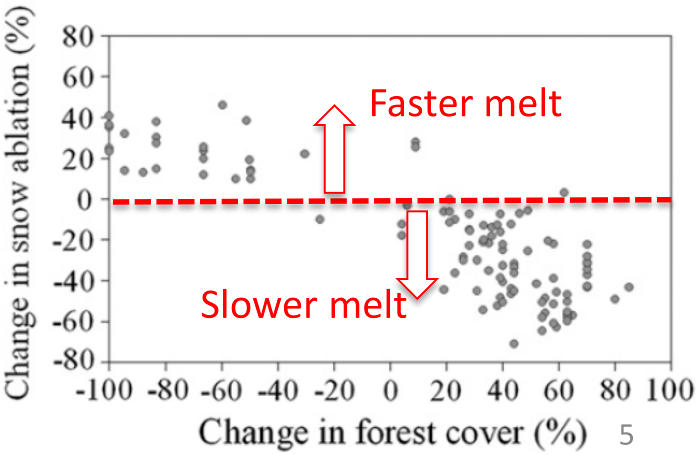
- Counter-acting processes of forest canopy:
  - Interception
  - Sheltering from energy (turbulence and solar radiation)
  - Emission of longwave radiation



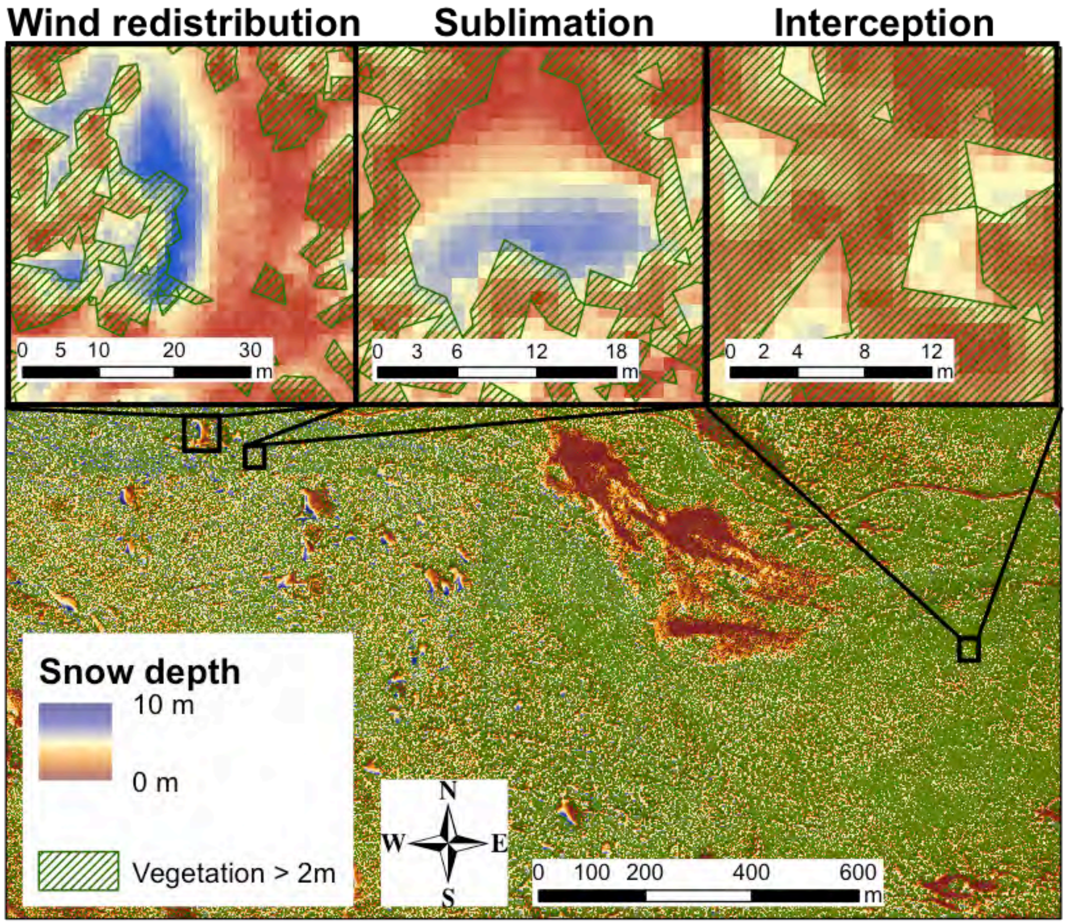


Varhola et al. (2010)





Lidar illustrates forest controls on snow accumulation

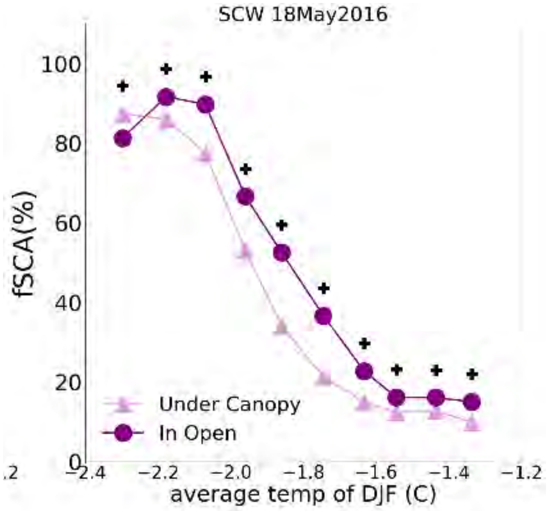


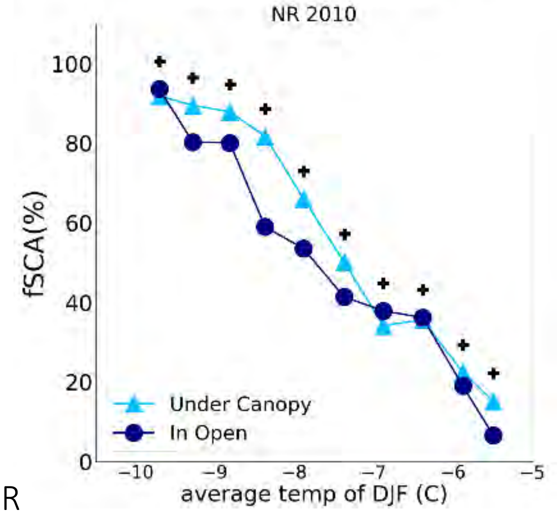
Niwot Ridge near Ameriflux tower

- Forest structure is highly variable and interacts with topography
- Patterns in melt timing, rate, and amount are function of:
  - Scour and deposition by wind
  - Ablation from sublimation and melt
  - Interception by forest canopy

Example of complex controls on snow disappearance in and out of forest canopy

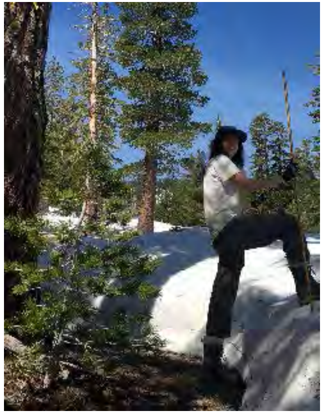
- Canopy controls ablation and timing of snow disappearance:
  - More snow in open areas in warm climates (Sagehen) where longwave radiation is larger
  - More snow under forest canopy in cold climates (Boulder Creek) where solar radiation drives ablation



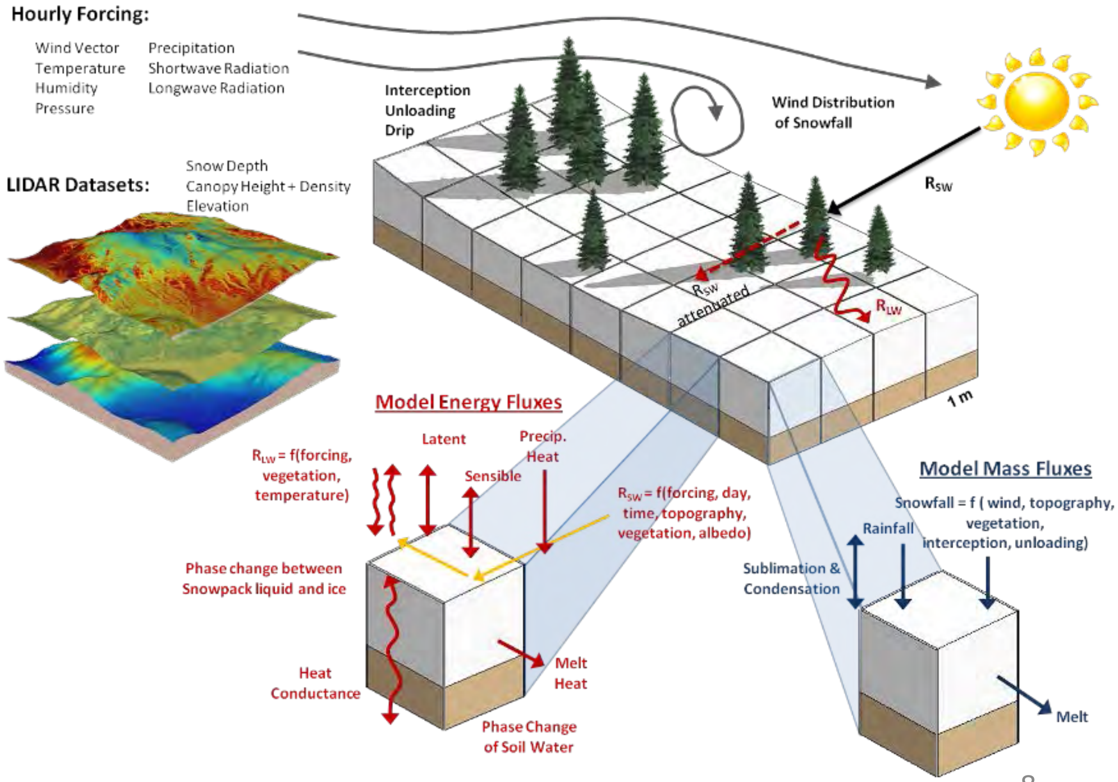


Safa et al., in review, WRR

SnowPALM modeling to represent tree-scale processes



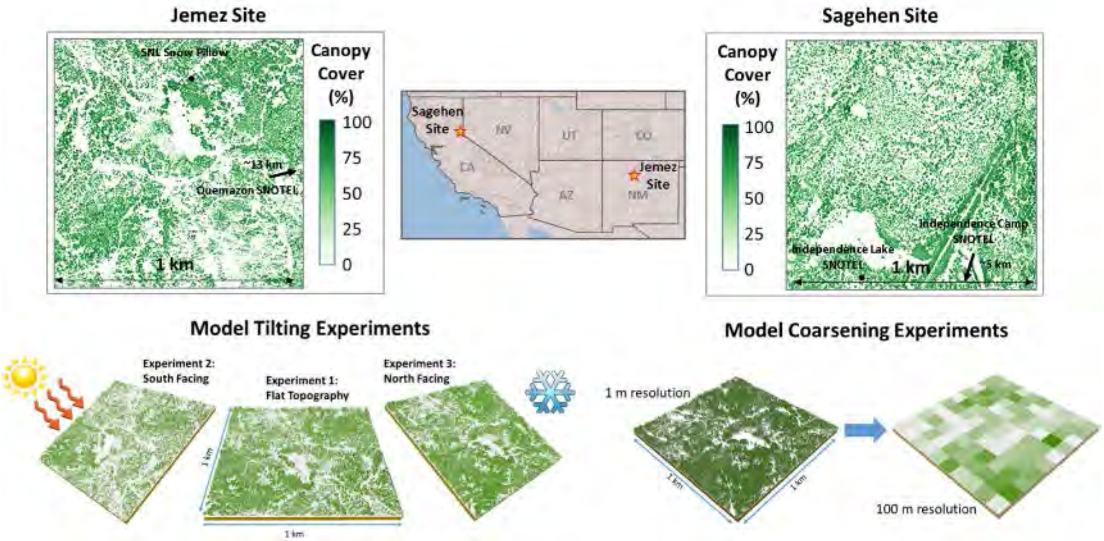
- Topography and canopy structure parameterized at 1-m resolution
- Forced by tower micrometeorology
- Verified with snow depth at 1-m scale

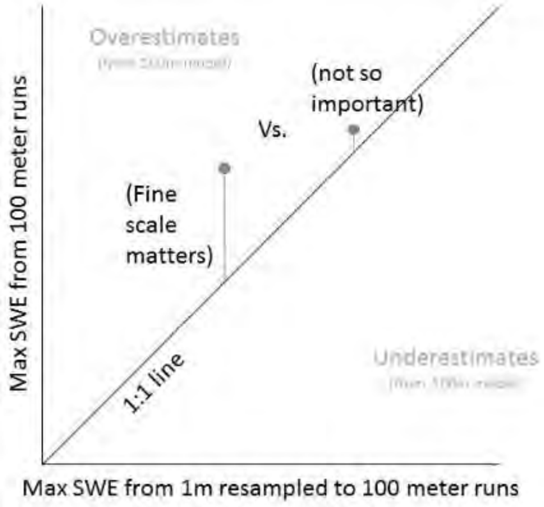


Broxton et al., Ecohydrology, 2015

Illustrating the importance of tree-scale processes with a coarsening experiment

- Coarsen model forcings and parameters (veg structure) from 1 m to 100 m
  - No microtopography, but apply tilting scenarios
  - Two sites with different climate
- We isolate differences due to fine scale vegetation (organization and distribution of forest structure within the 100 m pixel)

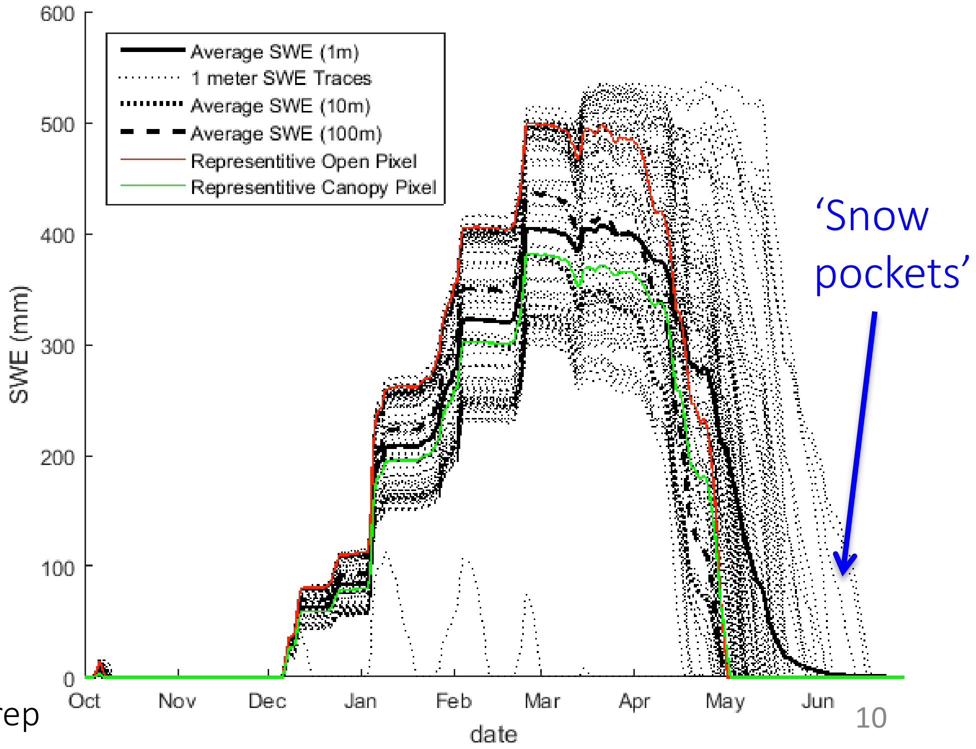




Broxton et al., in prep

Retaining tree-scale processes gives different snow predictions than coarser model

- Spatial organization of tree (i.e. small forest gaps) preserve/ablate snow in patches in the 1-m model that lead to 10-40% biases in high canopy cover



Broxton et al., in prep

Experimental design for Rubicon proof of concept

1. How does the high resolution model verify against open and forest canopy locations?
2. What are the effects of removing trees of different heights (<5, <10, <15, and <20 meters) on water and energy budgets?
3. Where do topographic and pre-existing vegetation conditions interact with tree removal scenarios to cause the largest increases in melt volume?

a)

Stand 3

Stand 2

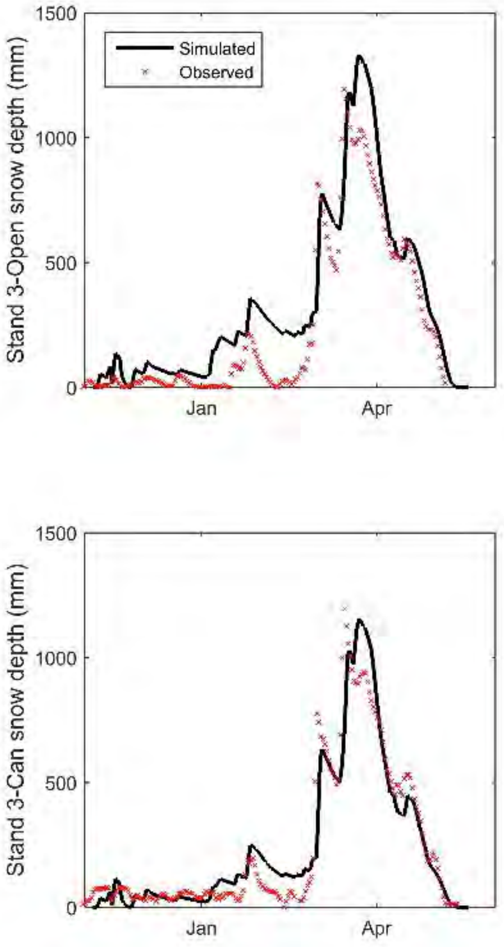
b)

c)

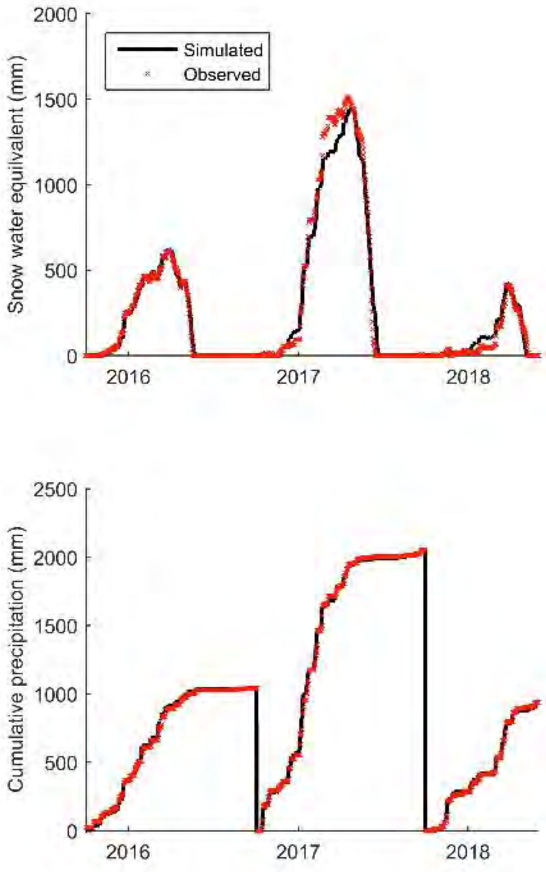
Model verification against snow mass observations

- Model verifies well against large forest clearing (Rubicon #2 SNOTEL)
  - Precipitation was adjusted to account for undercatch
- Model verifies adequately against three sets of open/under canopy snow depth sensors
  - Hard to capture early season poor snowpack

Stand-scale observations

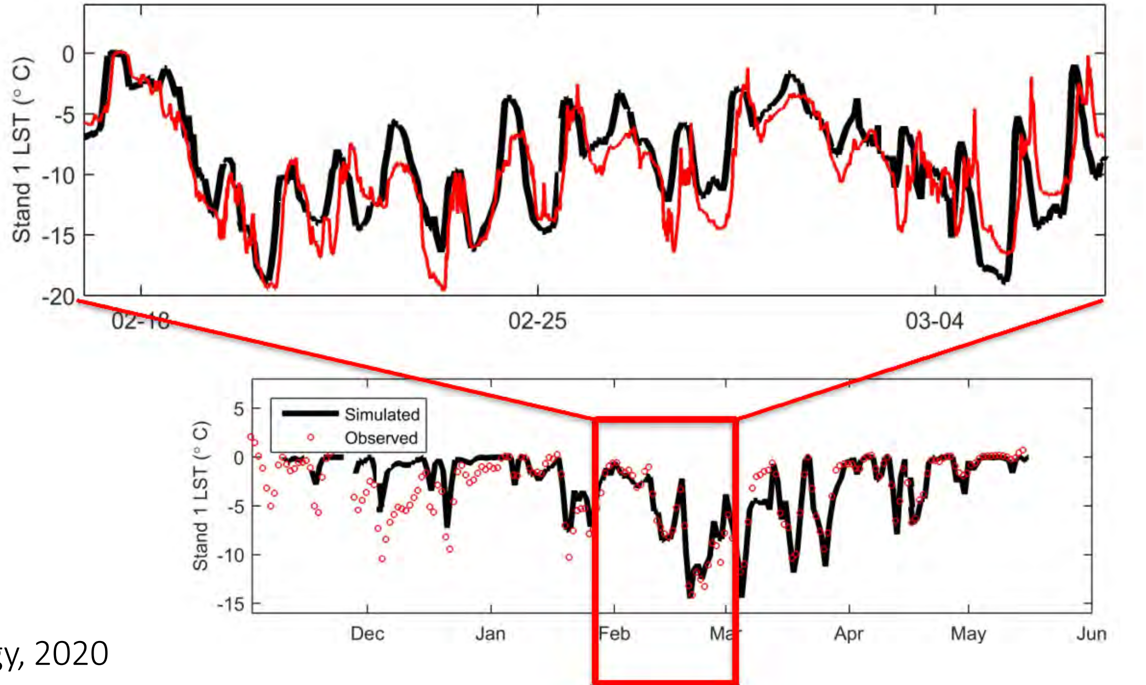


SNOTEL observations



Model verification against snow surface temperature

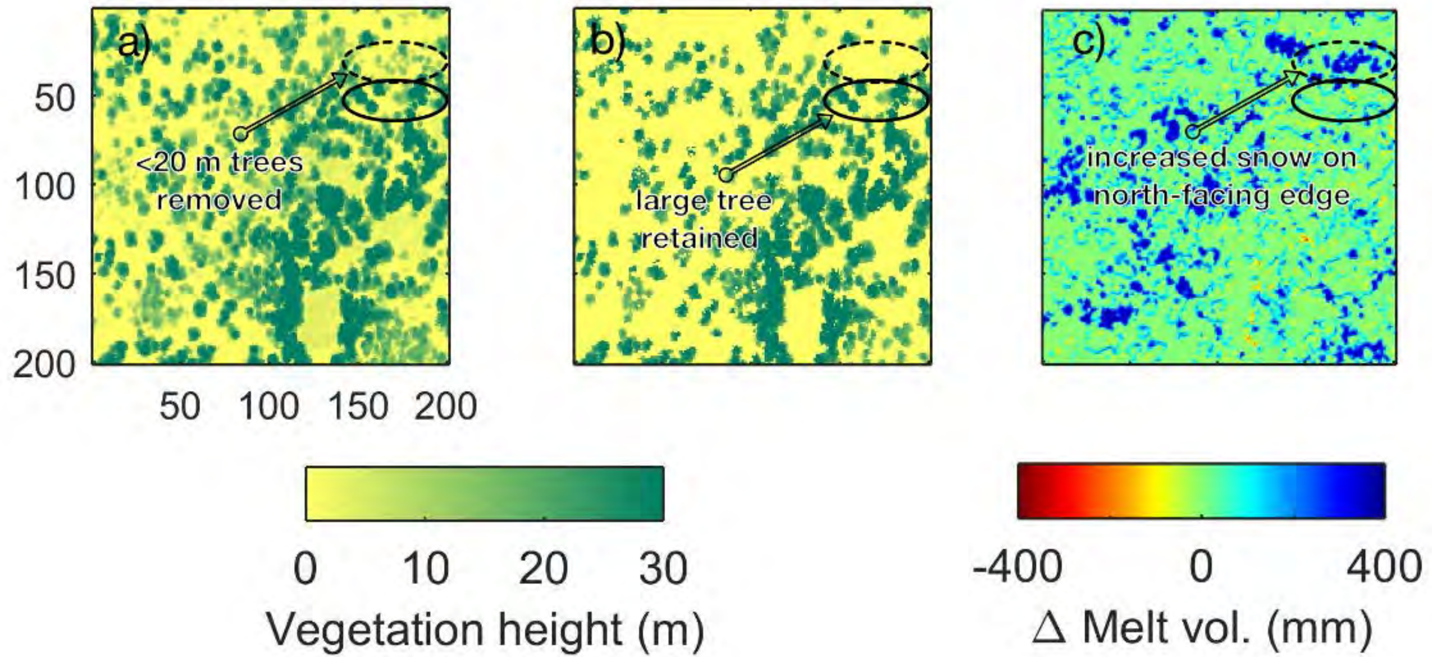
- Land surface temperature is an indication of snowpack energetics (and directly correlated to longwave radiation losses)
- Model impressively gets the timing of colder and isothermal snowpack periods



Harpold et al., Ecohydrology, 2020

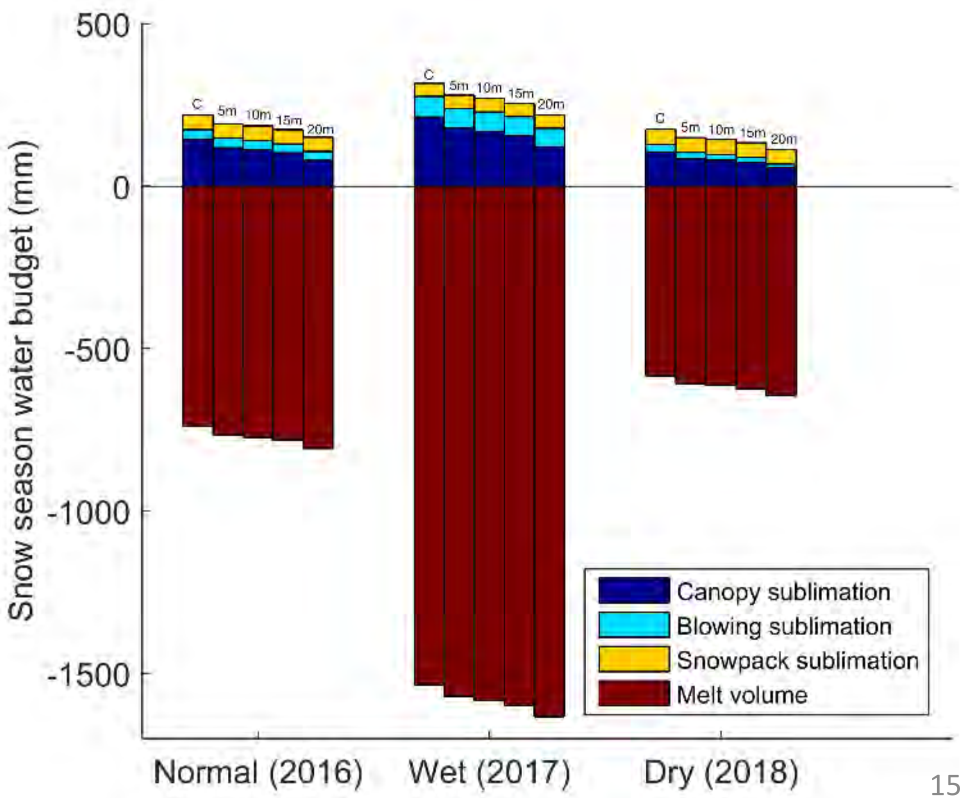
Virtual thinning experiment

- Removing the canopy leads to canopy gaps that accumulate snow in cold ‘snow pockets’
  - Depends on how much trees are removed and their orientation with remaining trees



Water budget partitioning

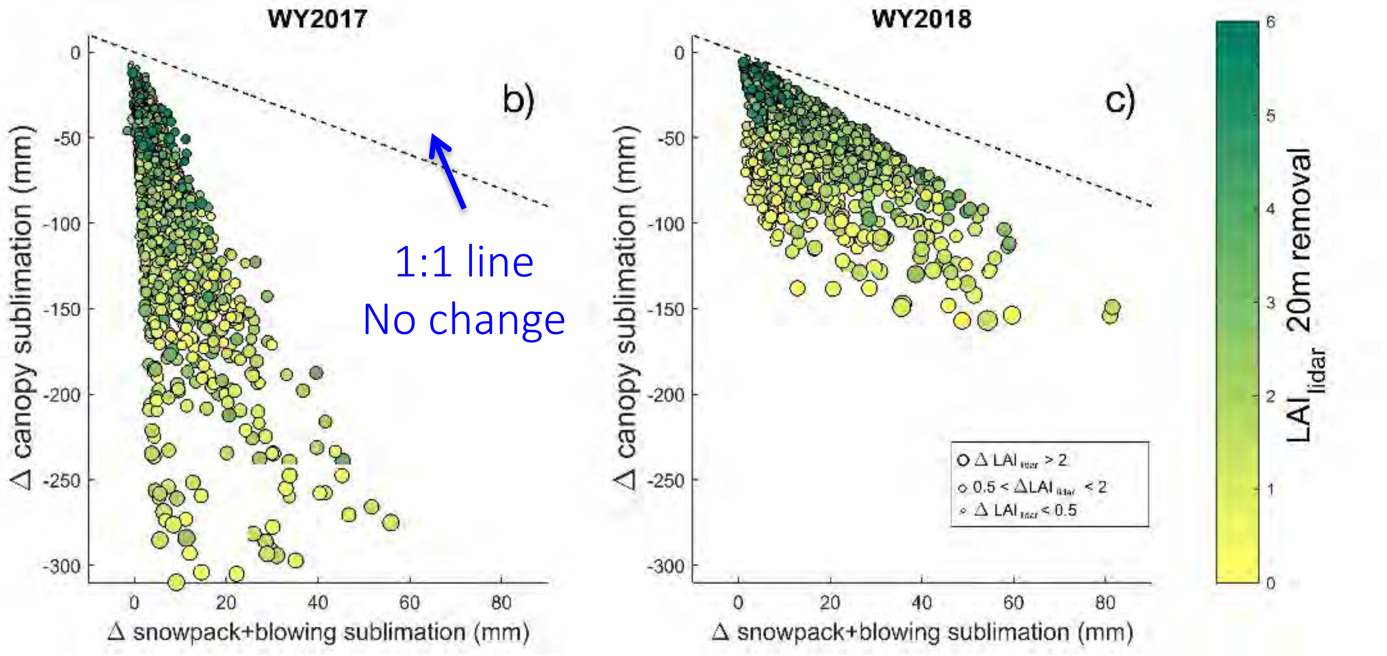
- Increased melt volume mostly due to decrease in canopy sublimation (interception) following tree removal
- About 1/4 to 1/6 of the winter precipitation becomes winter vapor loss
  - Dominated by canopy interception



Harpold et al., Ecohydrology, 2020

Virtual thinning experiment: water budget

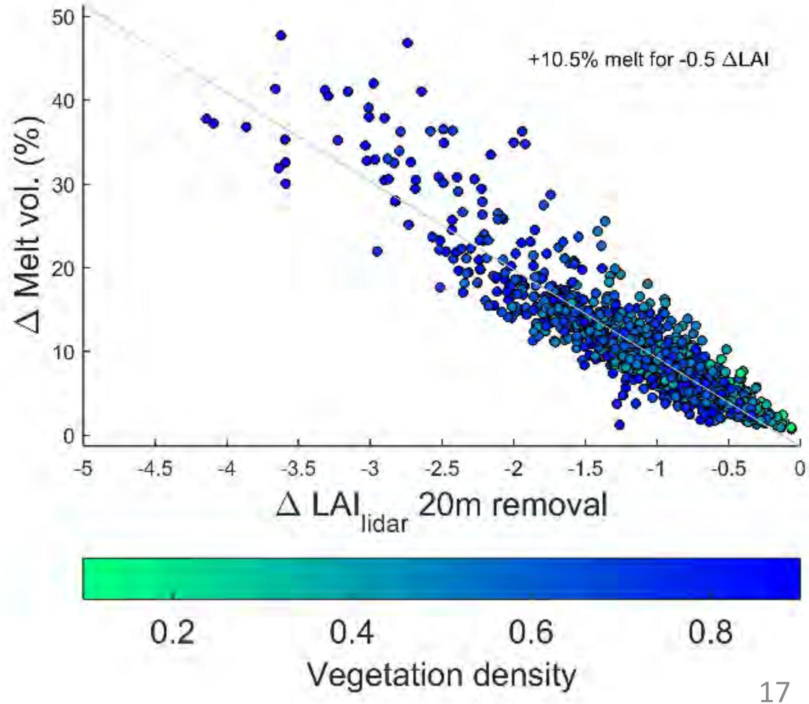
- Reductions in canopy sublimation were always larger than compensating increases in snowpack sublimation plus blowing snow sublimation
  - Bigger net differences in wet years



Harpold et al., Ecohydrology, 2020

Virtual thinning experiment: effects of forest removal 30-m stand snowpack

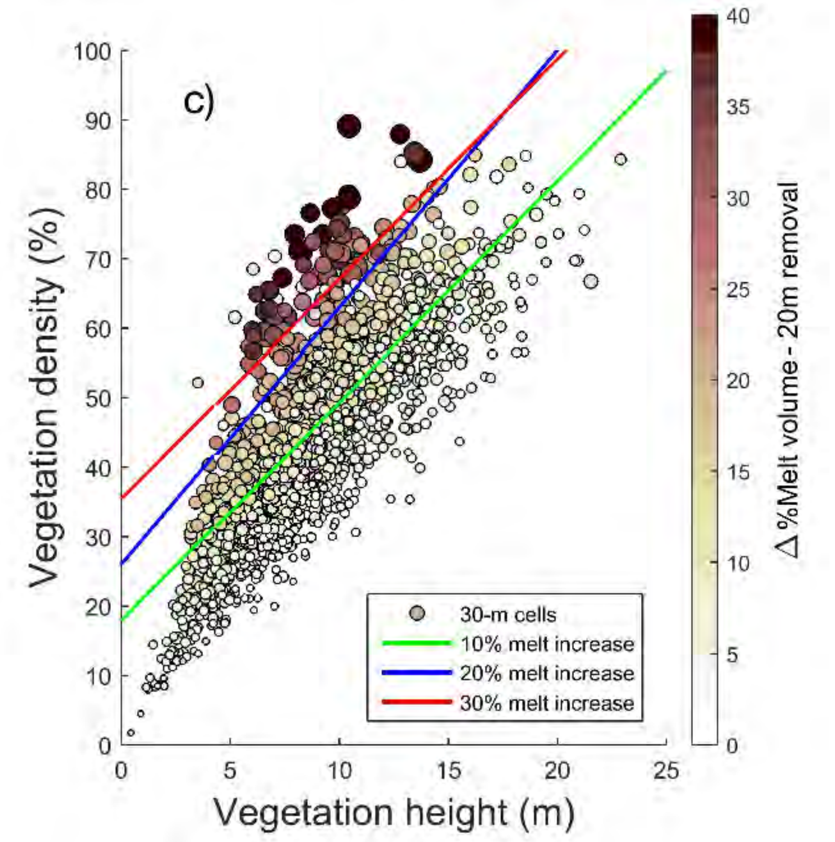
- Reducing LAI by 2 (averages of 3-5 in most places) increases melt volume ~20%
  - What explains more and less sensitive 30-m stands?



Harpold et al., Ecohydrology, 2020

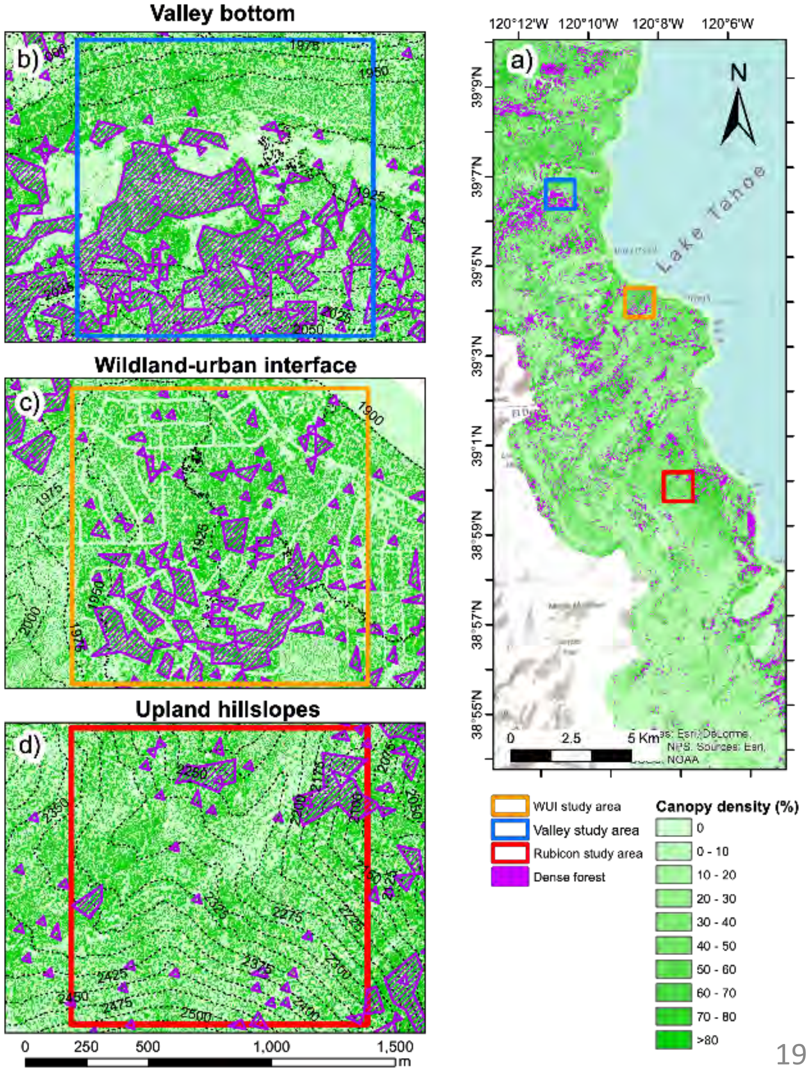
Virtual thinning experiment: stand-scale effects

- Simplifying into vegetation height and density show patterns
  - Moderately tall forest stands that are extra dense have the greatest sensitivity to snow removal
- How we does this represent West Shore forests?



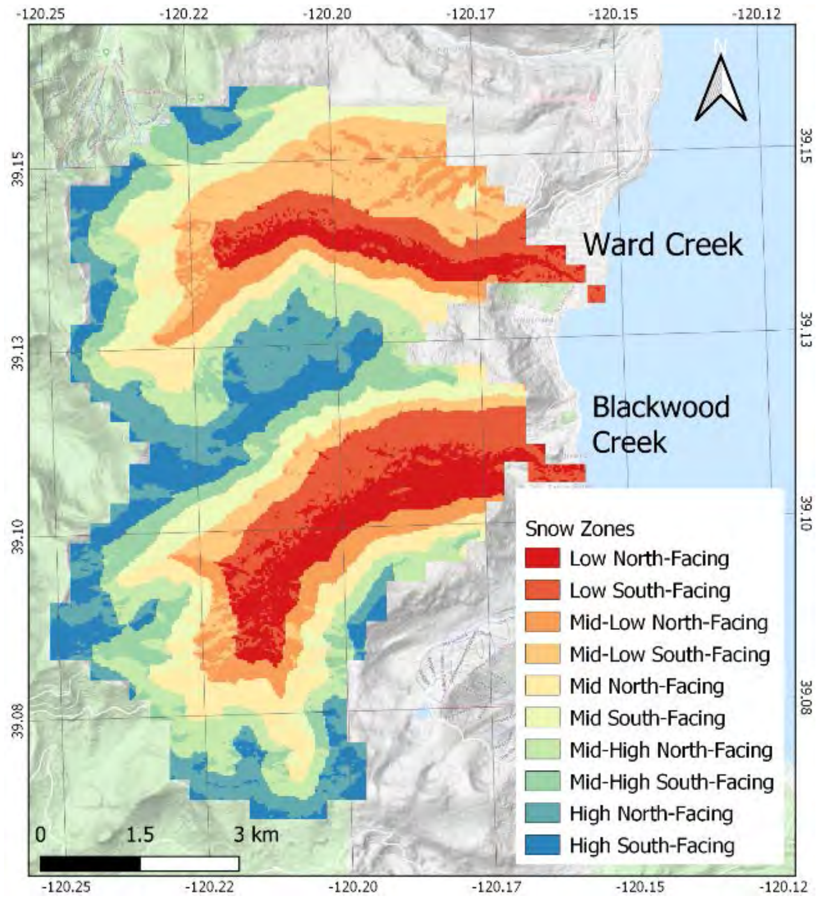
Where are the ‘dense’ forests?

- ‘Dense’ forests exist in three characteristic areas:
  - Valley bottoms and north-facing slopes
  - Wildland-urban interface
  - Upland forest locations
- Can we better characterize the value of thinning



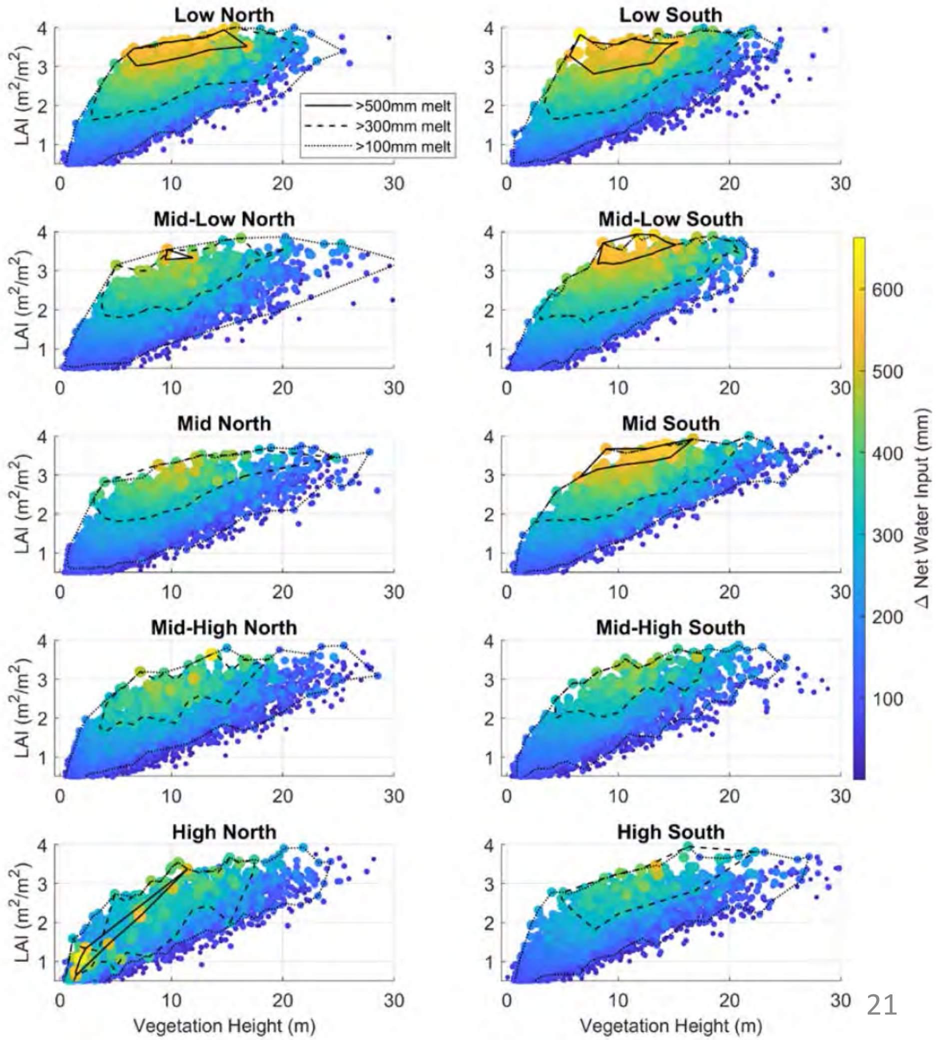
Larger modeling domain for decision support tools

- Results from two watershed domain
  - Divide into unique snow zones based on elevation and aspect
- Research questions
  1. Which tree removal scenario provides the largest increases in snow accumulation and melt volumes?
  2. What are the characteristics of forest stands that yield the greatest water benefits from thinning and what is their topographic distribution?
  3. What are the physical mechanisms that explain this variation in snow water benefits from thinning and how do they vary over topography?
  4. Can we develop a decision support tool that synthesizes high resolution modeling to more provide information about best thinning practices within and outside of the study area?



Response to forest thinning across snow zones

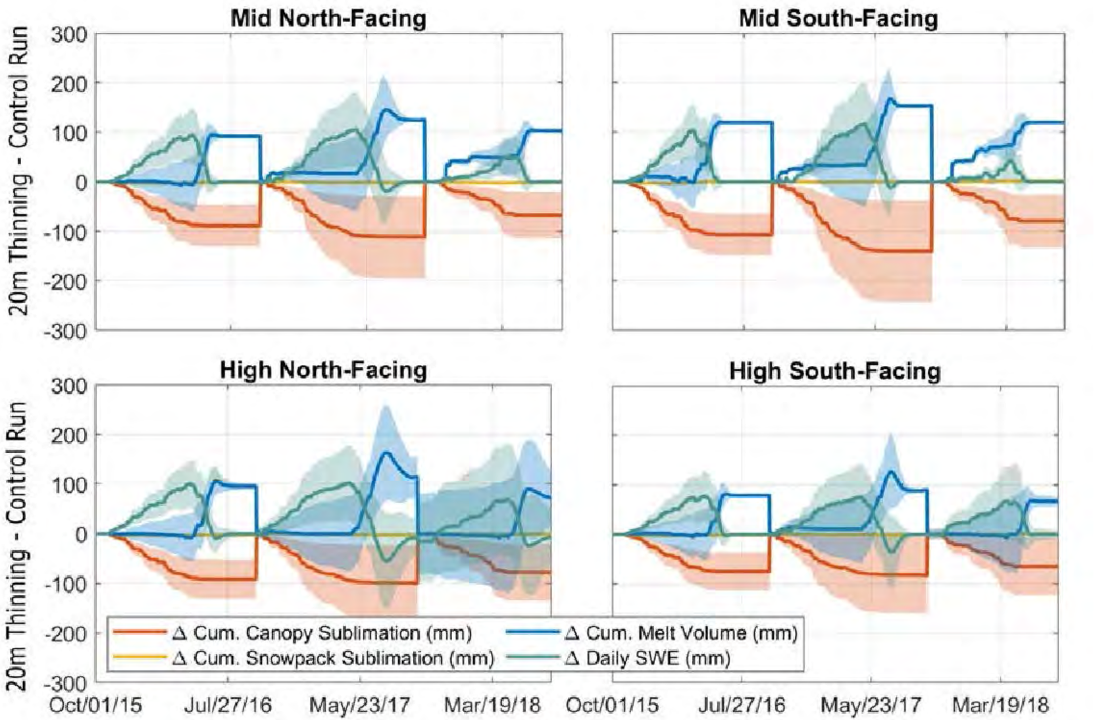
- Large percent changes at lower elevations
- Greater changes in south-facing snow zones



Krogh et al., Frontiers, 2020

Temporal changes in water budgets

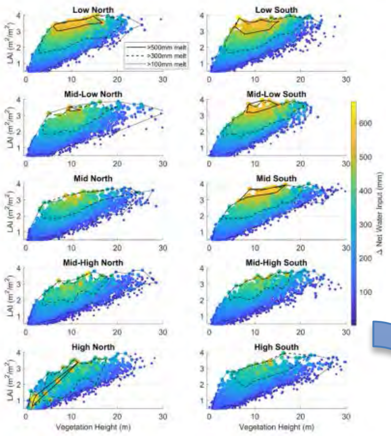
- Changes in water inputs are primarily confined to spring, especially in high elevation and north-facing areas
- Increased melt volume comes at expense of less canopy sublimation in the winter

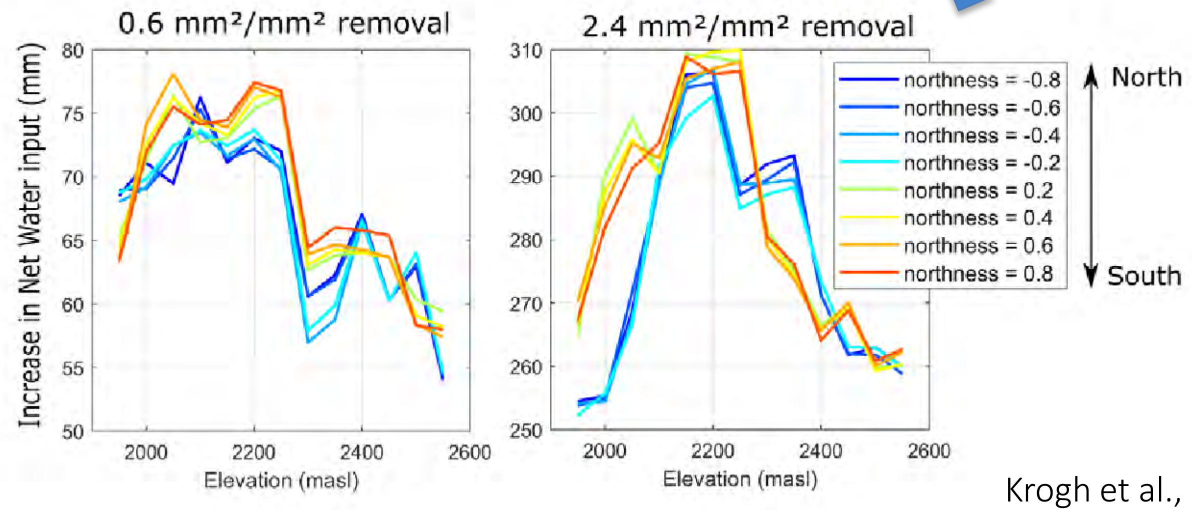


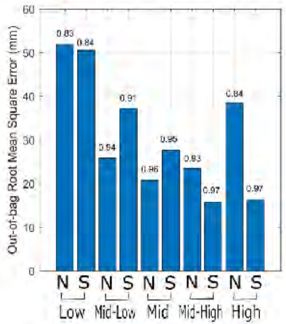
Krogh et al., Frontiers, 2020

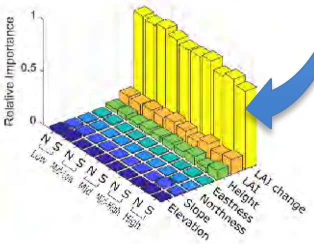
Developing a decision support tool

- Decision support tool is used to synthesize the results
  - Largest increases in low to mid elevation (especially at higher tree removal)
  - Largest increases in south-facing areas (especially at low to mid elevations)





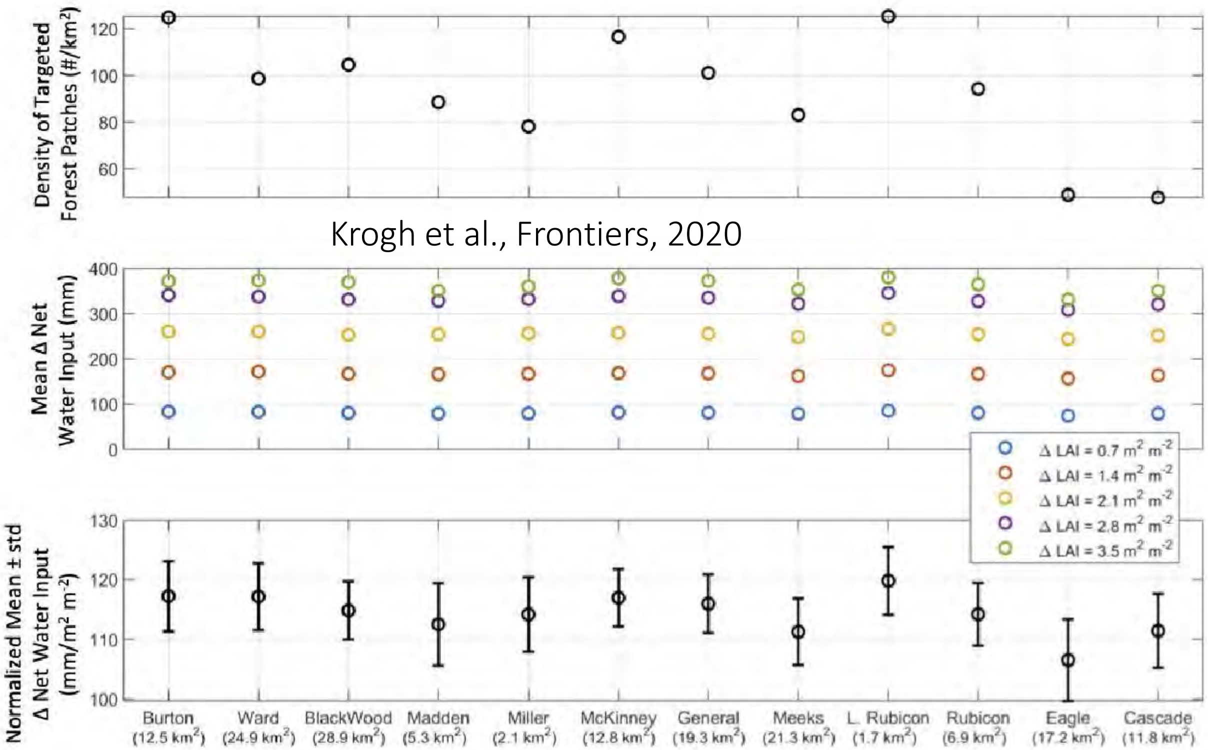




Krogh et al., Frontiers, 2020

Results from decision support tool

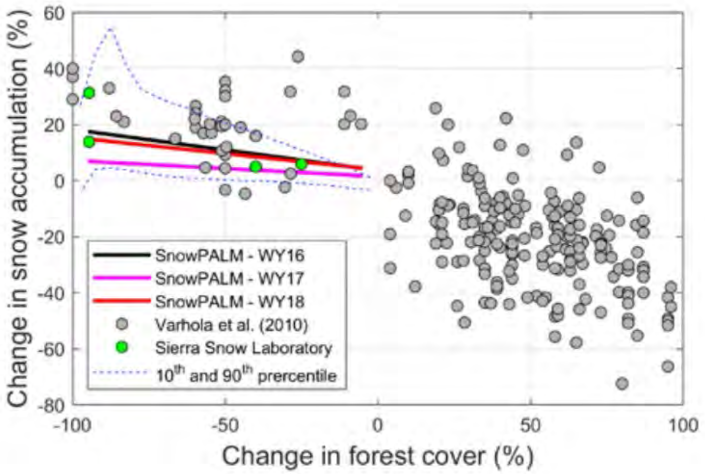
- Some watersheds have more dense forest patches than others
  - Eagle watershed has half that of Blackwood
- Differences in net water inputs are moderate (~10%) across watersheds

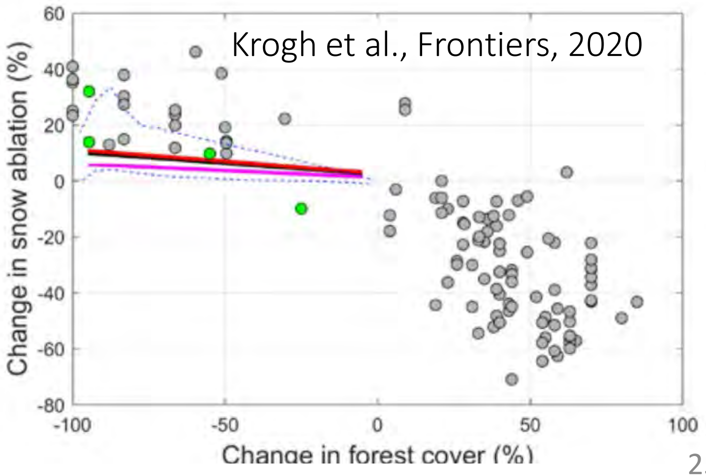


Krogh et al., Frontiers, 2020

The value of high-resolution modeling results

- Importance of variability in space (blue dotted line) and time (solid lines) show the limitations of observations
- This work helps to build the science around snow vegetation interactions and forest disturbance





Krogh et al., Frontiers, 2020

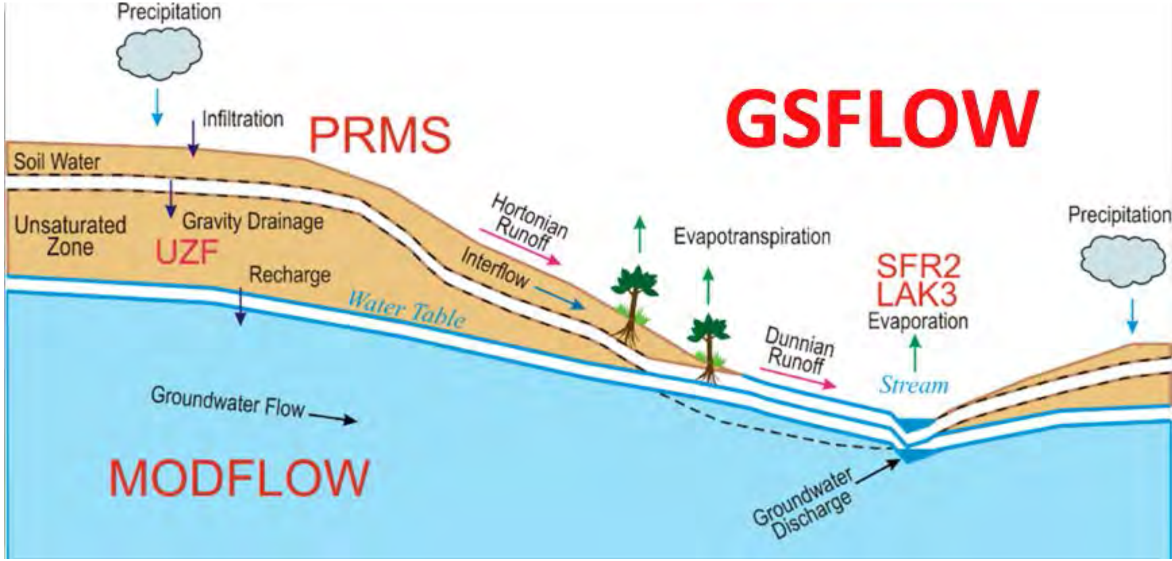
Where does that extra snow water go?

Potential mechanisms following forest removal

- Increased/compensating transpiration by remaining vegetation
- Increased transpiration in downslope areas receiving water subsidy

Very challenging to model:

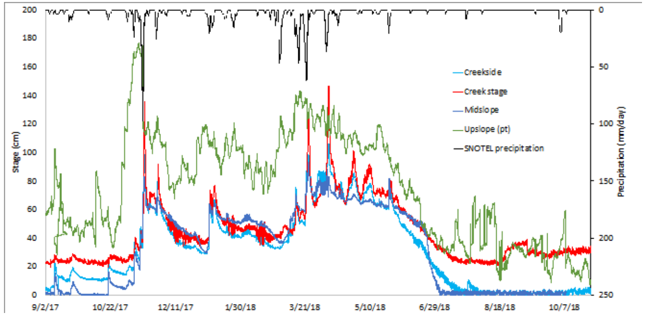
- Subsurface properties, e.g. water retention and tree rooting depth, etc.
- Ecophysiology, e.g. stomatal conductance, water use efficiency, etc.

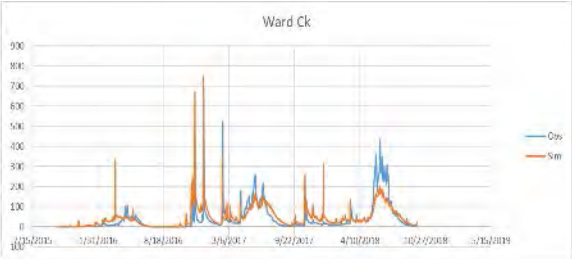


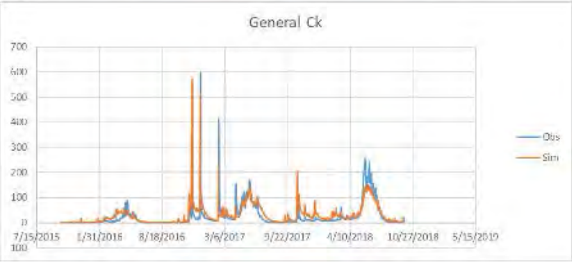
McGurk, 2015

Monitoring and modeling results

- Initial testing shows the model reasonably matches historical flows (previous calibration work at DRI) and snowpack was comparable with SnowPALM
- Shallow piezometers have been measuring groundwater levels since 2017
  - Sharing and collaborating with Paiute tribe







Continuing work

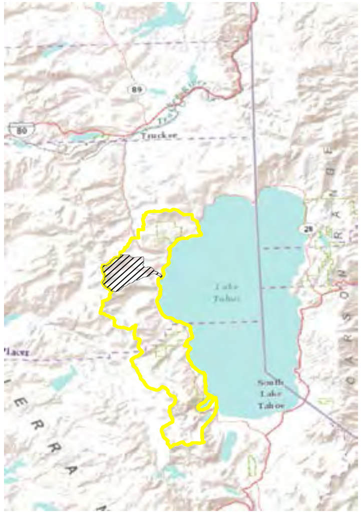
Limitations of current modeling approaches

- Do not look at climate change impacts
- Do not effectively consider compensating processes
- Do not consider tree growth or disturbance

Next research directions

- Cross-site SnowPALM modeling
  - Adding east shore, Sagehen, and French Meadows
  - TCSI scale decision support tools
- RHESSys modeling in Sagehen and Ward Creek watersheds
  - Better job considering compensating processes tree growth and disturbance
  - Naomi Tague, UCSB
- Sagehen is a Critical Zone Observatory
  - NSF project focused at
- Streamflow monitoring
  - GIANT potential for pre & post-restoration monitoring

e-Truckee Basin



Take homes for snow-forest management

- Importance of tree-scale snow processes
  - Research-grade model used to predict snow response using lidar
- Decision support tool synthesizes results to Tahoe West Scale
  - More thinning benefits from more tree removal
  - More water when low to mid-elevation forests are thinned
  - More benefits on south-facing slopes
- Next steps remain at the applied-basic research interface
  - How do compensating vegetation processes limit increases in downstream groundwater
  - Where do trees and streams get there water? Answer: We need to better characterize water storage in the critical zone.

Questions?




References

- Cooper, A.E., Kirchner, J.W., Wolf, S., Lombardozzi, D.L., Sullivan, B., Tyler, S.W. and A.A. Harpold . Snowmelt-driven differences in tree water use and limitations in the Sierra Nevada, USA. <accepted in *Agricultural and Forest Meteorology*>
- Harpold, A.A., Krogh, S., Kohler, M., Eckberg, D., Greenberg, J., Sterle, G., and Broxton, P.D. Increasing the Efficacy of Forest Thinning for Snow Using High-Resolution Modeling: A Proof of Concept in the Lake Tahoe Basin, California, USA. *Ecohydrology*. https://doi.org/10.1002/eco.2203
- Krogh, S., Broxton, P., Manley, P., and Harpold, A.A. Using Process Based Snow Modelling and Lidar to Predict the Effects of Forest Thinning on the Northern Sierra Nevada Snowpack. *Frontiers in Forests and Global Change*. 20. https://doi.org/10.3389/ffgc.2020.00021
- Safa, H., Krogh, S., Greenberg, J., and Harpold, A. Unraveling the Controls on Snow Disappearance in Montane Forests Using a Muli-Site Analysis of Lidar Observations <in review at *Water Resources Research*>
- Broxton, P.D., Moeser, C.D., and Harpold, A. Accounting for fine-scale canopy structure is necessary to model snowpack mass and energy budgets in montane forests. <near submission to *Water Resources Research*>

Modeling Sediment and Phosphorus Yield in the Lake Tahoe Basin with the Water Erosion Prediction Project (WEPP) Model

Mariana Dobre[1], Erin S. Brooks[1], Roger Lew[2], Chinmay Deval[1], Anurag Srivastava[1], William J. Elliot[1], Jonathan Long[3]

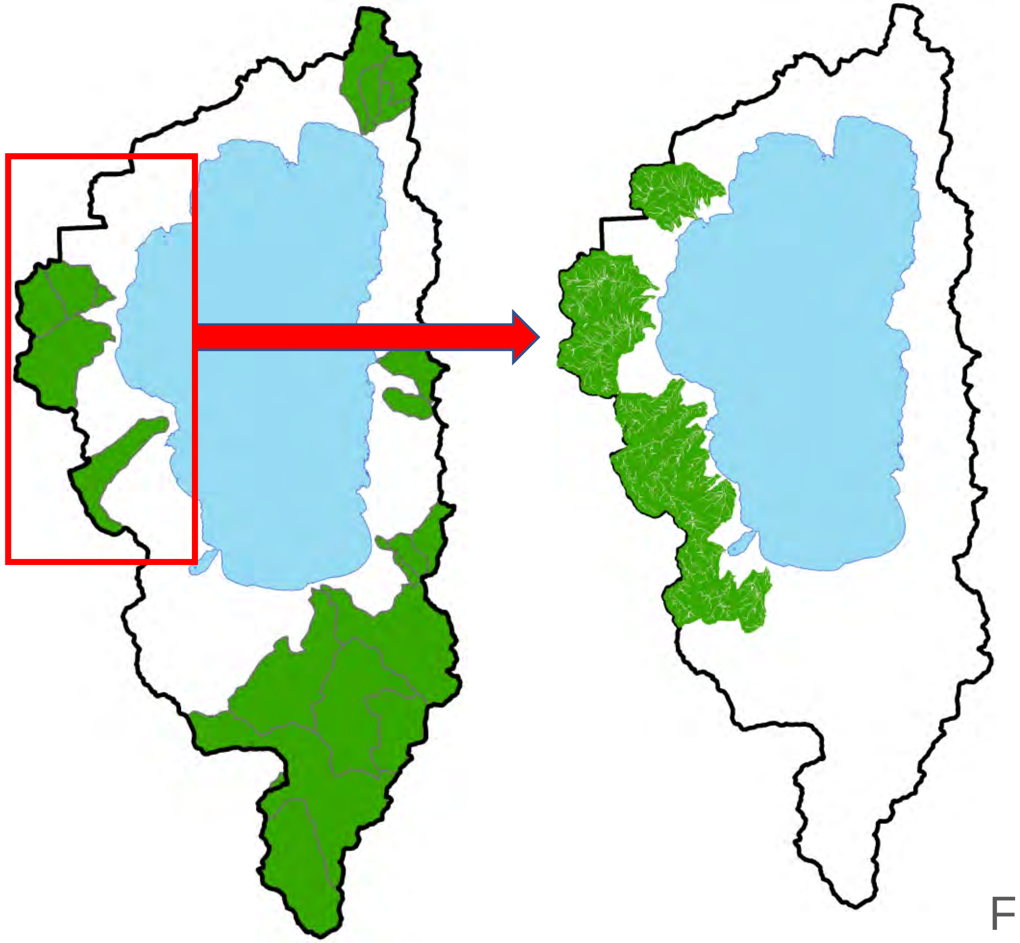
[1] *University of Idaho, Department of Soil and Water Systems*

[2] *University of Idaho, Virtual Technology and Design Lab*

[3] *USDA Forest Service*

WEPP model calibration

Calibrated model at 5 watersheds and applied calibrating parameters to other 15 watersheds in LTW



→ For model to be transferable we need minimal calibration

→ Input data

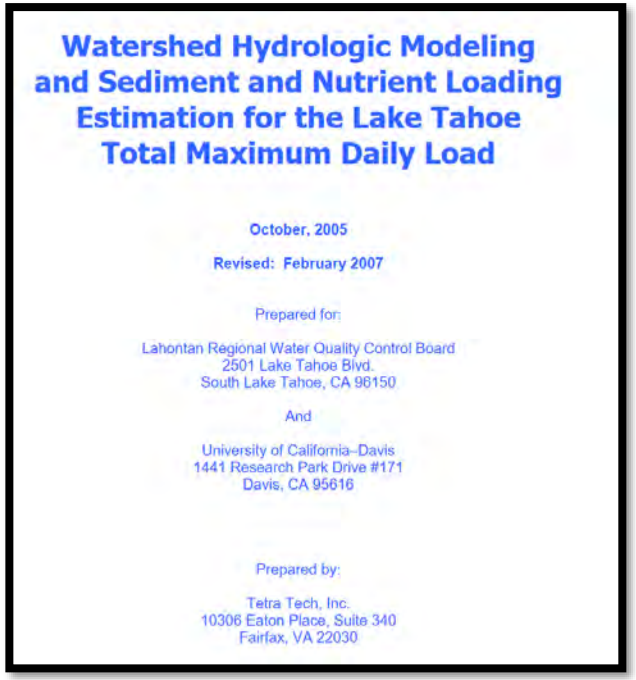
- DEM: 30-m
- Landcover: 2011 NLCD
- Soils: SSURGO
- Climate: DAYMET (1990-2016)

→ Streamflow and Water Quality data

USGS Name
BLACKWOOD C NR TAHOE CITY CA
GENERAL C NR MEEKS BAY CA
WARD C BL CONFLUENCE NR TAHOE CITY CA
WARD C A STANFORD ROCK TRAIL XING NR TAHOE CITY CA
WARD C AT HWY 89 NR TAHOE PINES CA

Flow-weighted load calculations LOADEST and Coats (1990-2014)

Comparison of Sediment and Total Phosphorus between WEPP-predicted and TMDL


Watershed Hydrologic Modeling and Sediment and Nutrient Loading Estimation for the Lake Tahoe Total Maximum Daily Load

October, 2005

Revised: February 2007

Prepared for:

Lahontan Regional Water Quality Control Board
2501 Lake Tahoe Blvd.
South Lake Tahoe, CA 96150

And

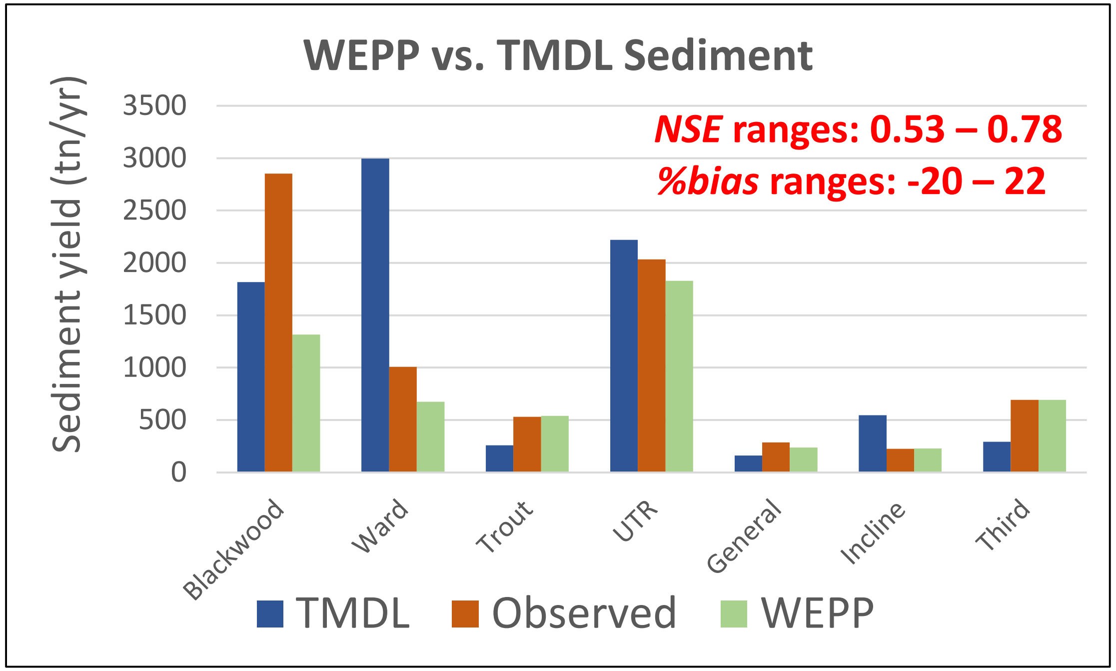
University of California–Davis
1441 Research Park Drive #171
Davis, CA 95616

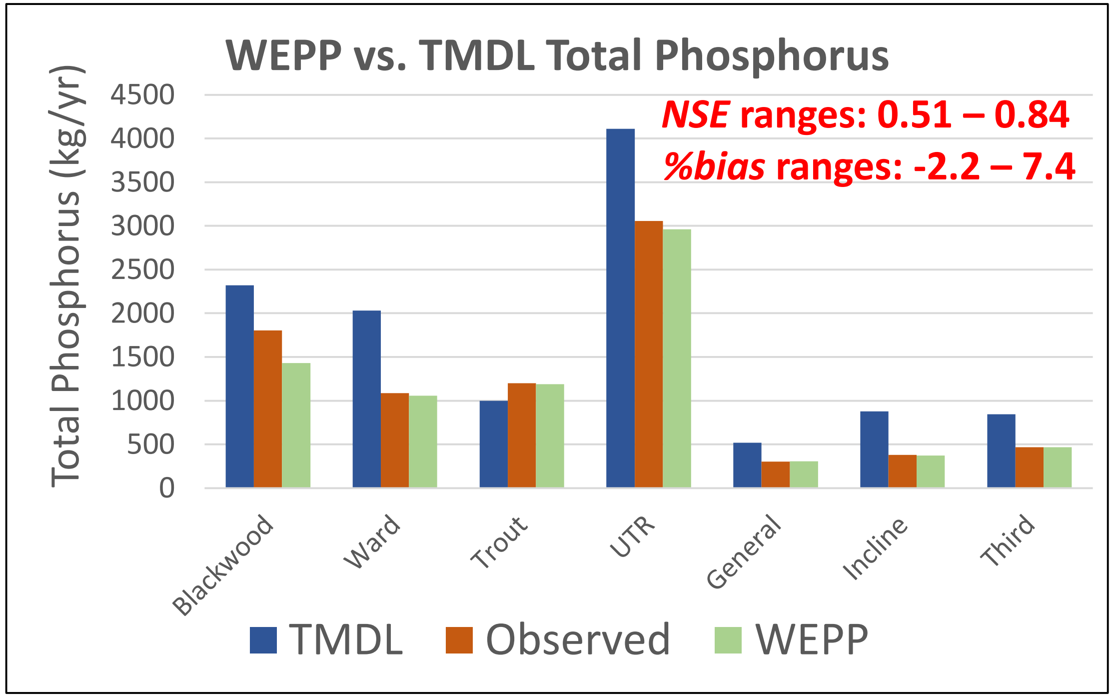
Prepared by:

Tetra Tech, Inc.
10306 Eaton Place, Suite 340
Fairfax, VA 22030

Model is able to reasonably capture Streamflow, Sediments, and Phosphorus with minimal calibration

Observed and WEPP predictions are for years 1990-2014.





Disturbance Conditions

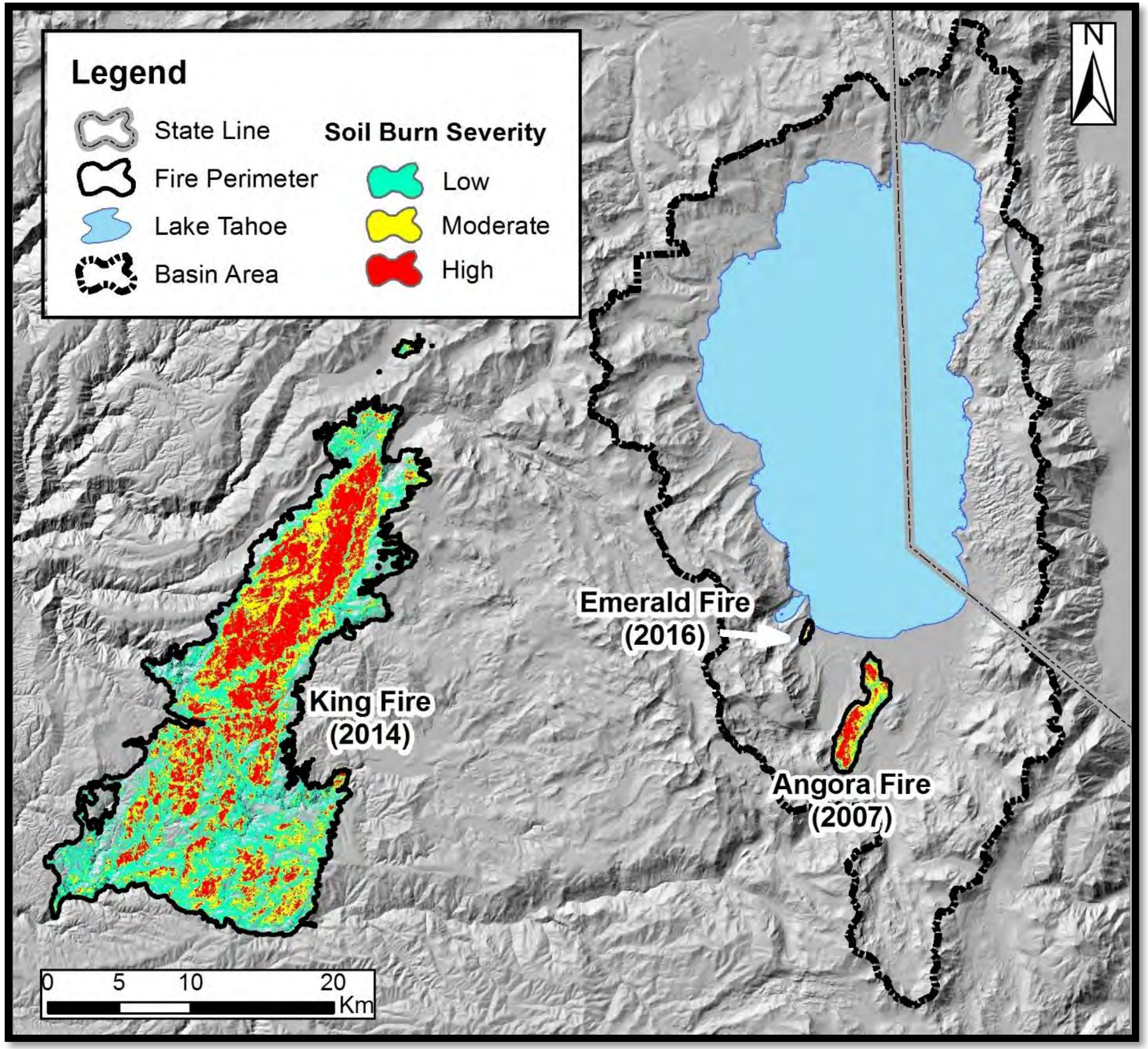
Eleven Disturbance conditions:

- *Current Condition*
- *3 Burn Severities*
- *3 Thinning intensities*
- *Prescribed Fire*
- *Current Conditions Wildfire*
- *LANDIS Wildfire for current and future climates*

Post-disturbance ground cover is the most critical WEPP management factor influencing soil erosion!

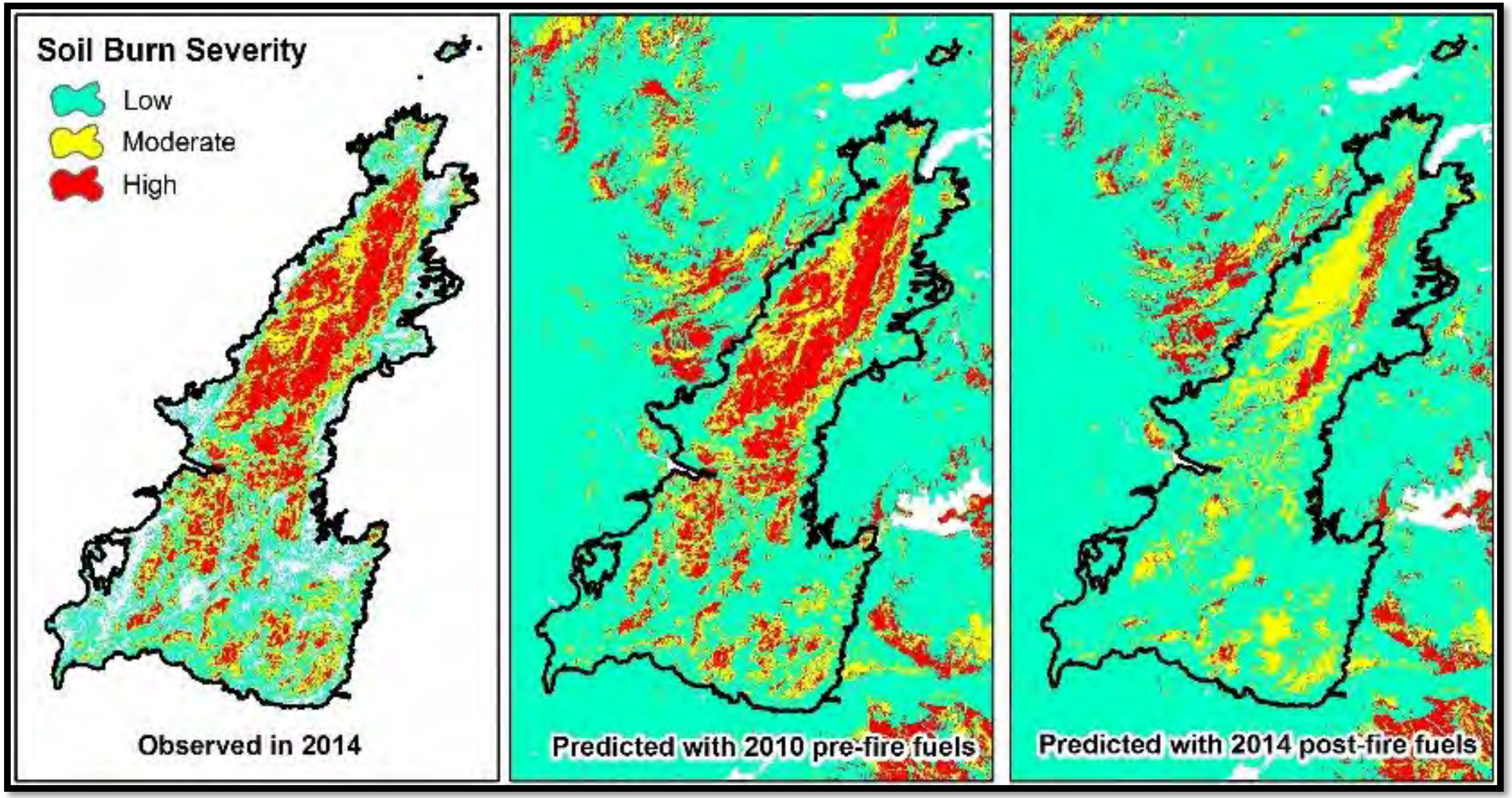
- *Three dominant soil types (Granitic, Volcanic & Alluvial)*
- *14 Vegetation files incorporating both forest and shrubland plant communities*

Soil Burn Severity prediction



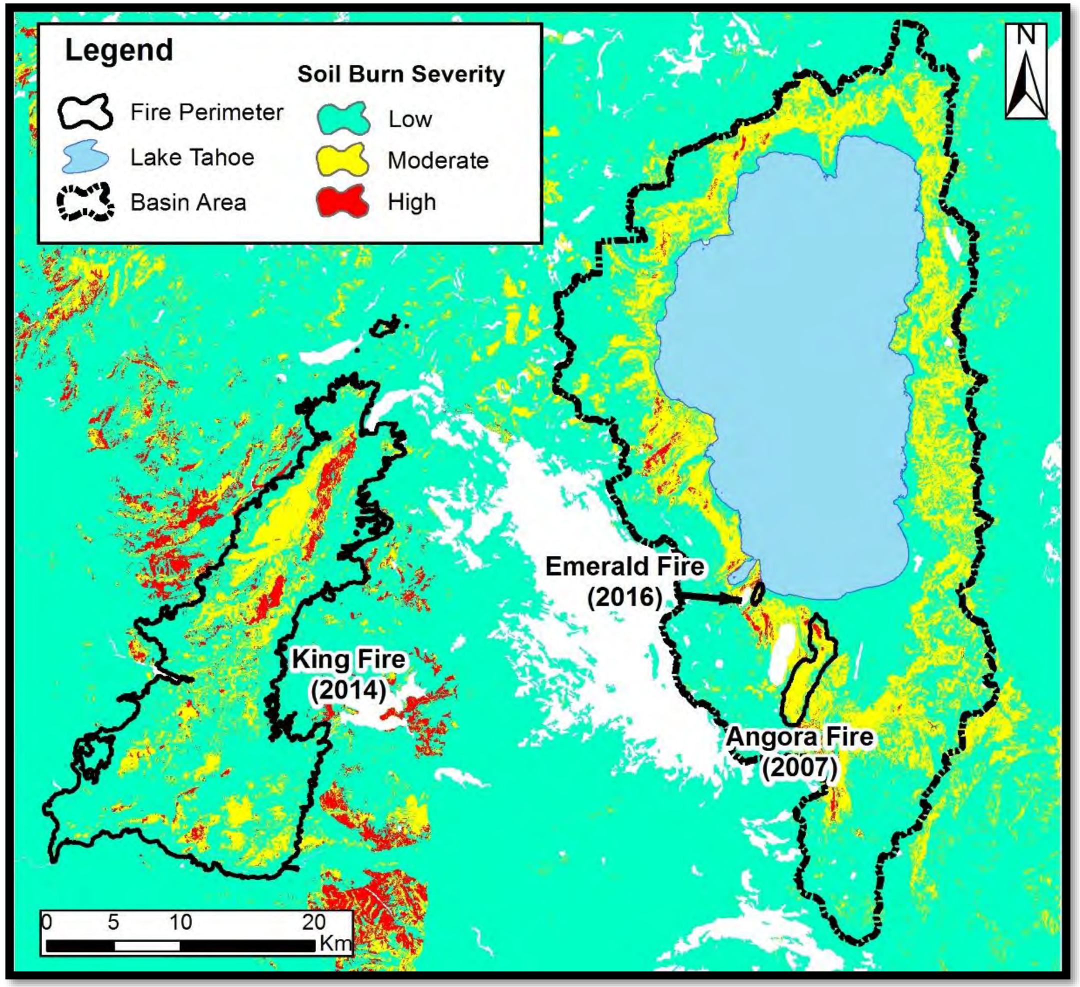
- Random Decision Forest approach
- Use SBS map pixels that burned at Low, Moderate, and High severity as observed data points.
- Develop a relationship between Soil Burn Severity and key climatic, topographic, soil, and vegetation variables.
- Use the generated SBS-equivalent map as input for the WEPPcloud interface.

Soil Burn Severity Validation on King Fire

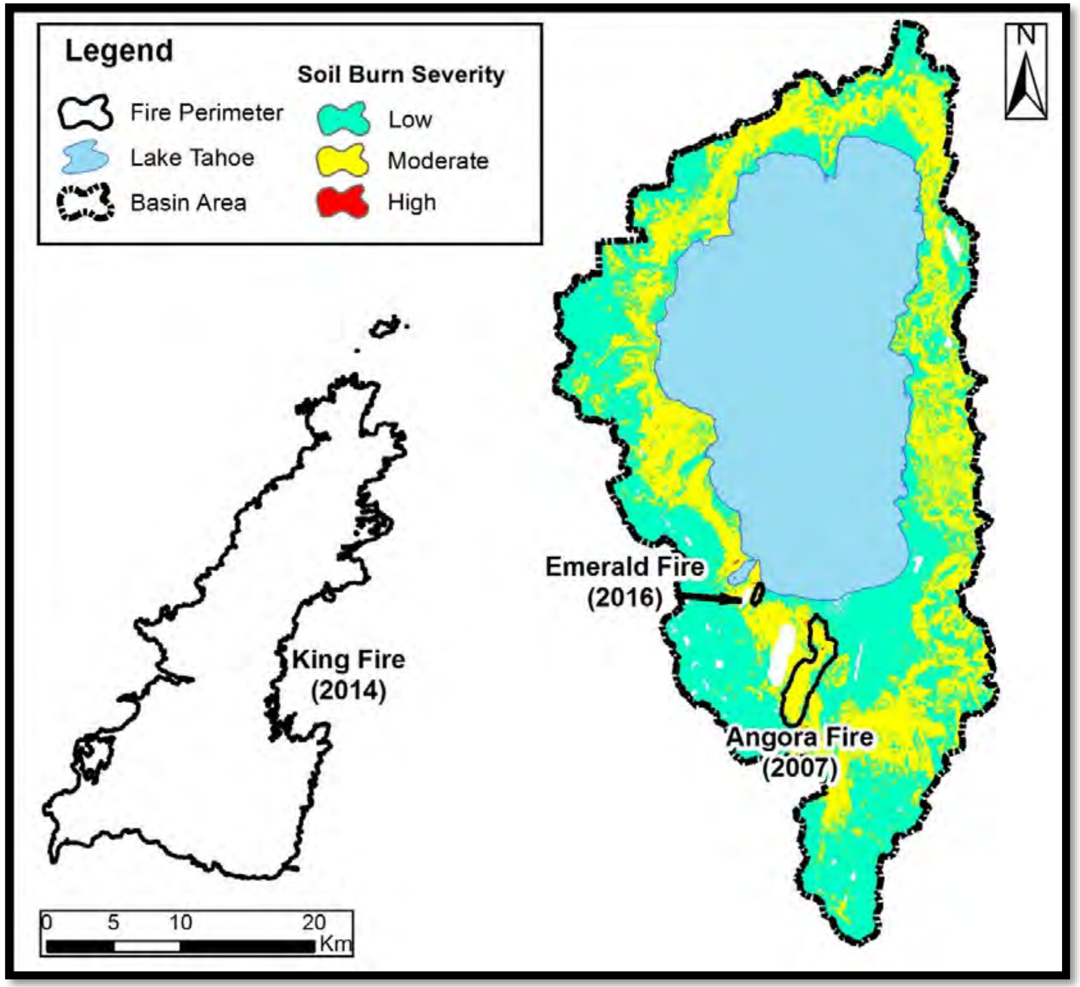


Soil Burn Severity Results

SBS current conditions
with FCCS fuels



SBS future conditions
with LANDIS fuels



WEPPcloud online interface

https://wepp1.nkn.uidaho.edu/weppcloud/

All results are online and downloadable!

Site Specific Resources

Lake Tahoe

The Lake Tahoe Project incorporates region specific soil, phosphorus, and estimated soil burn severity.

View Results and Run WEPP

Summarized All Conditions

Tabled Results by Condition

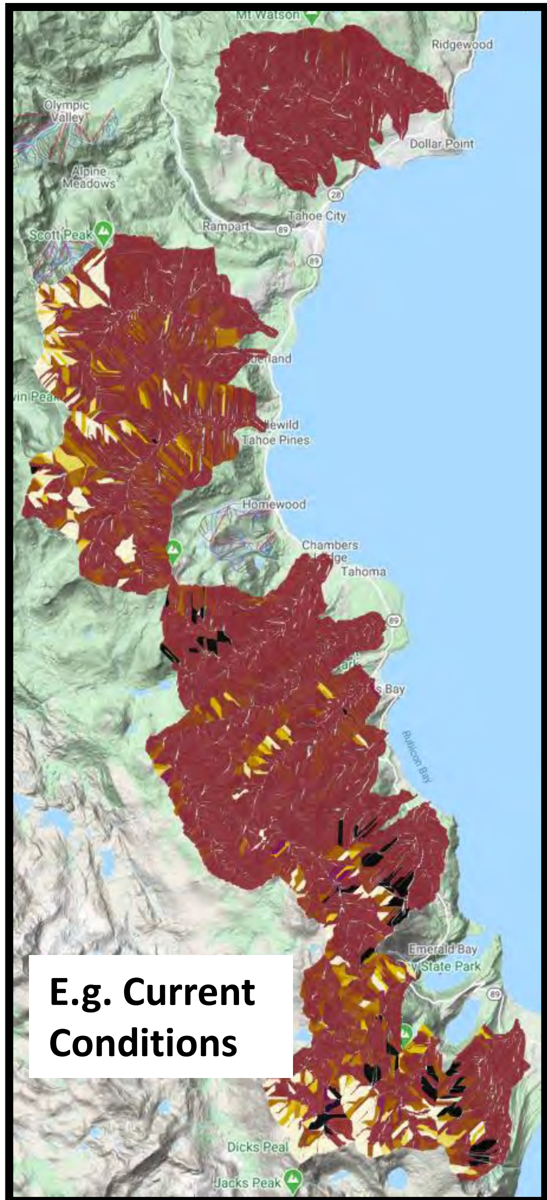
- Aggregated Outlet Summary Results (.csv)
- Aggregated Hillslopes Summary Results (.csv)
- Aggregated Channels Summary Results (.csv)
- Aggregated Sediment Delivery Summary Results (.csv)

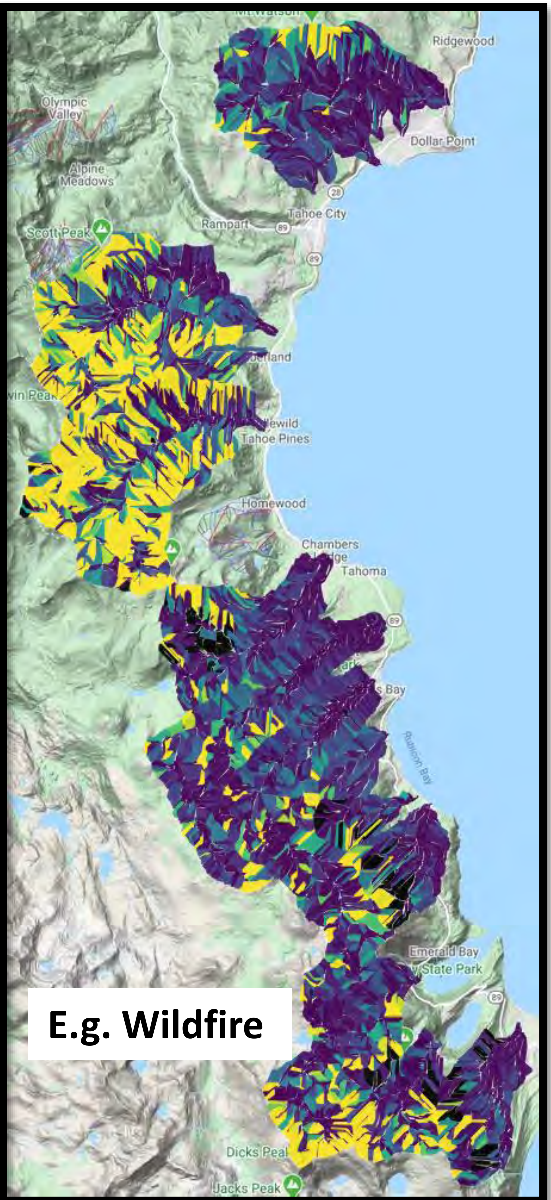
ESRI Shapefiles by Condition

- Aggregated Shapefiles of Results (.zip)

Results as text files

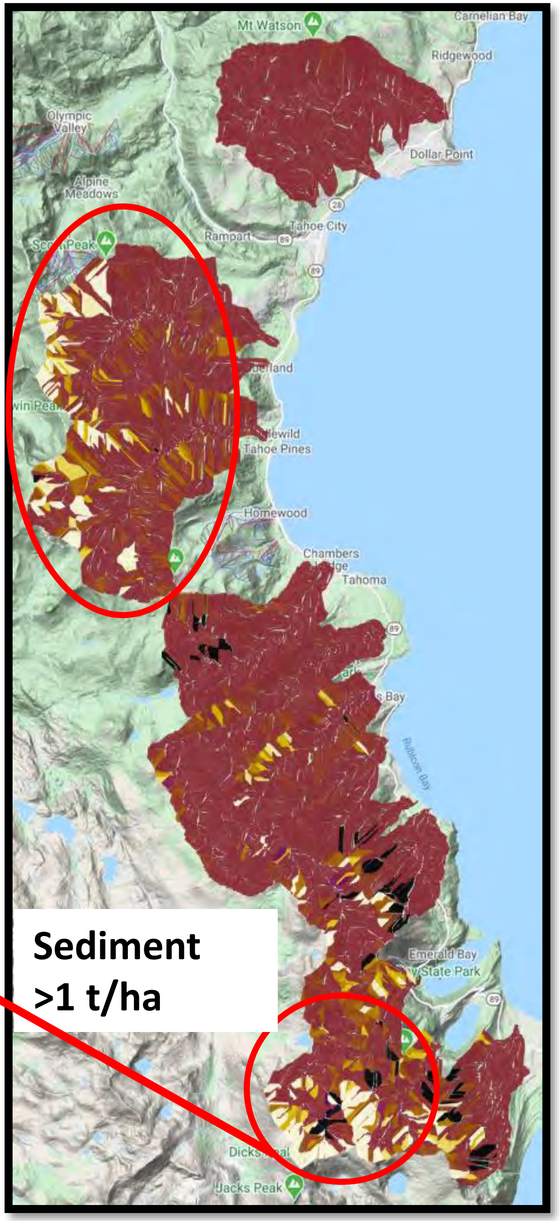
Results as .shp files

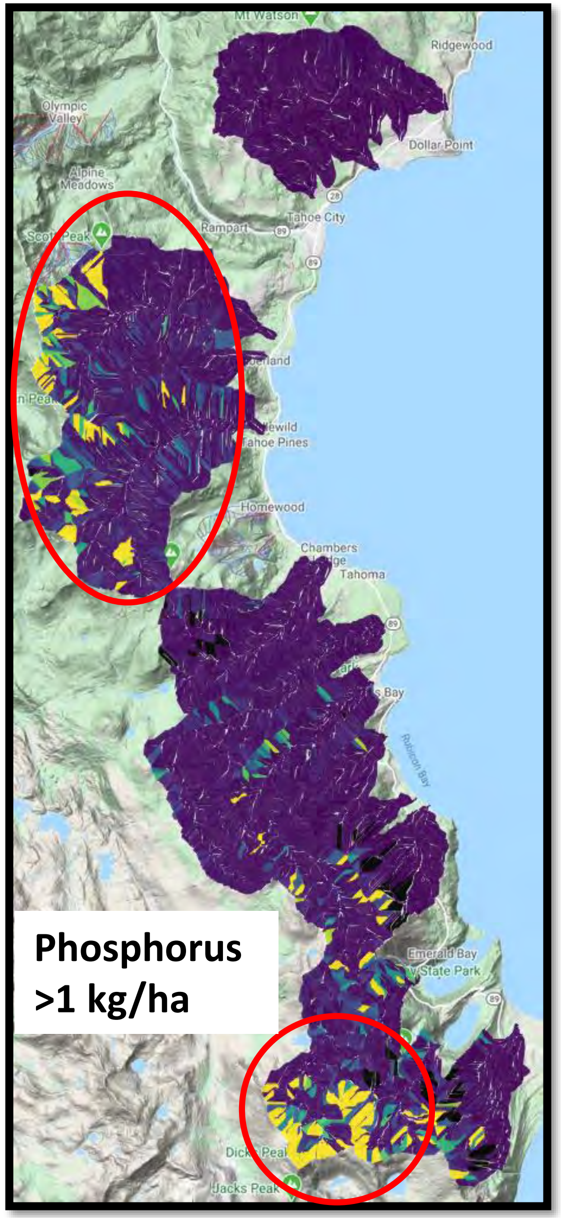




Watersheds Comparison - Current Conditions

Precipitation	900–1400	(mm/yr)
Runoff	200–900	(mm/yr)
Hillslope soil loss	0–2500	(kg/ha/yr)
Sediment yield	10–400	(kg/ha/yr)
Sediment Yield <0.016 mm	3–140	(kg/ha/yr)
Phosphorus yield	0–2	(kg/ha/yr)





Lighter areas generate more erosion and Phosphorus

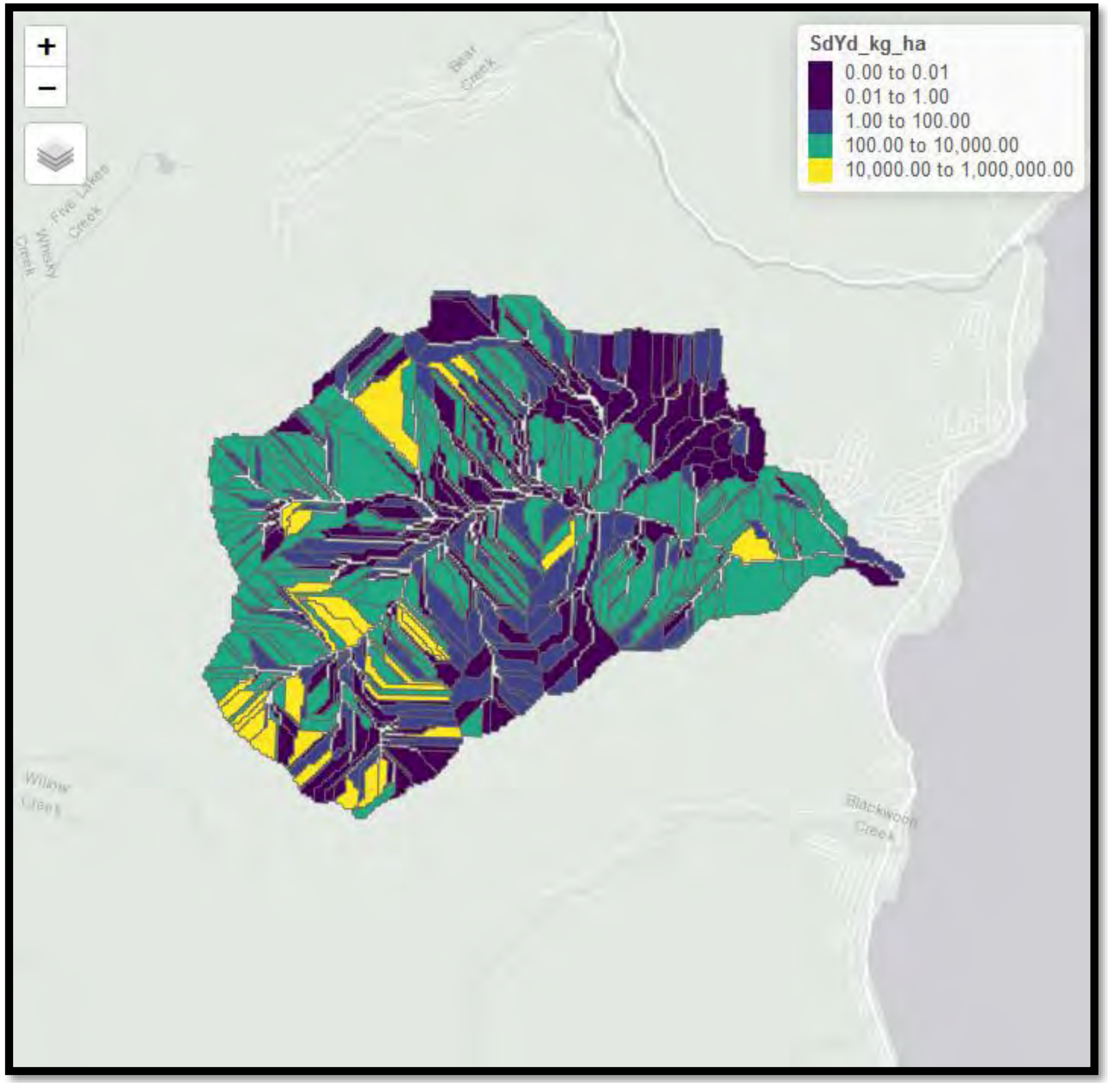
Scenarios Comparison

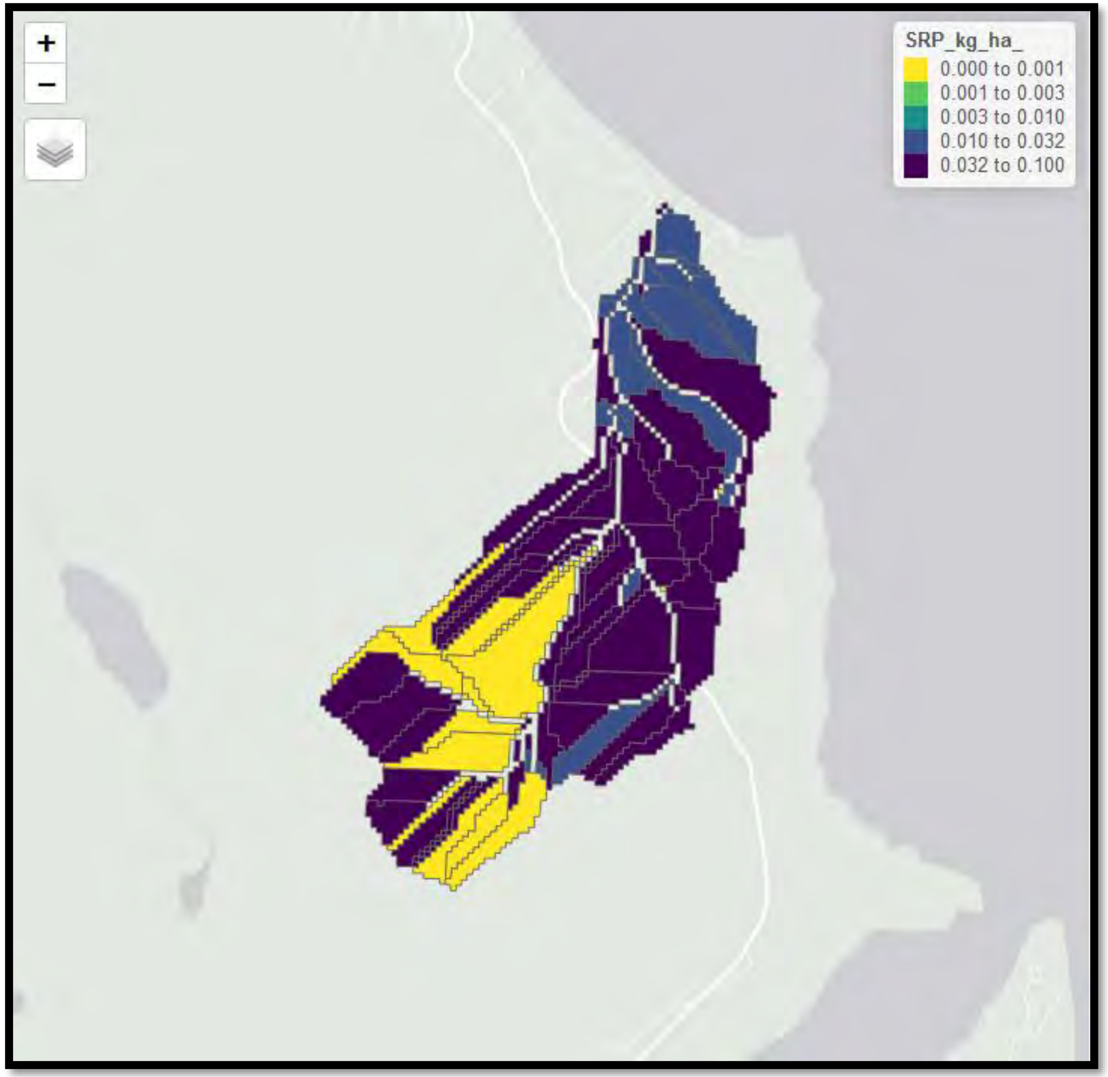
Disturbed Conditions*	Average Sediment Yield (kg/ha)	Average Total P (kg/ha)
Current Conditions	223	0.21
High Severity Fire	18291	14.68
Low Severity Fire	1252	1.04
Moderate Severity Fire	5519	4.46
Prescribed Fire	734	0.62
Simulated Fire FCCS Fuels Obs Clim	1741	1.43
Simulated Fire LANDIS Fuels Obs Clim	1658	1.37
Simulated Fire LANDIS Fuels Future Clim A2	5746	4.65
Thinning 85% Ground Cover	342	0.31
Thinning 93% Ground Cover	303	0.28
Thinning 96% Ground Cover	291	0.27

**Results without Watershed 18*

Results Visualization

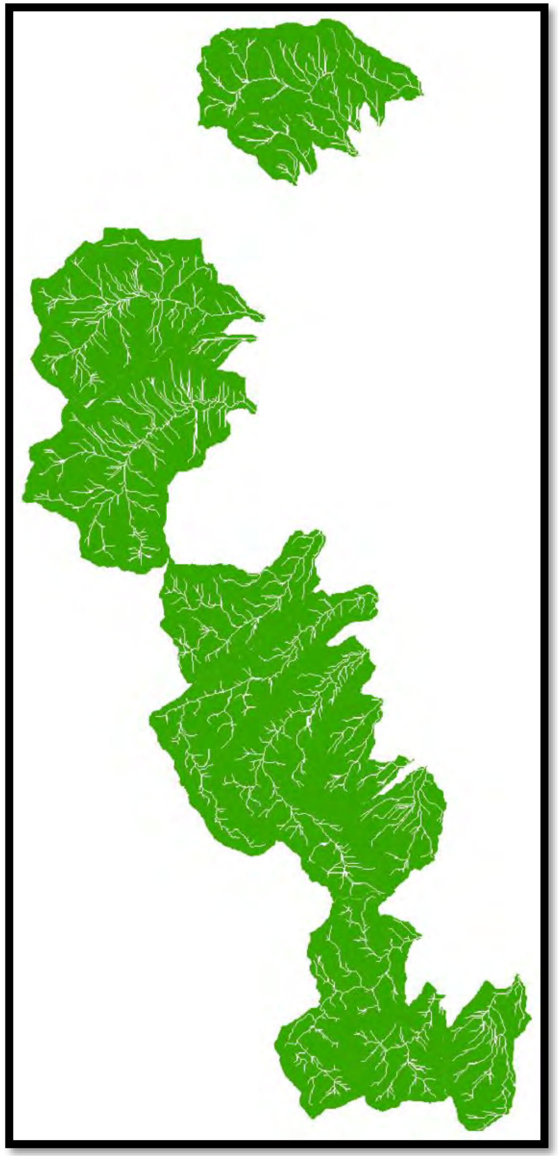
https://cdeval.shinyapps.io/Viz-WEPPCloud/





Results Visualization and Selection

All Hillslopes + Slopes < 30% + Landuse = Forest



Implications for management

- Watersheds Blackwood (#9), Ward (#7), Eagle Creek (#18), and Cascade Creek (#19) are generating most sediment overall.
- Blackwood and Ward include volcanic areas that yield high levels of fine sediments; Eagle and Cascade include steep (granitic) areas dominated by shrubs and rock outcrops.
- Thinning and prescribed fire reduce sediment delivery compared to a simulated wildfire, and thinning is expected to generate less sediment than prescribed fire.
- Future climates will increase erosion.
- Particulate Phosphorus is the predominant form of P delivered from the watersheds.
- Management practices that reduce erosion are more likely to result in a reduced P load.

Questions?

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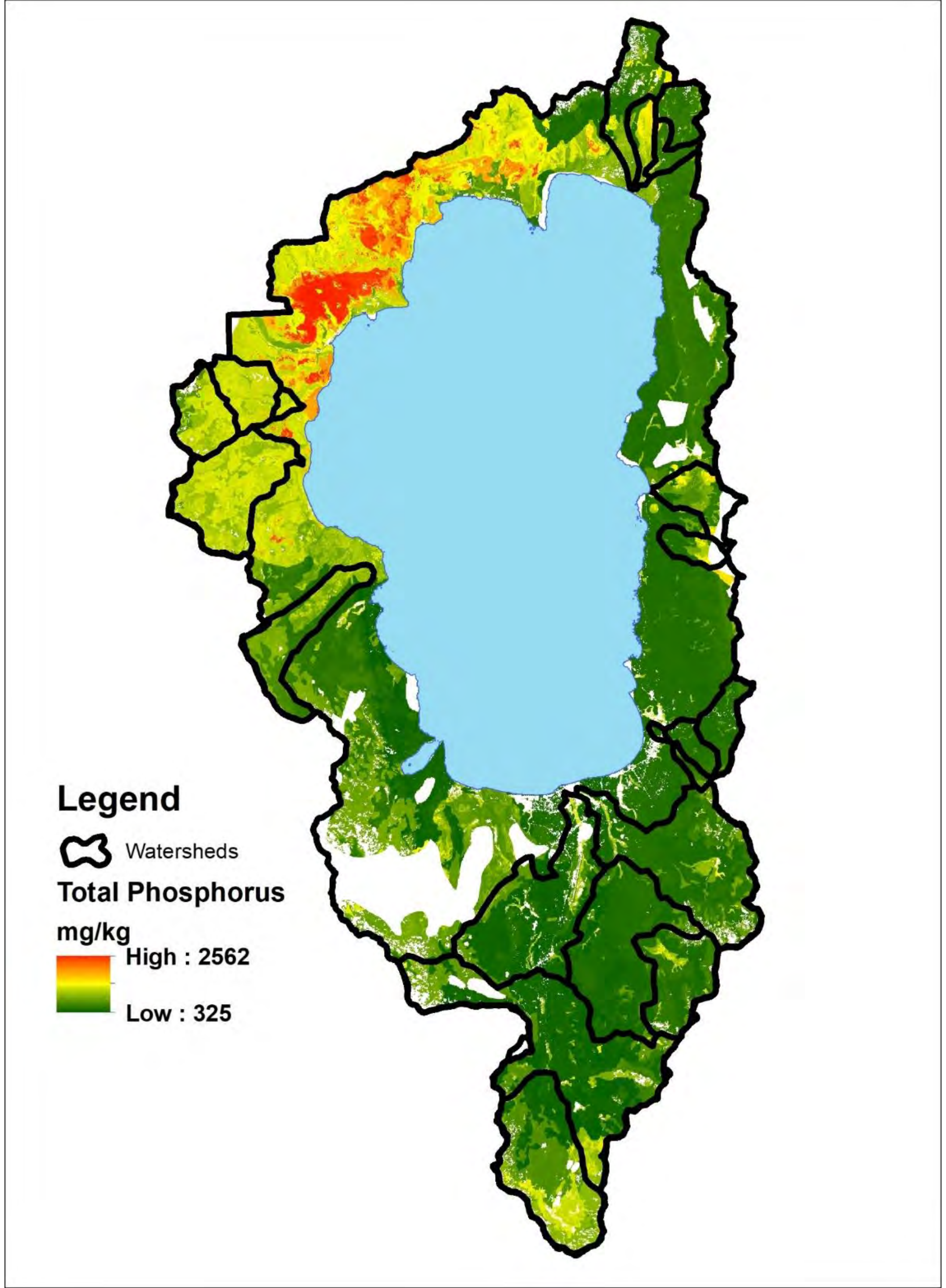
Modeled scenarios

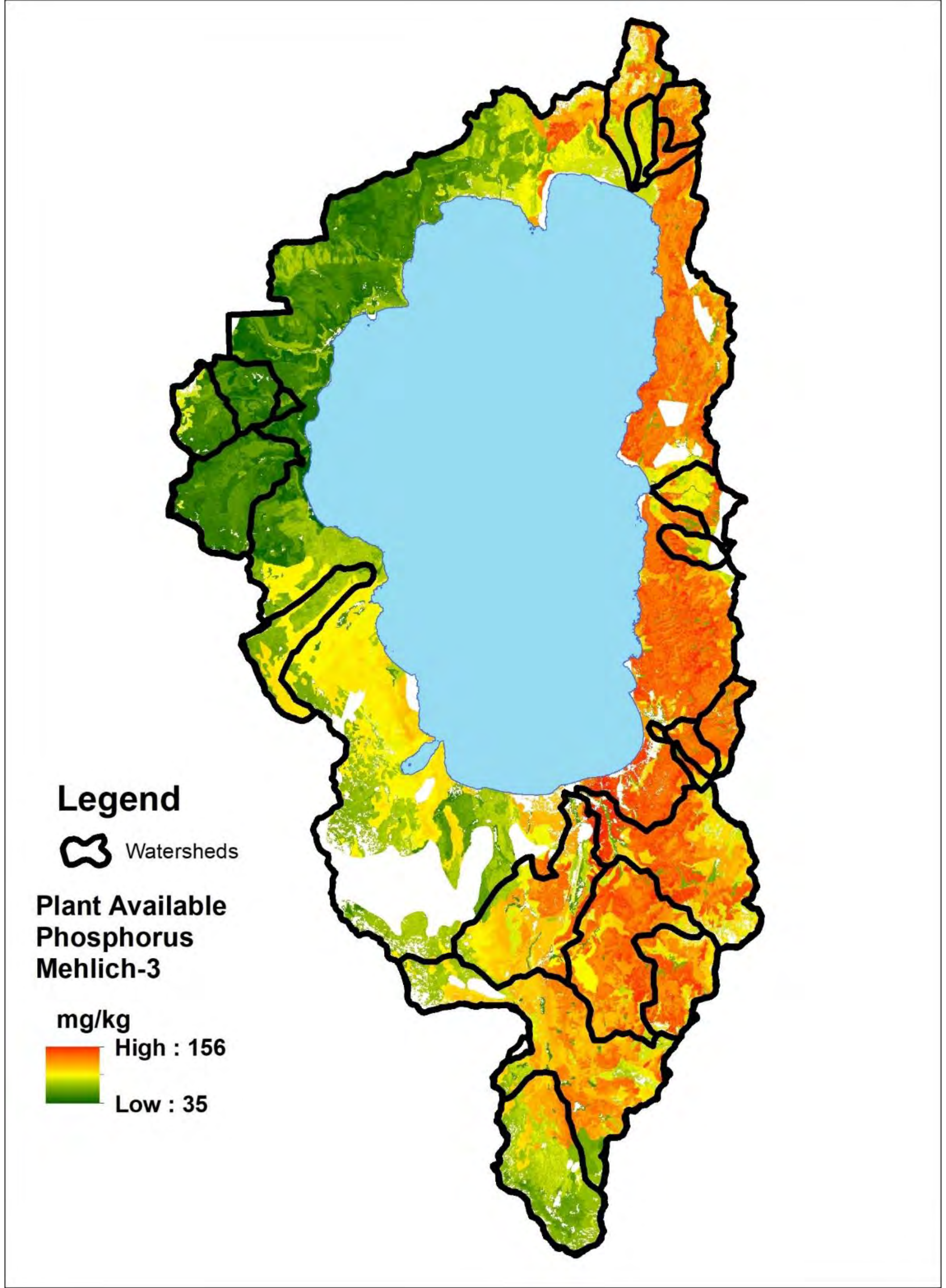
Effects of management on WEPP parameters. A similar table was created for Volcanic and Alluvial soils.

Soils	Management Name	Soil Parameters				Management Parameters		
		Critical Shear (Pa)	Eff. Hydraulic Conductivity (mm/h)	Interrill Erodibility (kg*s/m^4)	Rill Erodibility (s/m)	Canopy Cover (fraction)	Interrill Cover (fraction)	Rill Cover (fraction)
Granitic	Old Forest	4	45	250000	0.00015	0.9	1	1
Granitic	Young Forest	4	40	400000	0.00004	0.8	1	1
Granitic	Thinning 96% cover	4	40	400000	0.00004	0.4	0.96	0.96
Granitic	Thinning 93% cover	4	40	400000	0.00004	0.4	0.93	0.93
Granitic	Thinning 85% cover	4	40	400000	0.00004	0.4	0.85	0.85
Granitic	Forest Prescribed Fire	4	20	1000000	0.0003	0.85	0.85	0.85
Granitic	Forest Low Severity Fire	4	20	1000000	0.0003	0.75	0.8	0.8
Granitic	Forest Moderate Severity Fire	4	20	1000000	0.0003	0.4	0.5	0.5
Granitic	Forest High Severity Fire	4	15	1800000	0.0005	0.2	0.3	0.3
Granitic	Shrubs	4	35	300000	0.00006	0.7	0.9	0.9
Granitic	Shrub Prescribed Fire	4	35	350000	0.00006	0.7	0.75	0.75
Granitic	Shrub Low Severity Fire	4	35	400000	0.00006	0.5	0.7	0.7
Granitic	Shrub Moderate Severity Fire	4	35	400000	0.00006	0.3	0.5	0.5
Granitic	Shrub High Severity Fire	4	30	450000	0.00007	0.05	0.3	0.3

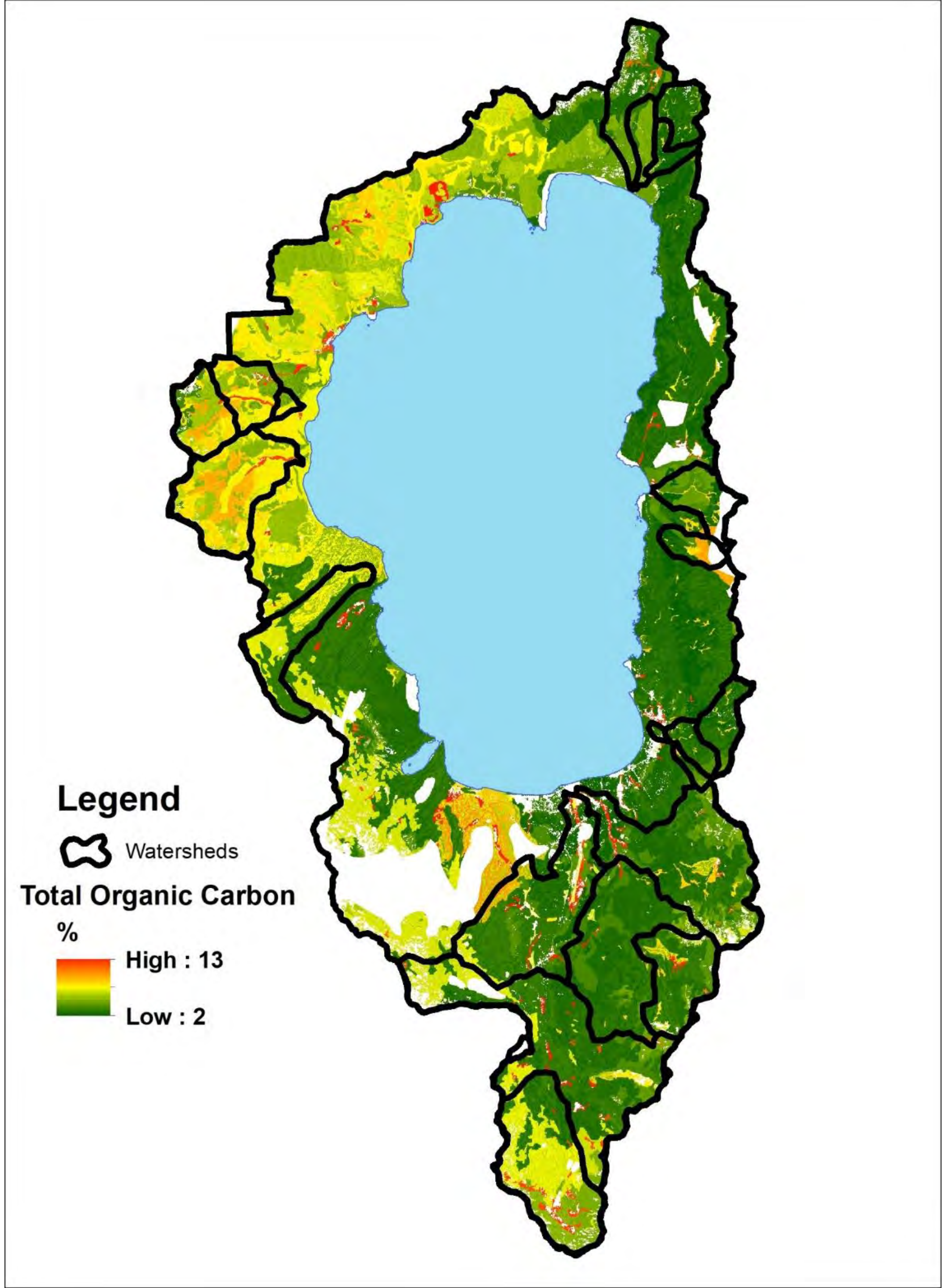
Table created based on observed data in both Lake Tahoe and other watersheds in Pacific Northwest (provided by Bill Elliot)

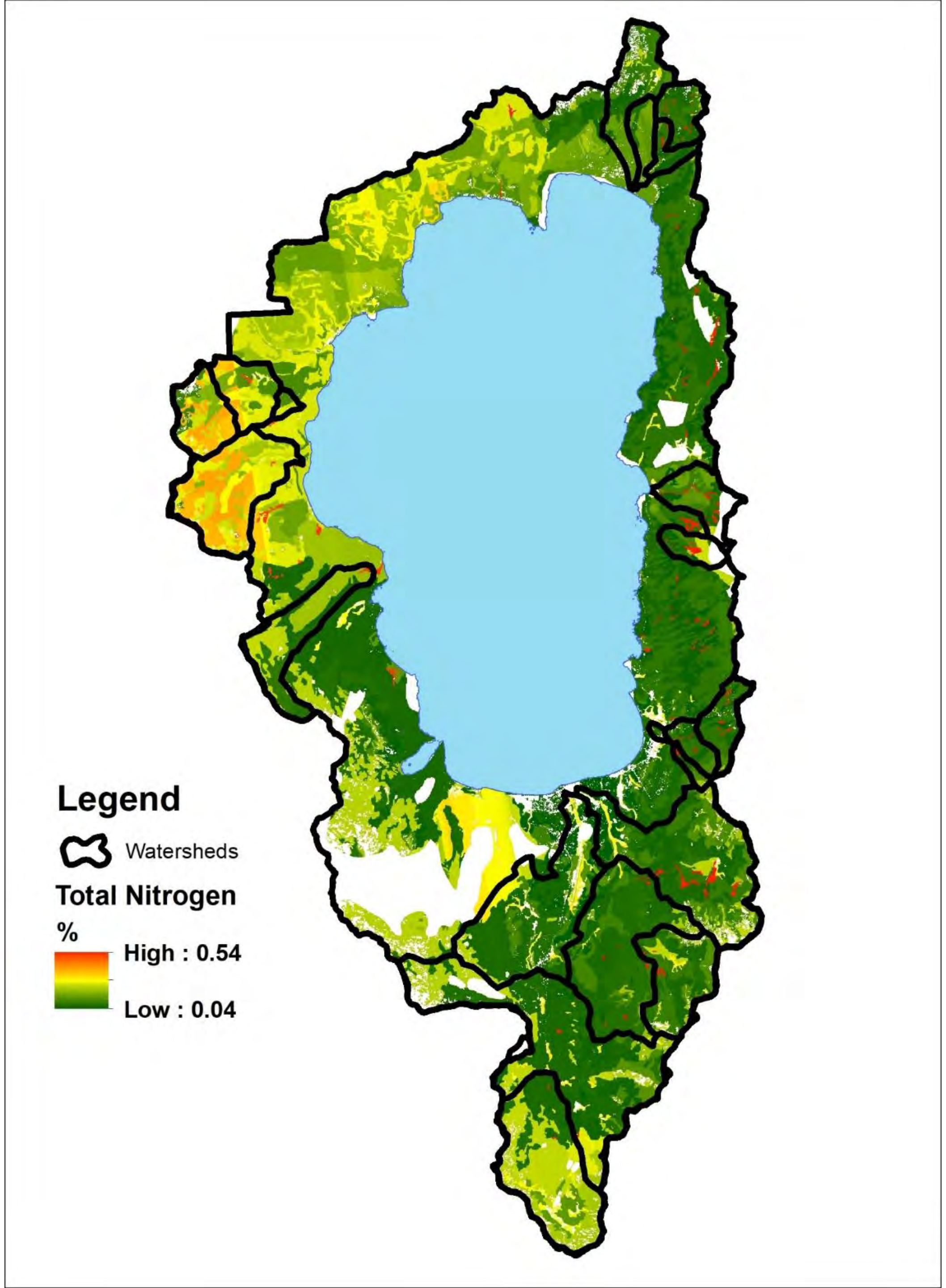


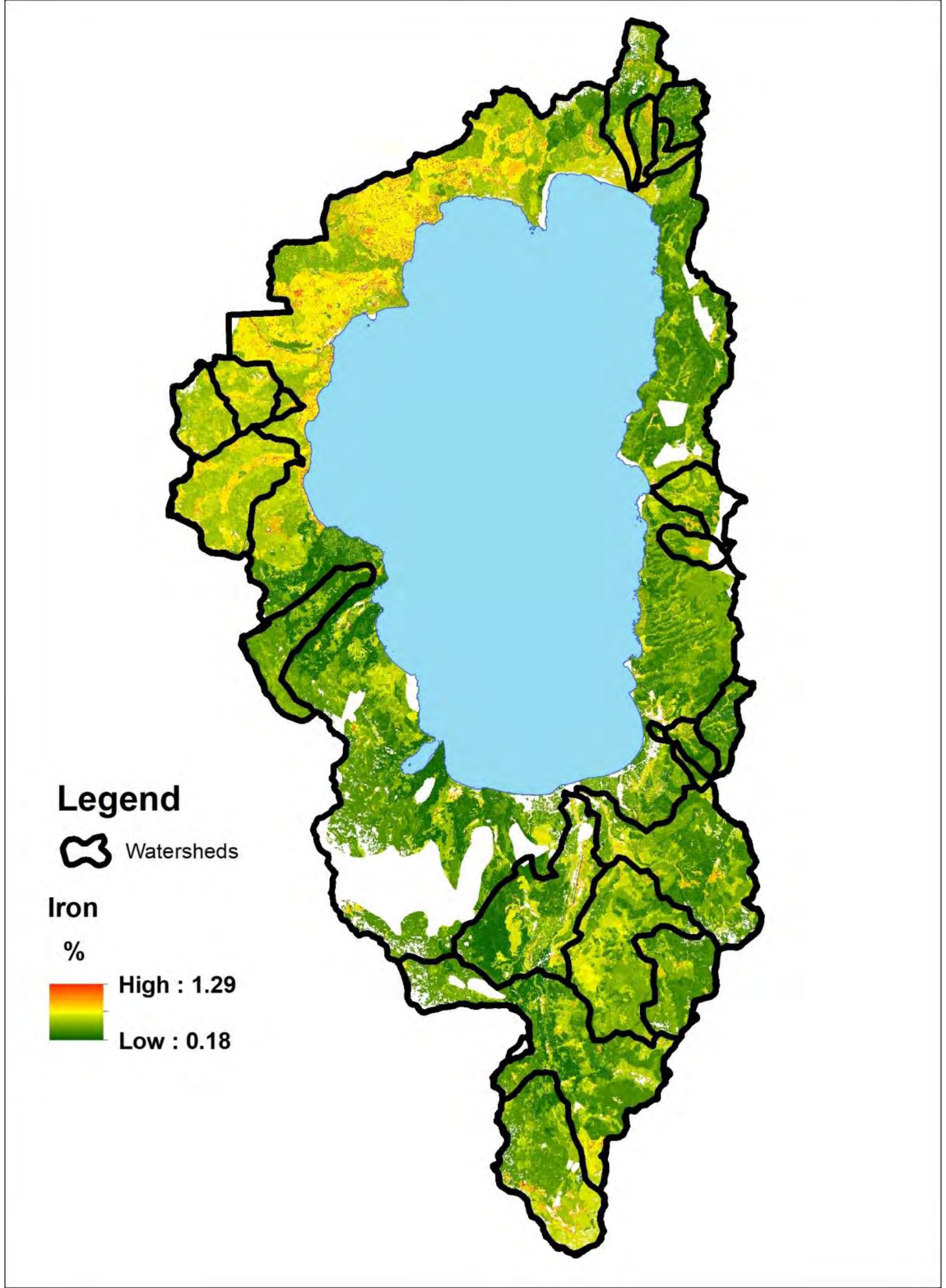
Legend
Watersheds
Total Phosphorus
mg/kg
High : 2562
Low : 325

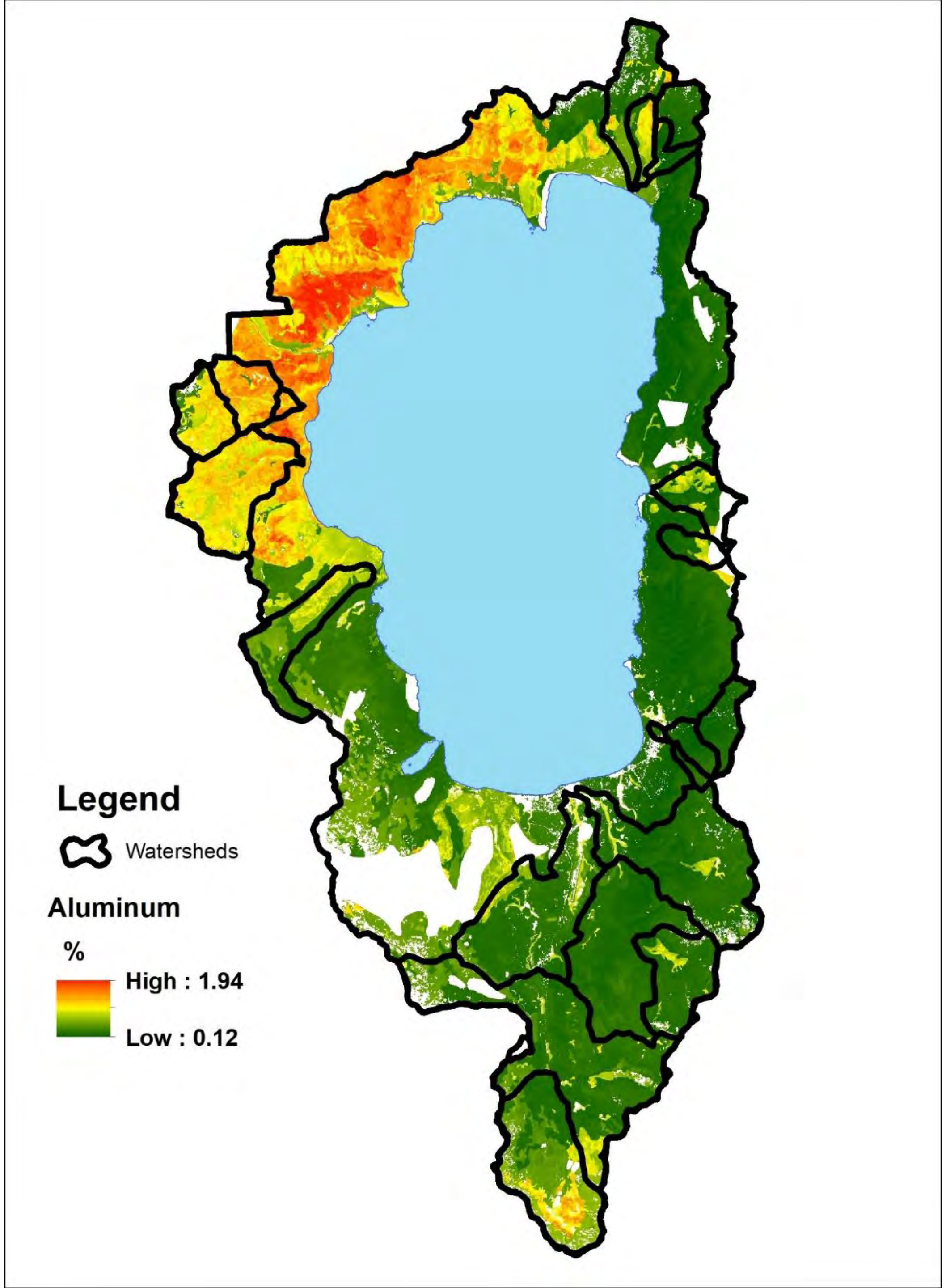


Legend
Watersheds
Plant Available
Phosphorus
Mehlich-3
mg/kg
High : 156
Low : 35


Legend
Watersheds
Total Organic Carbon
%
High : 13
Low : 2


Legend
Watersheds
Total Nitrogen
%
High : 0.54
Low : 0.04

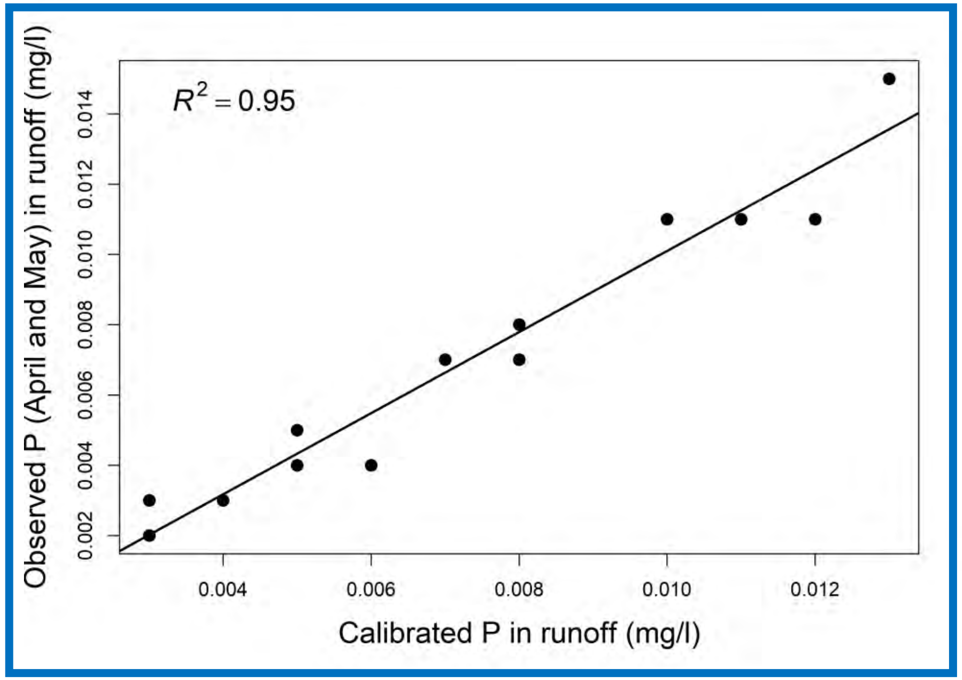

Legend
Watersheds
Iron
%
High : 1.29
Low : 0.18

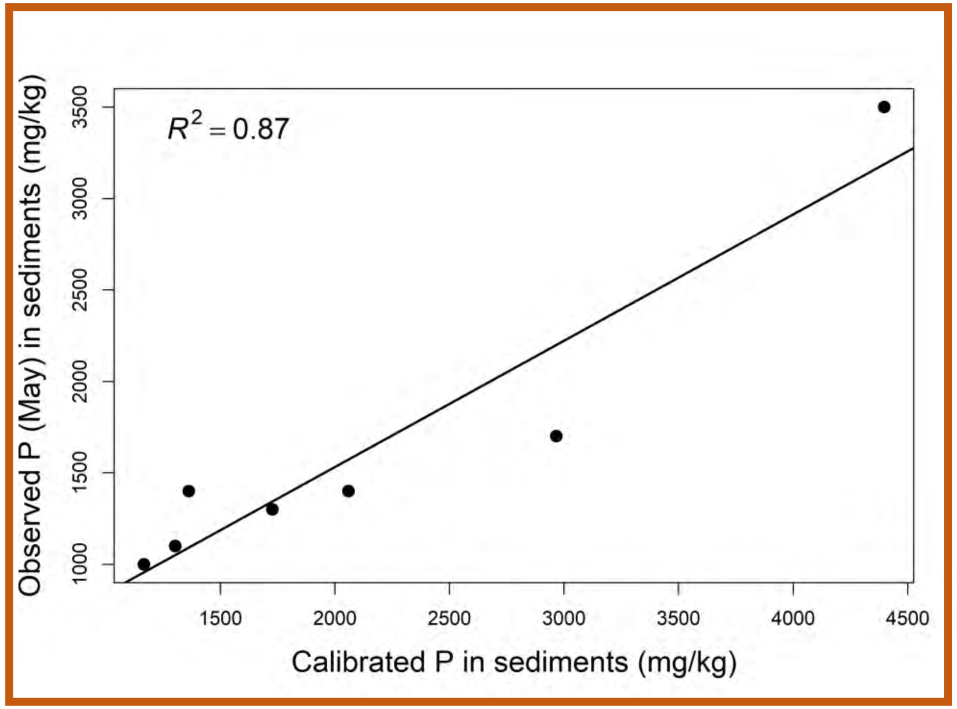

Legend
Watersheds
Aluminum
%
High : 1.94
Low : 0.12

Comparison between calibrated Phosphorus concentrations in observed data and critical shear

	OBSERVED P. CONC.		CALIBRATED P. CONC.				CALIB
	April and May (mg/l)	Sediments (May) (mgP/kgSoil)	Runoff (mg/l)	Lateral (mg/l)	Baseflow (mg/l)	Sediments (mgP/kgSoil)	Channel Critical Shear
Blackwood	0.004	1166*	0.003	0.004	0.005	1000*	10
General	0.003	1303*	0.002	0.003	0.004	1100*	30
Upper Truckee 1	0.005	1362*	0.004	0.005	0.006	1400*	20
Glenbrook	0.013	4397*	0.015	0.016	0.017	3500*	
Ward 8	0.006	2059*	0.004	0.005	0.006	1400*	75
Ward 7A	0.005	1188	0.005	0.006	0.007	1000	90
Ward 3A	0.003	1600	0.003	0.004	0.005	800	130
Trout 1	0.007	2966*	0.007	0.008	0.009	1700*	17
Trout 2	0.008	1789	0.007	0.008	0.009	2200	45
Trout 3	0.008	2545	0.008	0.009	0.010	1300	70
Incline 1	0.011	1727*	0.011	0.012	0.013	1300*	
Incline 2	0.012	1248	0.011	0.012	0.013	1500	
Incline 3	0.010	2280	0.011	0.012	0.013	1600	
All Watersheds			0.004	0.005	0.006	1000	25

** = Relationship developed only with data from the main watersheds*





Calibration results

	Daily streamflow			Annual Sediments		
	NSE	*KGE*	*%bias*	*NSE*	*KGE*	*%bias*
Blackwood Creek	0.60	0.68	-5.3	0.78*	0.85*	-4.7*
General Creek	0.56	0.73	4.8	0.53^	0.45^	0.2^
Ward Creek 8	0.66	0.68	-0.2	0.76*	0.78*	0.7*
Ward Creek 7	0.66	0.7	-3.4	0.74	0.81	-7.5
Ward Creek 3	0.64	0.72	-3.4	0.60^	0.69	-20^
Upper Truckee 1	0.60	0.76	-5.7	0.76~	0.69~	22~
Trout Creek 1	0.57	0.79	-3.0	0.57	0.63	-2.0

NSE = 1 best model

NSE ≤ 0 model not better than average

%bias = 0 best model

%bias ± 0 over/under prediction

Model reasonably captures Streamflow, Sediments, and Phosphorus with minimal calibration

	Annual TP			Annual SRP			Annual PP		
	NSE	*KGE*	*%bias*	*NSE*	*KGE*	*%bias*	*NSE*	*KGE*	*%bias*
Blackwood Creek	0.69*	0.84*	-2.2*	0.66	0.42	7.1	0.66*	0.82*	-3*
General Creek	0.83	0.87	-1.5	0.76	0.75	3.4	0.80	0.86	-2.1
Ward Creek 8	0.72*	0.84*	-0.5*	0.78	0.45	8.2	0.67*	0.8*	-1.3*
Ward Creek 7A	0.72	0.71	7.1	0.94	0.84	1.7	0.63	0.67	8.4
Ward Creek 3A	0.69^	0.74^	7.4^	0.60	0.38	4.0	0.61^	0.69^	7.6^
Upper Truckee 1	0.51~	0.71~	2.1~	0.74~	0.45~	-4.3~	0.70~	0.79~	10~
Trout Creek 1	0.84	0.91	0.1	0.78	0.62	-2.9	0.81	0.9	1.1

** = without years 1997 and 2006*

^=without year 2006

~=without year 2011

2. Modelled Scenarios

Scenario 1: Current conditions

Scenario 2: Uniform High Severity

Scenario 3: Uniform Moderate Severity

Scenario 4: Uniform Low Severity

Scenario 5: Uniform Thinning (96% cover)

Scenario 6: Uniform Thinning (93% cover)

Scenario 7: Uniform Thinning (85% cover)

Scenario 8: Uniform Prescribed Burn

Scenario 9: Simulated Wildfire (using FCCS fuels)

Scenario 10: Simulated Wildfire (using LANDIS outputs) with current climate

Scenario 11: Simulated Wildfire (using LANDIS outputs) with future climate

Post-disturbance ground cover is the most critical WEPP management factor influencing soil erosion!

Water Quality
Modeling Scenarios over Time

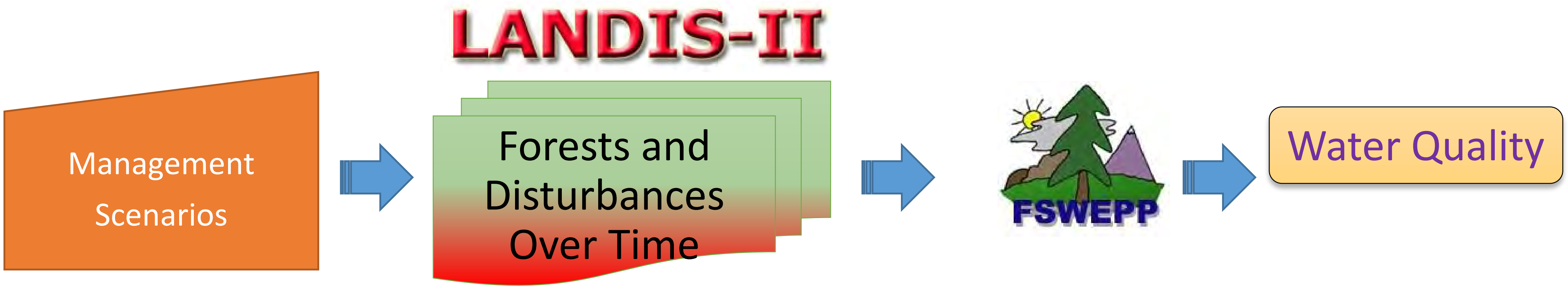
Lake Tahoe West Science Symposium

5/29/20

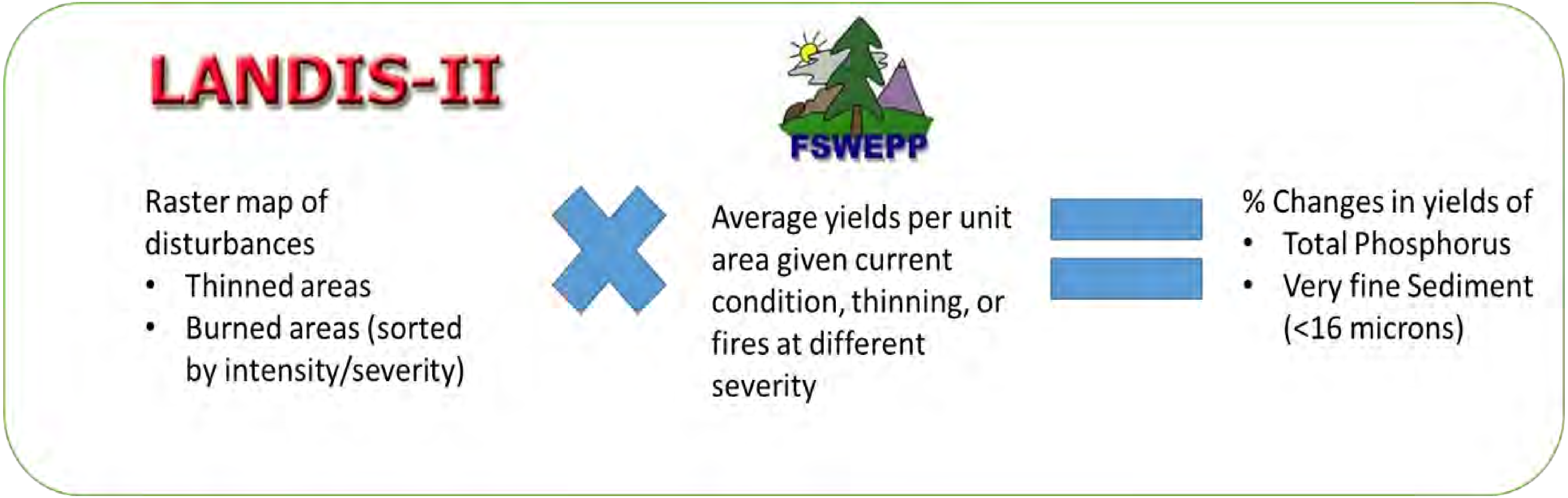
Compiled and Presented by Jonathan Long

Based upon WEPP modeling by Mariana Dobre and
LANDIS modeling by Charles Maxwell

Overlay analysis by Charles Maxwell



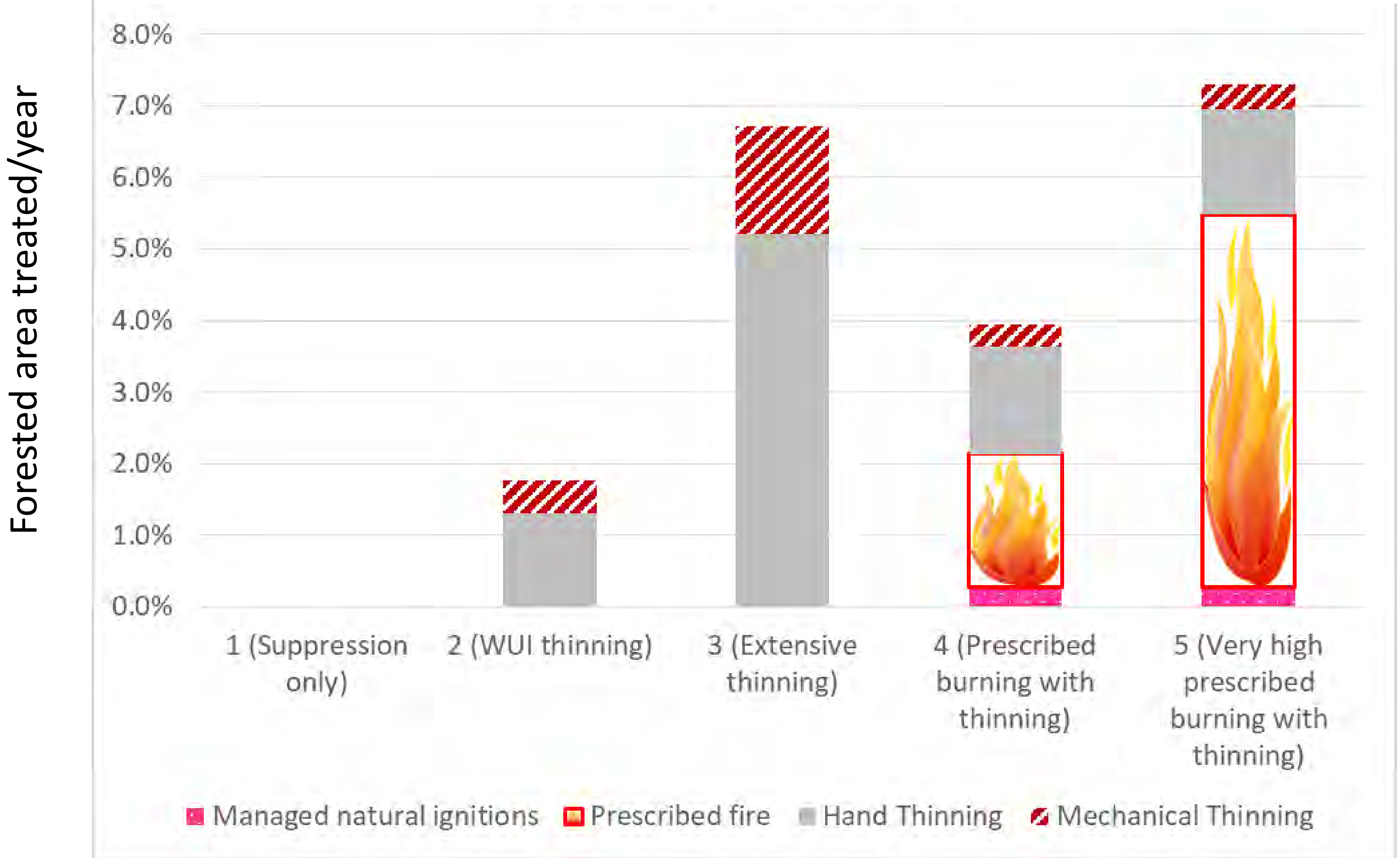
Framework for Linking WEPP watershed modeling with Long-term Landscape Modeling



This linked approach allows us to account for the frequency and intensity of different disturbances to evaluate effects of the overall management regimes

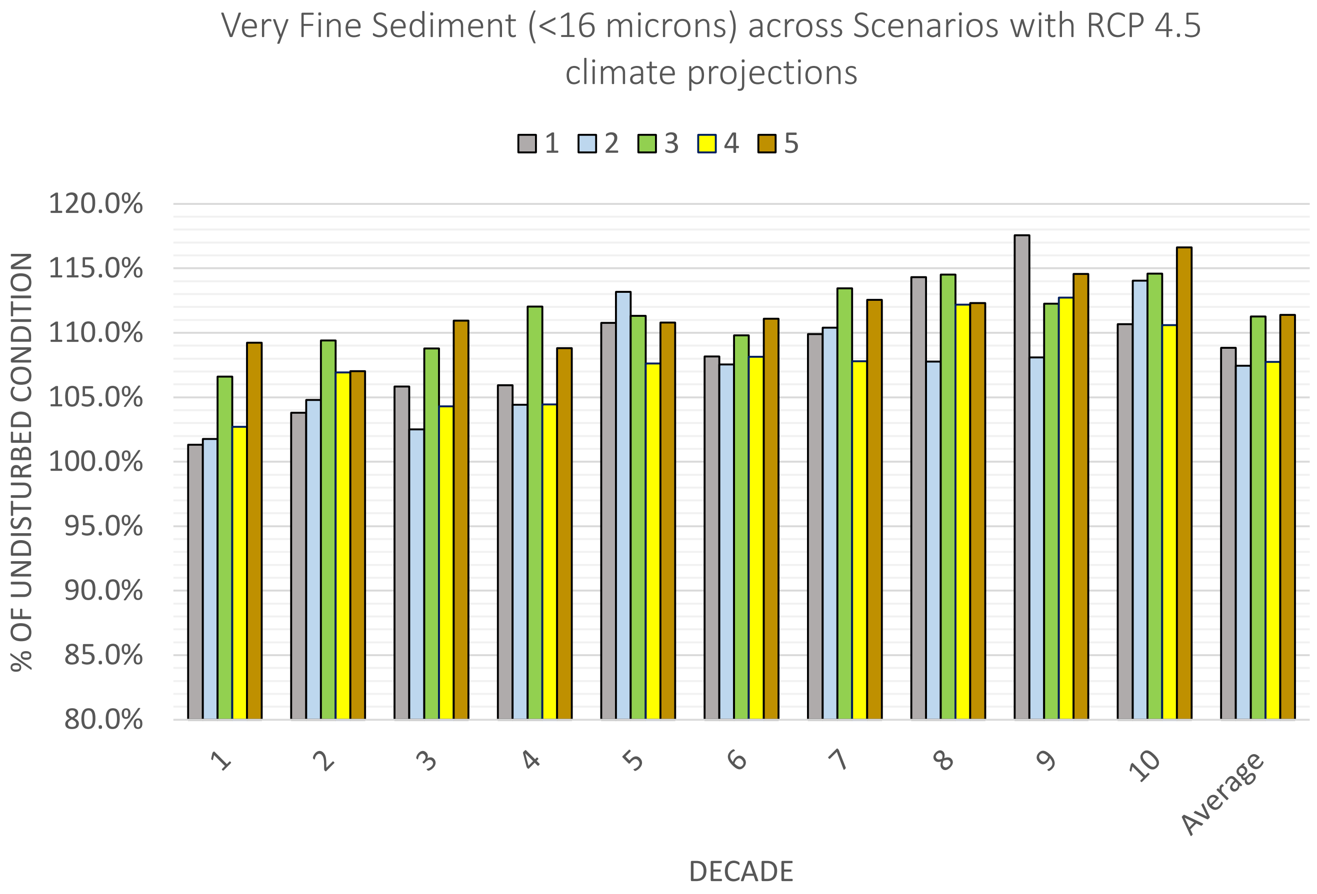
Results are presented as cumulative averages per decade

Management Scenarios: Amount and Type of Treatment per Year



Very Fine Sediments

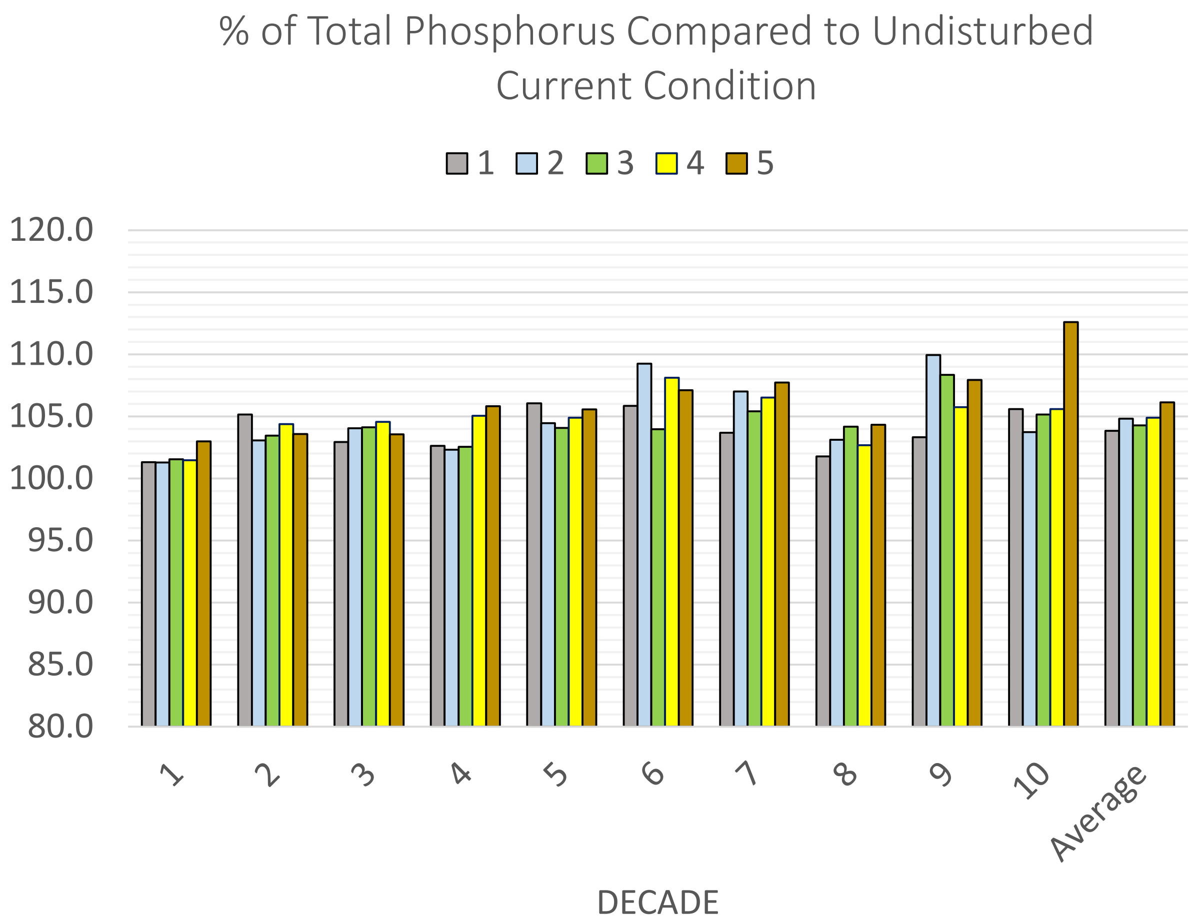
RCP4.5	Scenario				
Decade	1	2	3	4	5
1	101.3%	101.8%	106.6%	102.7%	109.2%
2	103.8%	104.8%	109.4%	106.9%	107.0%
3	105.8%	102.5%	108.8%	104.3%	110.9%
4	105.9%	104.4%	112.0%	104.4%	108.8%
5	110.8%	113.2%	111.3%	107.6%	110.8%
6	108.2%	107.5%	109.8%	108.2%	111.1%
7	109.9%	110.4%	113.4%	107.8%	112.6%
8	114.3%	107.8%	114.5%	112.2%	112.3%
9	117.6%	108.1%	112.3%	112.7%	114.6%
10	110.7%	114.0%	114.6%	110.6%	116.6%
Average	108.8%	107.4%	111.3%	107.7%	111.4%



- Disturbance increases sediment loads, so the loads increase over time (due to wildfires) and under the scenarios with more treatment (3 and 5)
- Relative loads by scenario: 2 ~ 4 < 1 < 3 ~ 5
- Scenarios that increased treatment raised values earlier, but sometimes yielded lower values in future

Total Phosphorus

	Scenario				
Decade	1	2	3	4	5
1	101.3%	101.3%	101.6%	101.5%	103.0%
2	105.1%	105.1%	103.5%	104.4%	103.6%
3	102.9%	102.9%	104.1%	104.6%	103.6%
4	102.6%	102.6%	102.5%	105.1%	105.8%
5	106.1%	106.1%	104.1%	104.9%	105.6%
6	105.8%	105.8%	104.0%	108.1%	107.1%
7	103.7%	103.7%	105.4%	106.5%	107.7%
8	101.8%	101.8%	104.2%	102.7%	104.3%
9	103.3%	103.3%	108.3%	105.7%	107.9%
10	105.6%	105.6%	105.2%	105.6%	112.6%
Average	103.8%	103.8%	104.3%	104.9%	106.1%



- Results for phosphorus were more similar across management scenarios
- Increased disturbance (particular prescribed burning) was associated with higher loads
- Scenario 5 had highest average values, but was not always the highest in a given decade

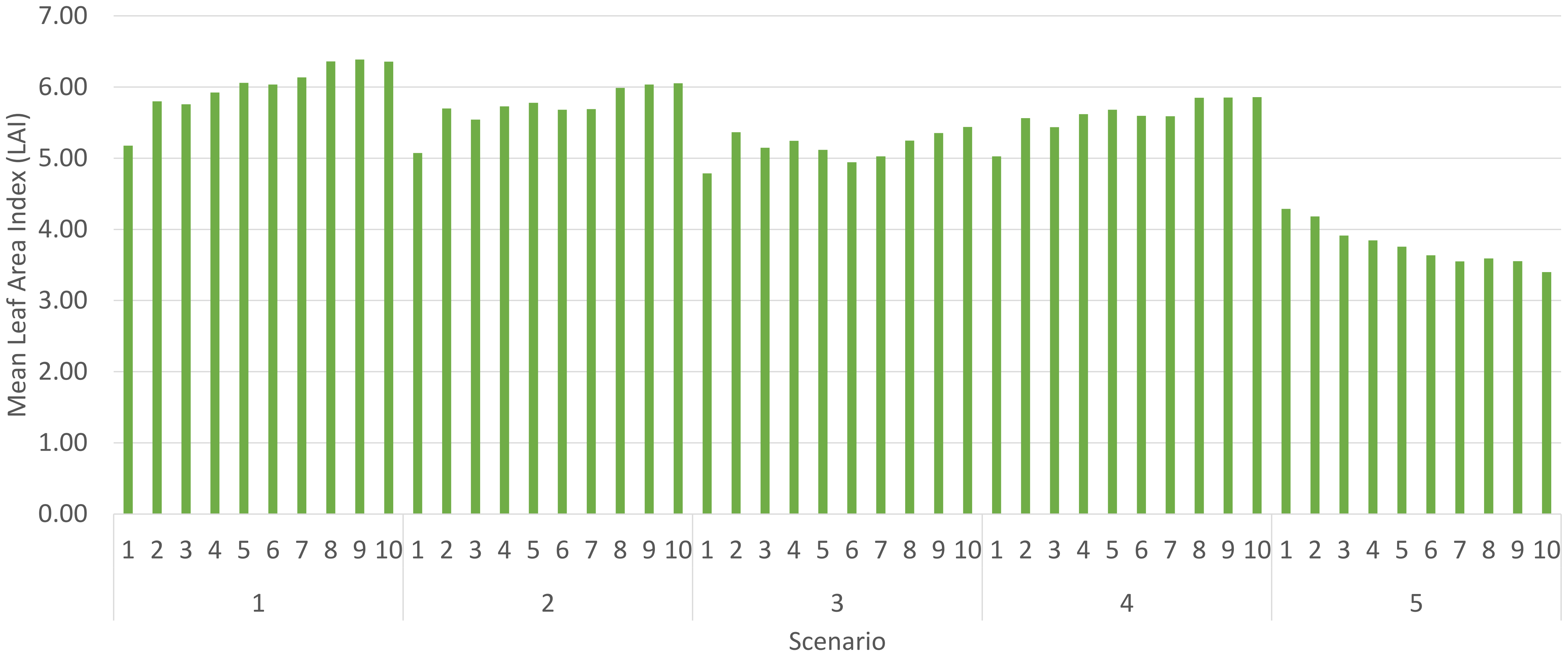
Other Water Indicators

(Not from WEPP modeling)

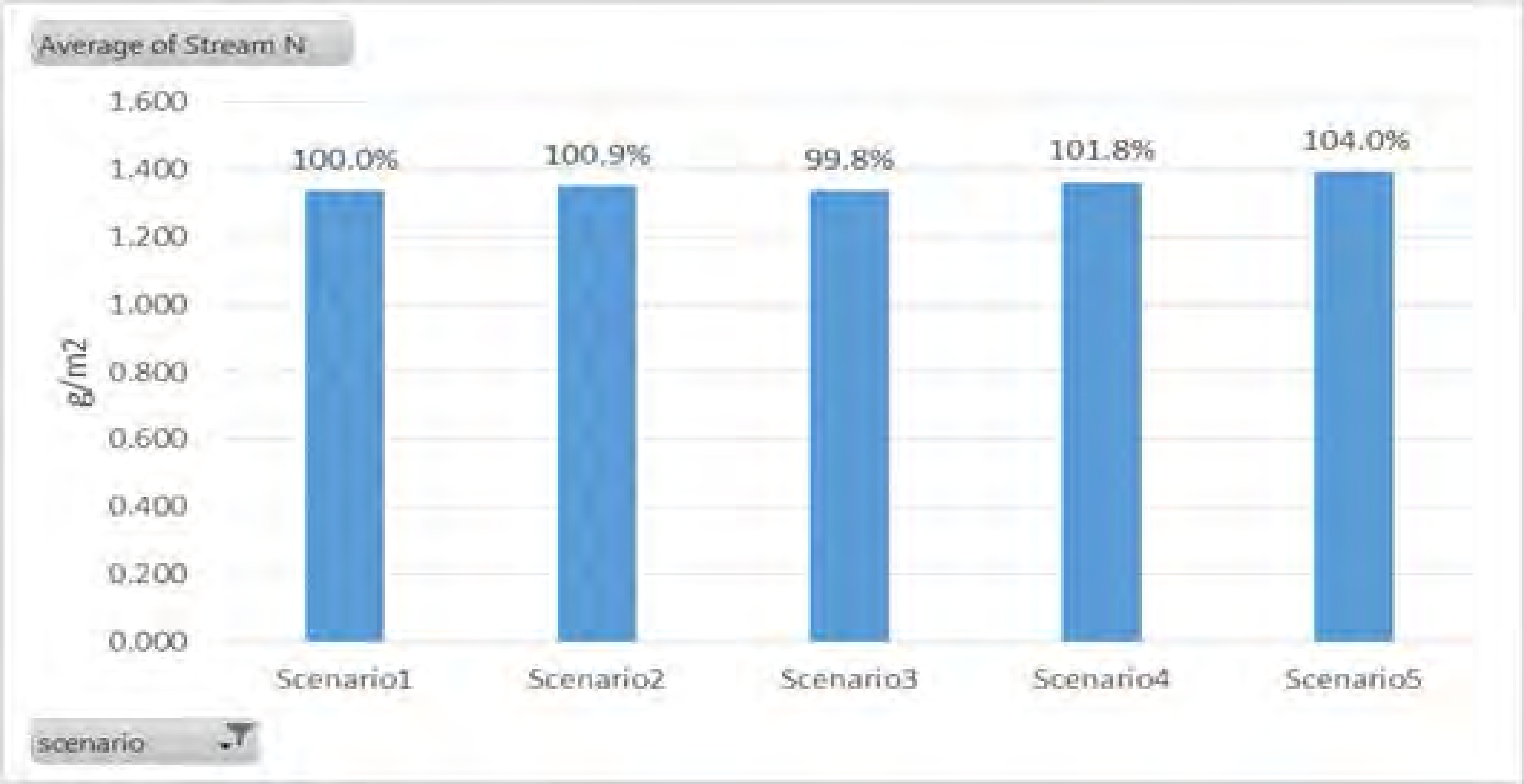
Water quantity

Nitrogen

Leaf Area Index (Proxy for Potential Water Yield) by Scenario



Stream Nitrogen Indicator Results from LANDIS-II Modeling



Implications for Management

- Increased loads from treatments were partially offset by avoided wildfire impacts
- Wildfire activity is expected to increase over time, indicating that loads will increase (don't expect load reductions from the general forest)
- Landscape water quality modeling did not directly account for changes in storm regimes in the future; however, WEPP runs using a future climate projection indicated that expected loads could **greatly increase** over time

→ Therefore, increasing treatment when storm conditions are more favorable (in the near-term) may further yield net benefits by avoiding wildfire impacts when storm conditions become more intense in the future

Implications for Monitoring

- Overall values were fairly similar compared to a baseline assumption of no disturbance, suggesting that landscape-scale effects on pollutant loads would be difficult to detect
- Monitoring ground cover (a key variable) in treated areas (especially large prescribed burns) may be valuable for testing assumptions regarding treatment effects and interpreting results from stream monitoring
- Large-scale prescribed burning has more uncertain effects:
  →monitoring of ground cover and sediment yield would help reduce that uncertainty

Water Quality and Roads

Bill Elliot (USDA FS RMRS-Retired)

Sue Miller (USDA FS RMRS)

Longxi Cao

Jonathan W. Long (USDA FS PSW)

Mariana Dobre (University of Idaho), Roger Lew, Mary Ellen Miller

Study 1: Forest Road Network Analysis

- Evaluated the road surface erosion and sediment delivery to the nearest channel for 181 km of roads inventoried by LTBMU within Lake Tahoe West
  - 1359 road segments
  - 3 different climates zones
  - 5 different road use categories defined by the LTBMU;
- Considered sediment loading under:
  - Current condition (low use)
  - Harvest traffic (high use)
  - Closed

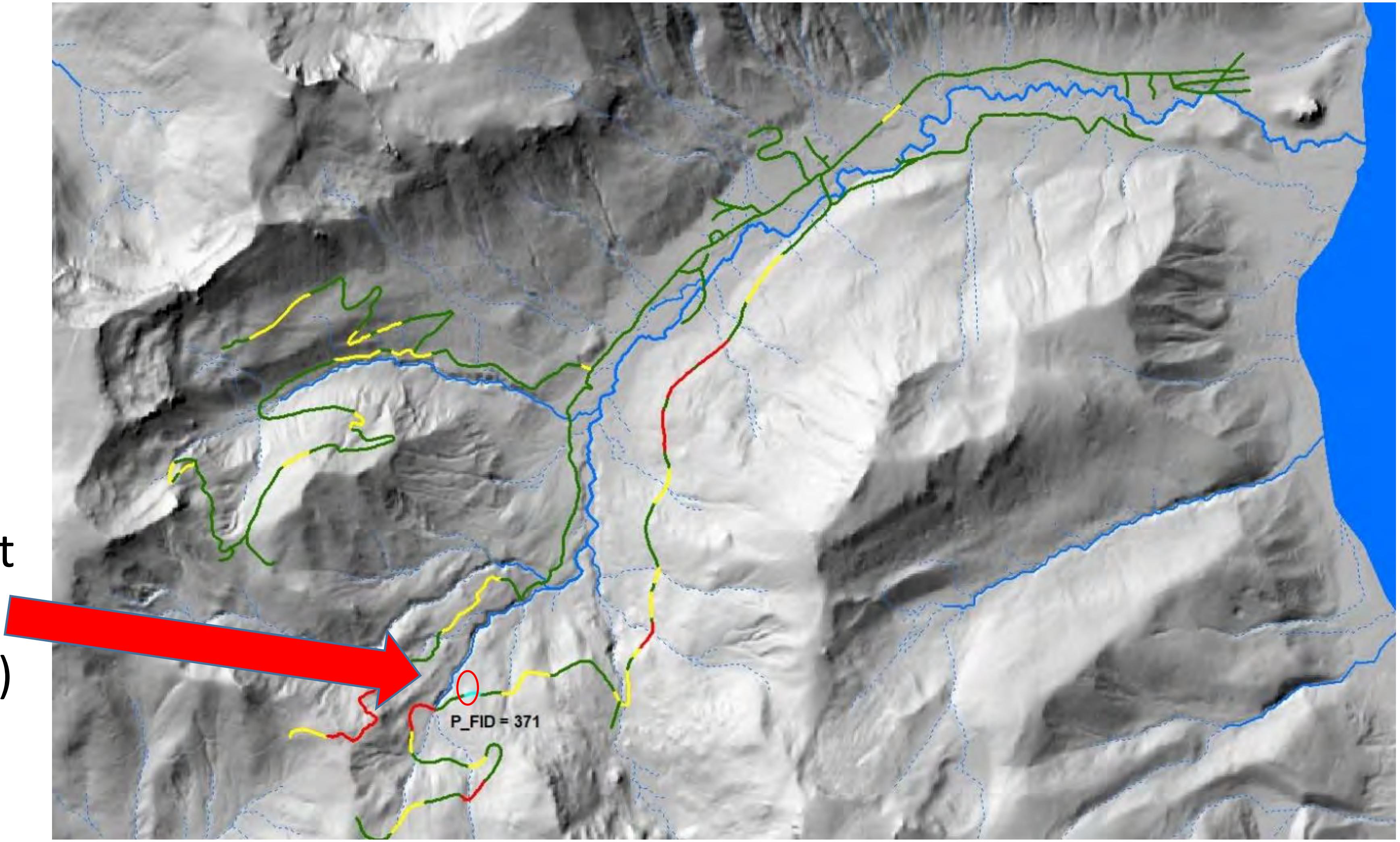
Results from Study 1: Road Network Analysis

- The study estimated that 55 Mg sediment per year is generated by existing LTW forest road network
- The total is estimated to be less than 1% the amount generated from hillslopes, reflecting the generally low density of the road network*
- Closing unpaved roads would reduce sediment generation by 20 percent
- Increasing use for harvest would increase erosion by a factor of 19 on high traffic segments during the period of active use

→ If the road segments are likely to be opened for harvest for 2 years out of every twenty then **total expected loads from those segments might be 2.8 times higher** over those two decades than if not used

Example Results: Blackwood Watershed

Highest sediment generating segment (861 kg) (This segment is paved with sediment coming from the buffer)



Dark green segments: 0 - 75 kg
Yellow segments: 75 - 240 kg
Red segments 248 - 861 kg

Results from Road Network Study

- Results are summarized by road segment in GIS project files and spreadsheets (posted on the University of Idaho WEPP Cloud Server Tahoe pages)
- Managers can visit road segments of concern in the field to confirm problem segments.
- If the field survey of high-risk segments confirms road or downslope erosion, then appropriate management practices can be applied to mitigate that erosion.

Study 2: Erosion and Sedimentation after the Emerald Wildfire

- Questions :
  - Were the erosion predictions of the Burned Area Response (BAER) team reasonable?
  - How well did the erosion predictions match observations?
  - How did roads within the fire perimeter affect runoff, erosion and sediment delivery?
- Methods:
  - GIS analyses
  - WEPP modeling tools
  - Debris flow & landslide modeling

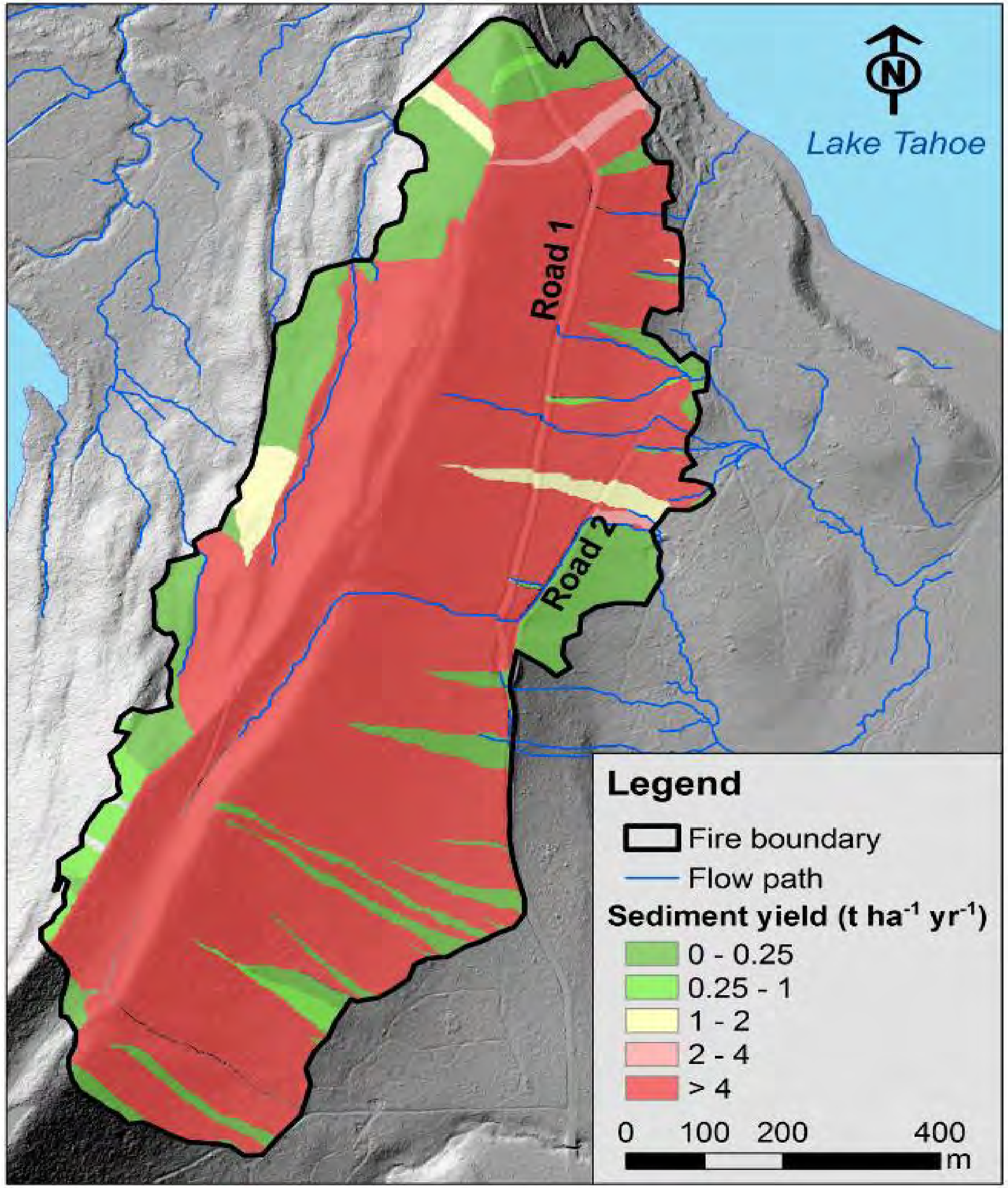
Tahoefund.org

Results of Emerald Fire Study

- The erosion estimated with the Erosion Risk Management Tool (ERMiT) as widely used by the BAER teams was reasonable (0.2 – 14.8 Mg ha^{-1}) based upon more detailed WEPP modeling and reported sediment deposition;
- Estimated sediment delivery was consistent with observations;
  - Mike Vollmer with TRPA reported that **227 Mg** of sediment were removed from Highway 89 following the three big storm events after the wildfire
  - The WEPP modeling estimated **255 Mg** of sediment deposited along Highway 89
- The risk of debris flows following this fire was low on this fire;
- For three to five years following the fire, modeling suggested there is a risk of translational landslides on Highway 89, should the hillslope above the highway become saturated.

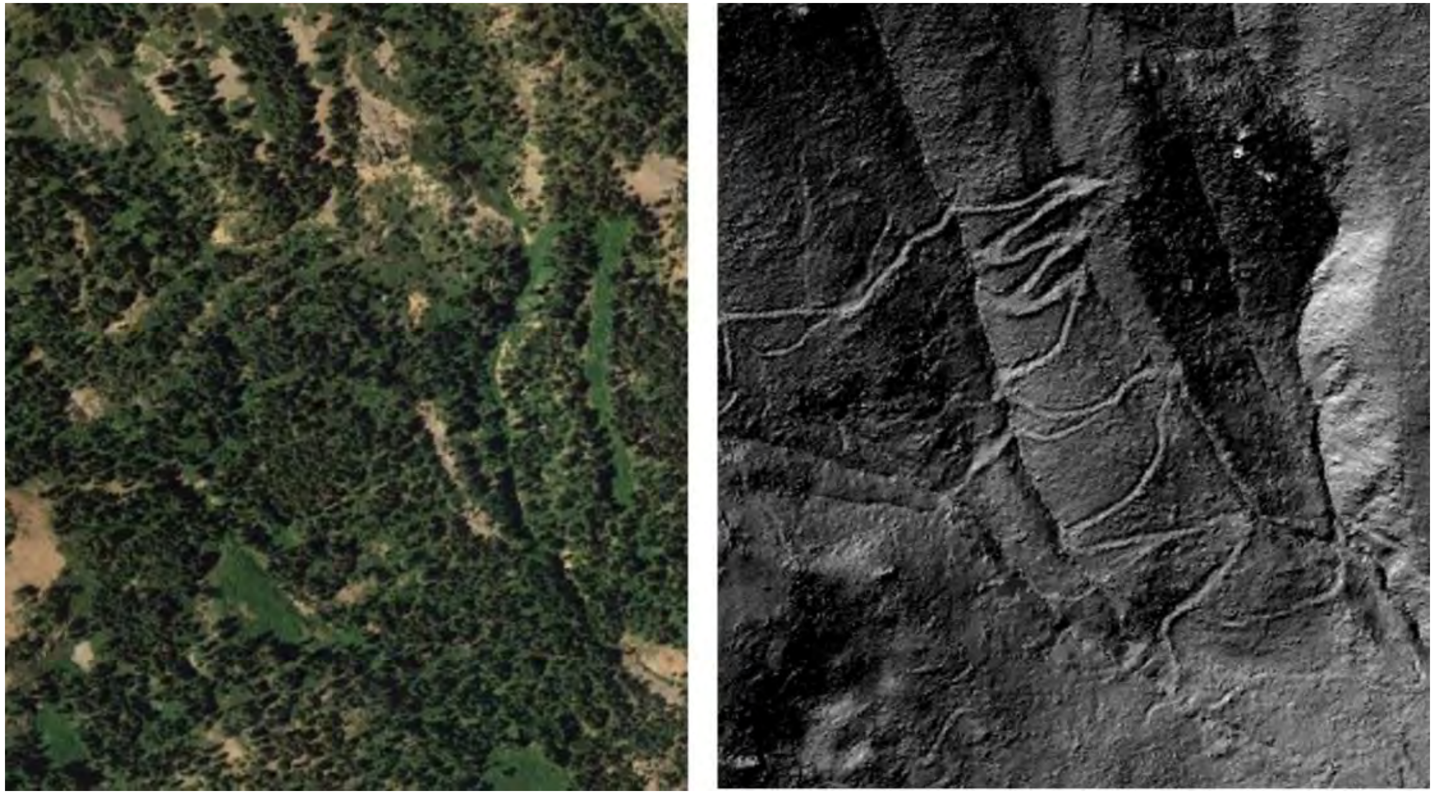
Results of Emerald Fire Study

- Roads segments actually reduced erosion and sediment delivery in some areas by intercepting flows
- Sediment delivery appeared to be contained by retention features (ditches and basins)



Estimated hillslope erosion rates after the Emerald Fire

Study 3: Effects of Opening Abandoned Forest Roads on Hydrology and Soil Loss



Abandoned road in satellite image (left) and LiDAR based hillshade (right)

- Applied GIS and WEPP modeling tools to Blackwood watershed, which has a legacy of old logging roads

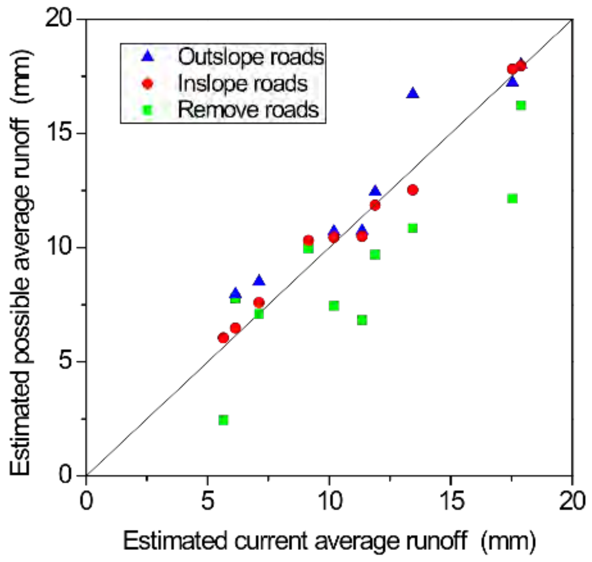
Most forest roads in Blackwood watershed are apparently abandoned

Table 1. Quantitative description of road networks in Blackwood watershed

Type	Count	Width (m)	Length (km)
Current Roads	1	8	10.25
	2	6	5.72
Abandoned Roads	13	6	25.24
	27	5	19.4
	16	4	7.65

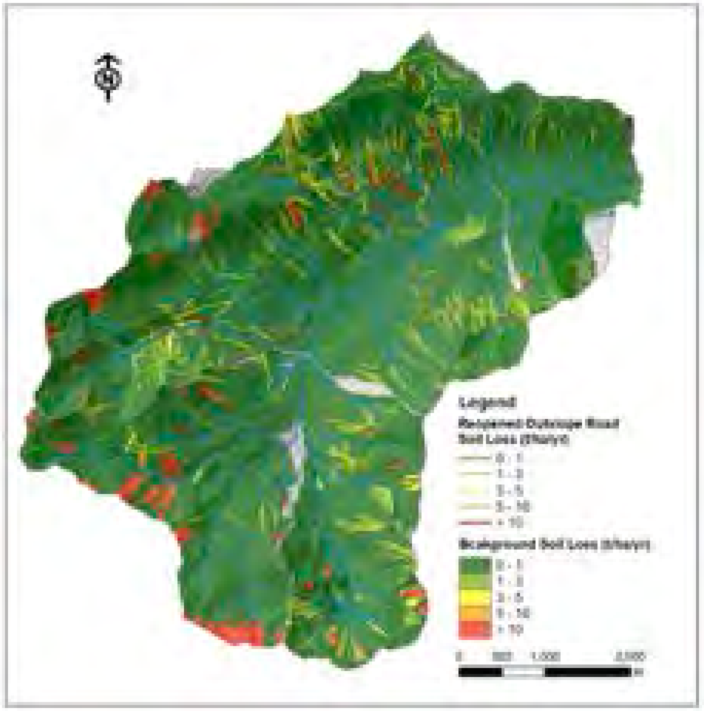
Results of Abandoned Roads Study

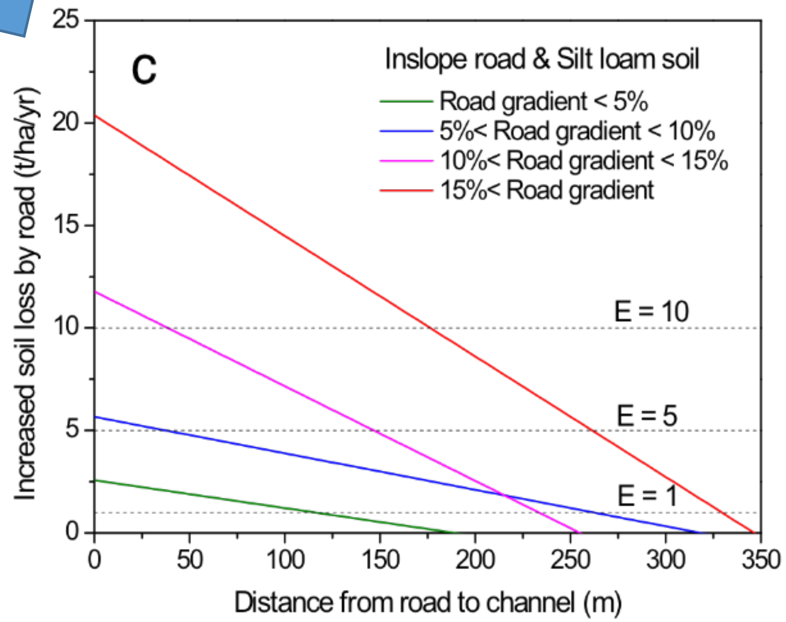
- Road soil loss is, on the average 7 times greater per unit area than in undisturbed forested hillslopes, but they represent a relatively small area
- If all roads in the watershed are reopened using an in-sloping profile, sediment delivery is estimated to increase by 15.5%, and if using an outsloping profile, by 6%
- If all the ghost roads are **removed**, sediment delivery from the road network is estimated to **decrease by nearly 20%**
- By altering flow paths, opening roads will increase upland *channel erosion*, resulting in more sediment *from the channels than the roads* following reopening



Implications of the Road Studies

- Managers can use the current and abandoned road network analyses to analyze potential impacts of opening or removing specific road segments
- Steep road segments that are close to streams pose greatest risk of sedimentation
- To decrease channel erosion due to road runoff:
  - locate culverts where an outlet can drain into a wetland area.
  - Locate ditch relief culverts and waterbars 50 ft before stream crossings to intercept runoff and divert it into the forest further from the channel
  - Apply slash for filter windrows on active roads





Smoke Impacts from Future Wildland Fires under Alternative Forest Management Regimes

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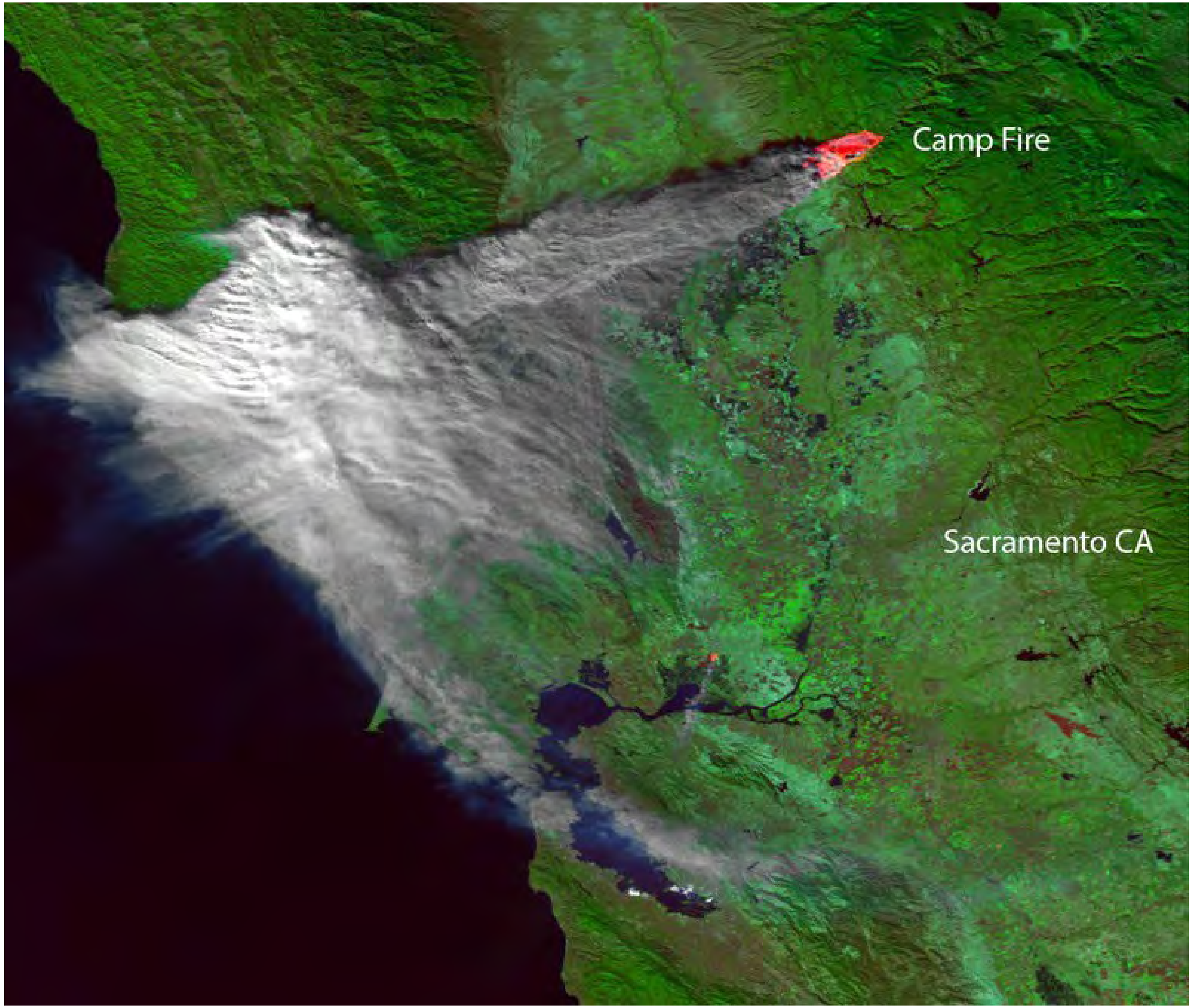
Sam Evans, Assistant Adjunct Professor of Public Policy, Mills College, Sevans@mills.edu

Stacy Drury, Research Ecologist stacy.a.drury@usda.gov

Charles Maxwell, NC State University, Post-doctoral Researcher, cjmaxwe3@ncsu.edu

The Big Question

Can more treatment (especially lots of prescribed burns) mitigate the costly smoke impacts of big wildfires?



Management Scenarios

Amount of Active Treatment

None

~1000 acres annually

~4000 acres annually

Management Scenarios

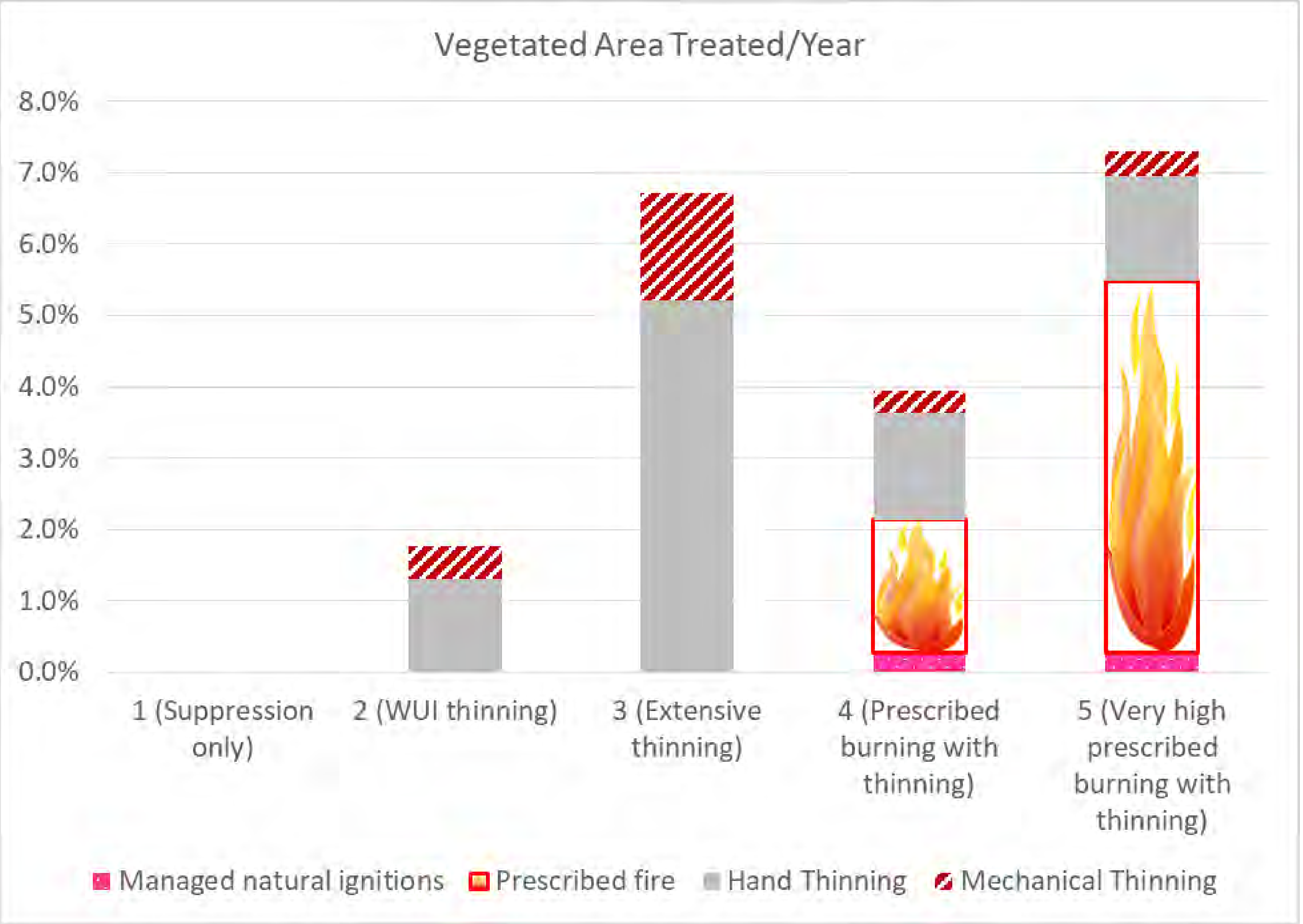
1) **Suppression-Only**: No land management actions except fire suppression in all management zones.

2) **Wildland Urban Interface (WUI)**: Forest thinning in the WUI only (most like recent treatment).

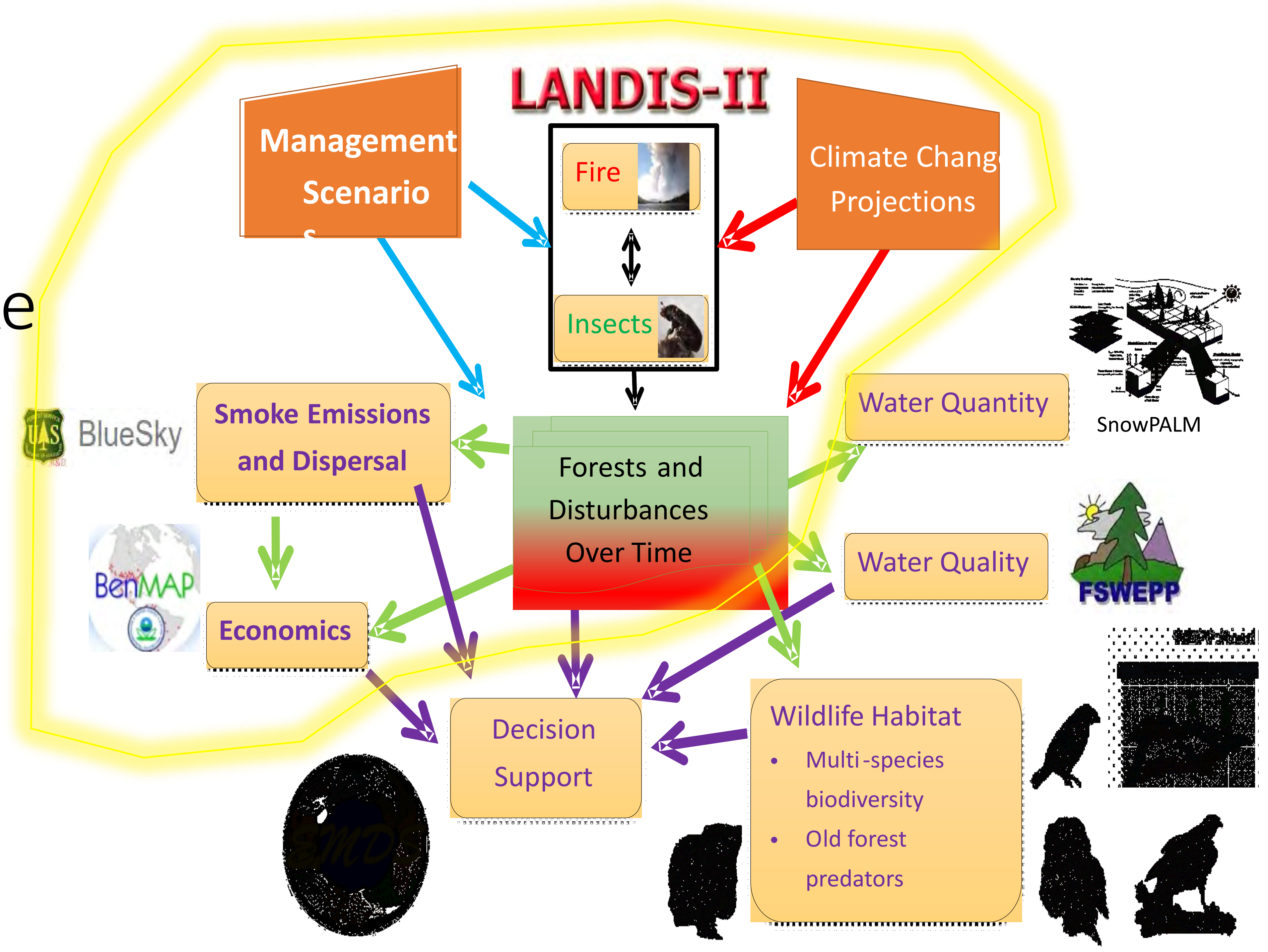
3) **Thinning-Focused**: High levels of forest thinning in the WUI, General Forest, and Wilderness.

4) **Fire-Focused (moderate prescribed burning)**: Modest forest thinning in the WUI, moderate levels of prescribed fire in all management zones, and some wildfire managed for resource objectives outside of the WUI

5) **Fire-Focused (high prescribed burning)**: Modest forest thinning in the WUI, high levels of prescribed fire in all management zones, and some wildfire managed for resource objectives outside of the WUI


Vegetated Area Treated/Year
8.0%
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
1 (Suppression only)
2 (WUI thinning)
3 (Extensive thinning)
4 (Prescribed burning with thinning)
5 (Very high prescribed burning with thinning)
Managed natural ignitions
Prescribed fire
Hand Thinning
Mechanical Thinning

Modeling the Social and Ecological System in Lake Tahoe



Approach

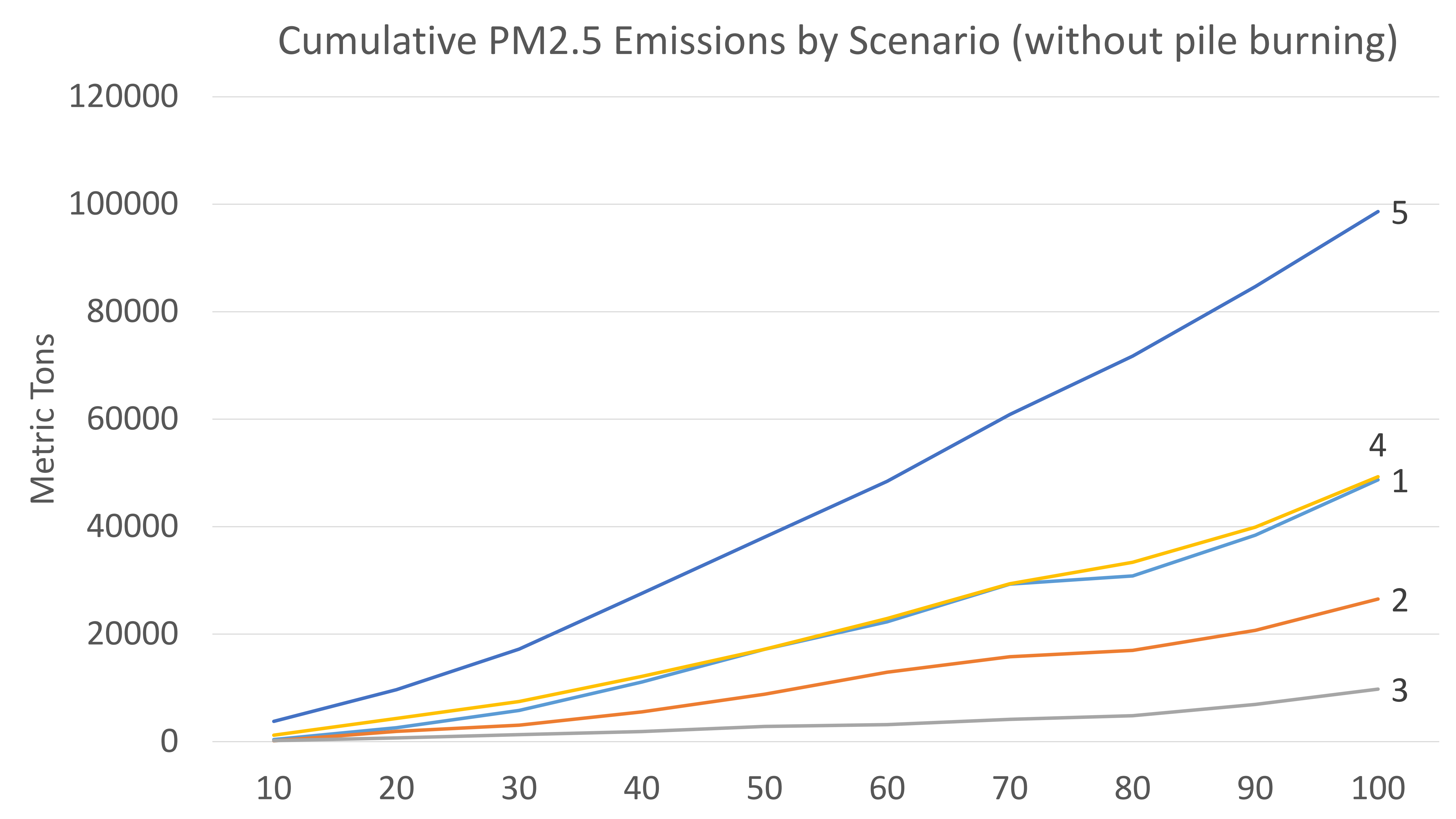
1) daily emissions	2) conveyance to downwind communities	3) size and vulnerability of those communities

Type of modeling	Emissions modeling (full century)	Smoke modeling (representative events)	Health Impacts economics modeling (representative events)
Modeling Tool	LANDIS-II	BlueSky	BenMAP

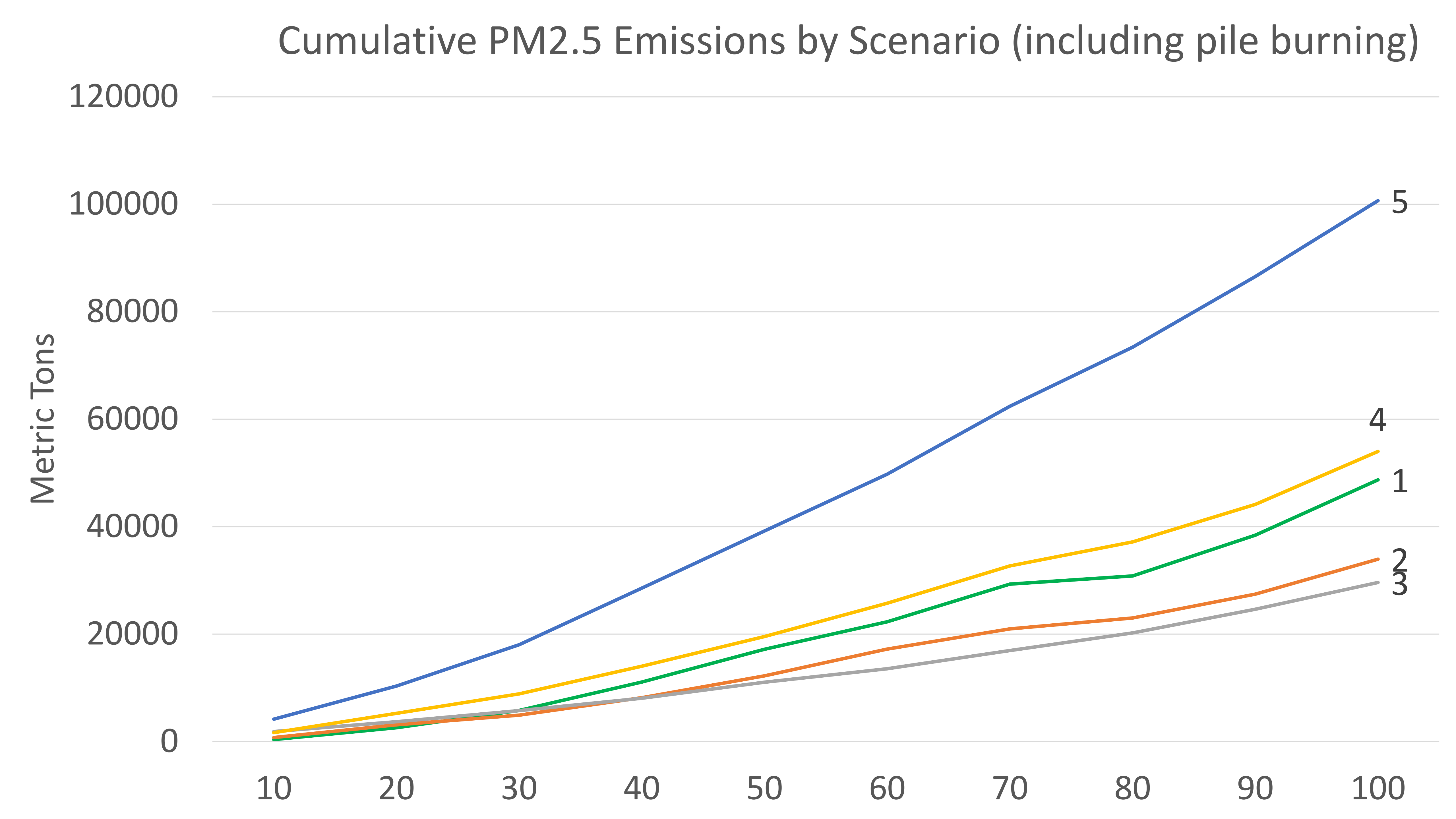
1) Emissions Modeling

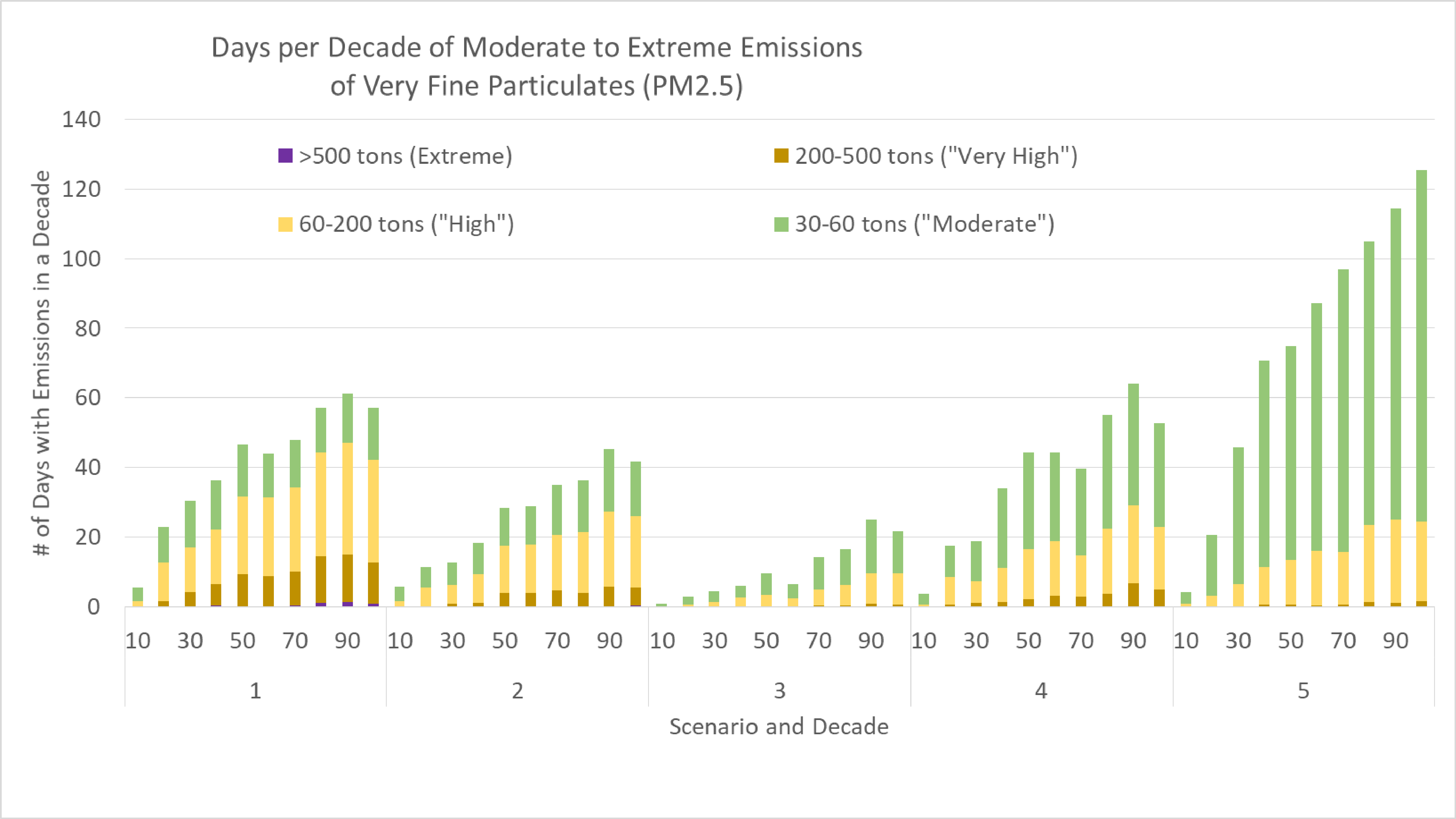
Indicators of interest:

- Total amount of wildfire at different severities
- Total emissions of fine particulates
- Days of daily emissions binned into different levels, from moderate to extreme
- Days of intentional burning (prescribed understory or pile burns) as a measure of feasibility

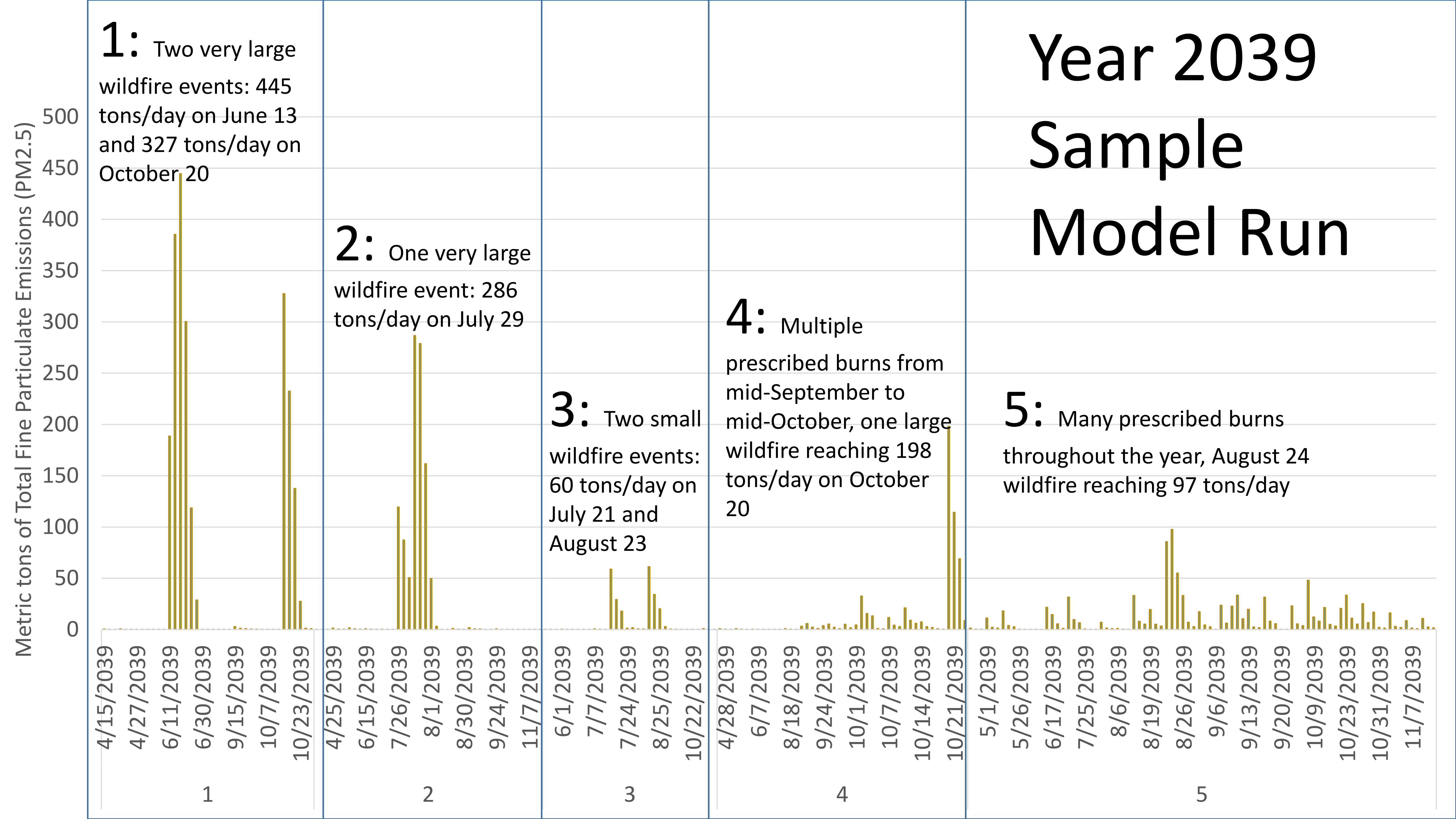


Cumulative PM2.5 Emissions by Scenario (without pile burning)
Metric Tons
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
5
4
1
2
3


Cumulative PM2.5 Emissions by Scenario (including pile burning)
Metric Tons
120000
100000
80000
60000
40000
20000
0
10
20
30
40
50
60
70
80
90
100
5
4
1
2
3



Days per Decade of Moderate to Extreme Emissions of Very Fine Particulates (PM2.5)
>500 tons (Extreme)
200-500 tons ("Very High")
60-200 tons ("High")
30-60 tons ("Moderate")
# of Days with Emissions in a Decade
0
20
40
60
80
100
120
140
10 30 50 70 90
1
2
3
4
5
Scenario and Decade

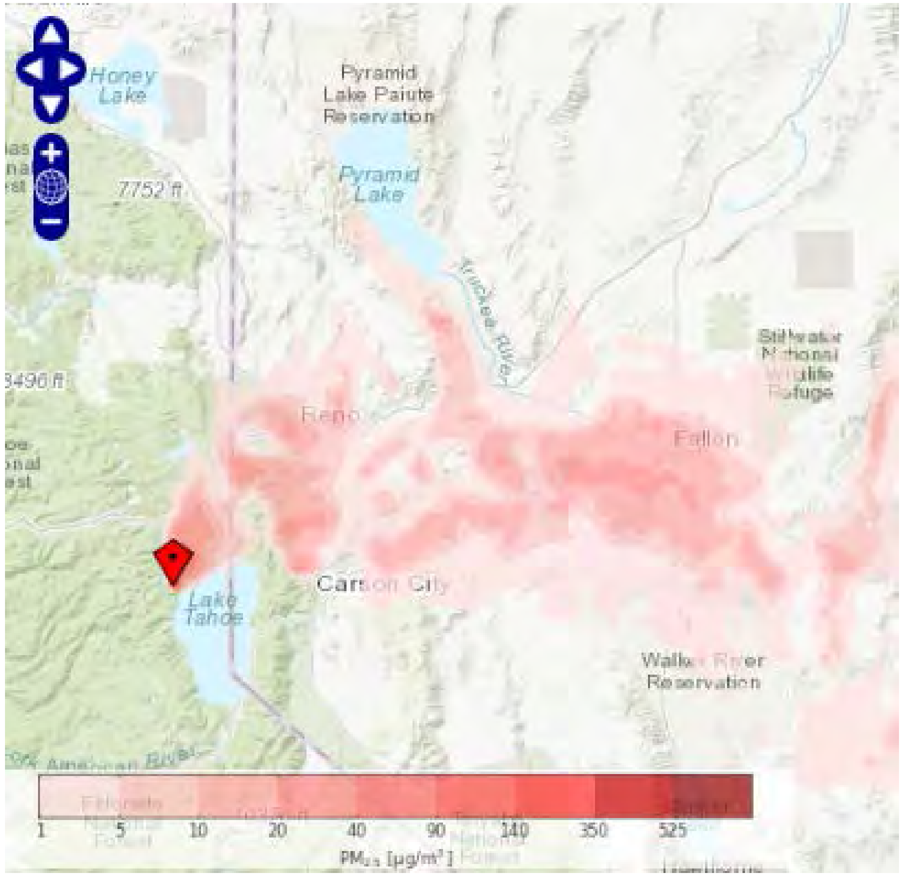


Year 2039 Sample Model Run
1: Two very large wildfire events: 445 tons/day on June 13 and 327 tons/day on October 20
2: One very large wildfire event: 286 tons/day on July 29
3: Two small wildfire events: 60 tons/day on July 21 and August 23
4: Multiple prescribed burns from mid-September to mid-October, one large wildfire reaching 198 tons/day on October 20
5: Many prescribed burns throughout the year, August 24 wildfire reaching 97 tons/day
Metric tons of Total Fine Particulate Emissions (PM2.5)
0
50
100
150
200
250
300
350
400
450
500
4/15/2039
4/27/2039
6/11/2039
6/30/2039
9/15/2039
10/7/2039
10/23/2039
4/25/2039
6/15/2039
7/26/2039
8/1/2039
8/30/2039
9/24/2039
11/7/2039
6/1/2039
7/7/2039
7/24/2039
8/25/2039
10/22/2039
4/28/2039
6/7/2039
8/18/2039
9/24/2039
10/1/2039
10/7/2039
10/14/2039
10/21/2039
5/1/2039
5/26/2039
6/17/2039
7/25/2039
8/6/2039
8/19/2039
8/26/2039
9/6/2039
9/13/2039
9/20/2039
10/9/2039
10/23/2039
10/31/2039
11/7/2039
1
2
3
4
5

2) Smoke Modeling using BlueSky

To evaluate the effects of the extreme wildfires, we modeled “snapshot” future fire events using:

- Fire locations and tons of PM2.5 emissions from LANDIS outputs for model year 30 (2039) for scenarios 1-4 for the biggest wildfire events in three of the replicates
- Modeled dispersions using different historical weather conditions (2-km gridded weather data for 2016, 2017, 2018)



Dispersion Analyses

Trying to select representative events

- Model year 30 (future year 2039)
- From the 10 replicates per scenario, modeled 3 replicates based upon the highest peak daily emissions

DailyPM2.5	Scenario			
Replicate	1	2	3	4
1st	**705**	**406**	**209**	**362**
2nd	445	287	164	260
3rd	327	252	123	240
4th	319	245	61	227
5th	**313**	**233**	**61**	**199**
6th	**245**	**218**	**51**	**198**
7th	111	166	45	132
8th	99	140	43	59
9th	2	137	2	29
10th	2	132	2	11

Dispersion Analyses – Phase II – 5th Worst Replicate using 2018 weather

Fire Size

S1 = 900 acres (363 ha)

S2 = 685 acres (277 ha)

S3 = 484 acres (196 ha)

S4 = 418 acres (169 ha)

PM 2.5 emitted

S1 = 820 tons (743 Mg)

S2 = 572 tons (519 Mg)

S4 = 440 tons (400 Mg)

S3 = 130 tons (118 Mg)

Reno

S1 = 35.1 µg/m3

S2 = 30.5 µg/m3

S3 = 1.8 µg/m3

S4 = 25.5 µg/m3

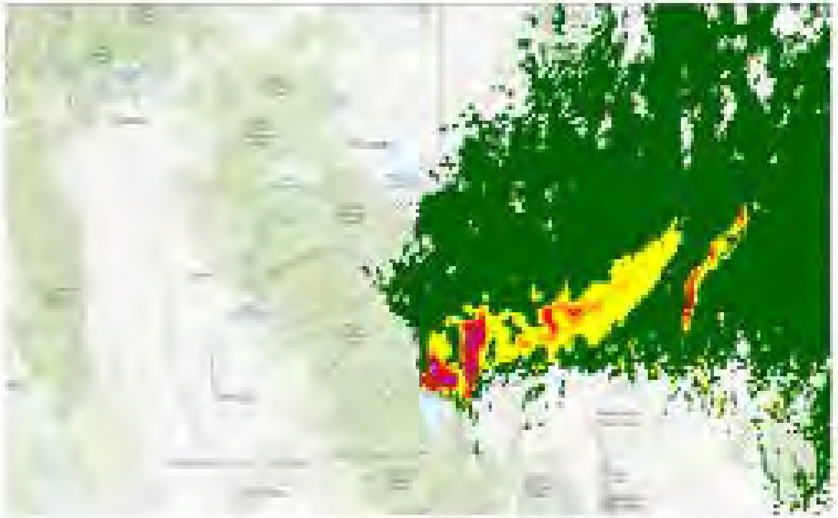
Carson City

S1 = 5.2 µg/m3

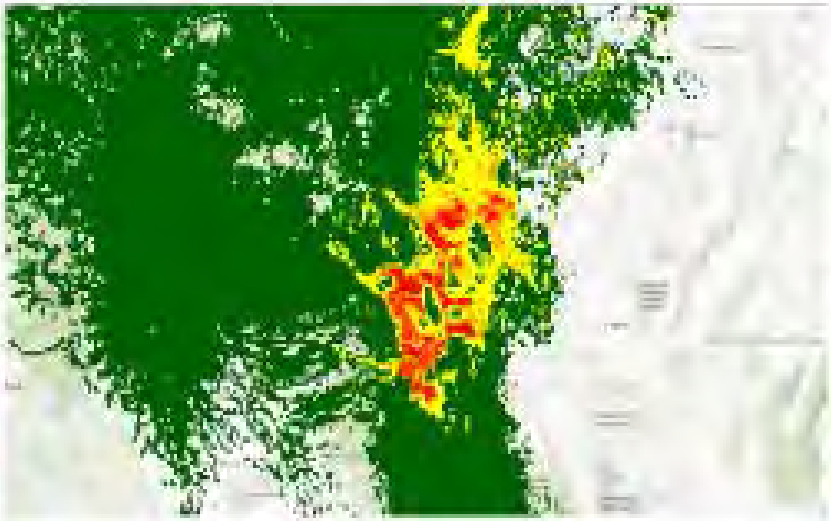
S2 = 4.0 µg/m3

S3 = 0.3 µg/m3

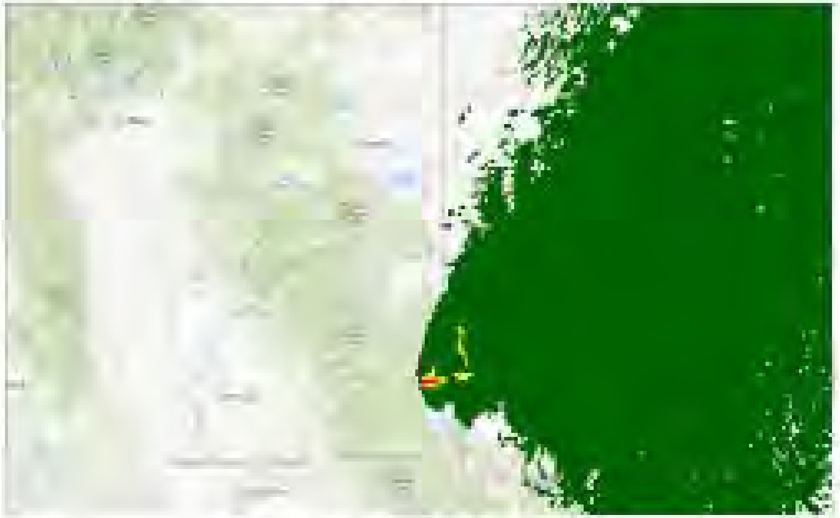
S4 = 0.0 µg/m3



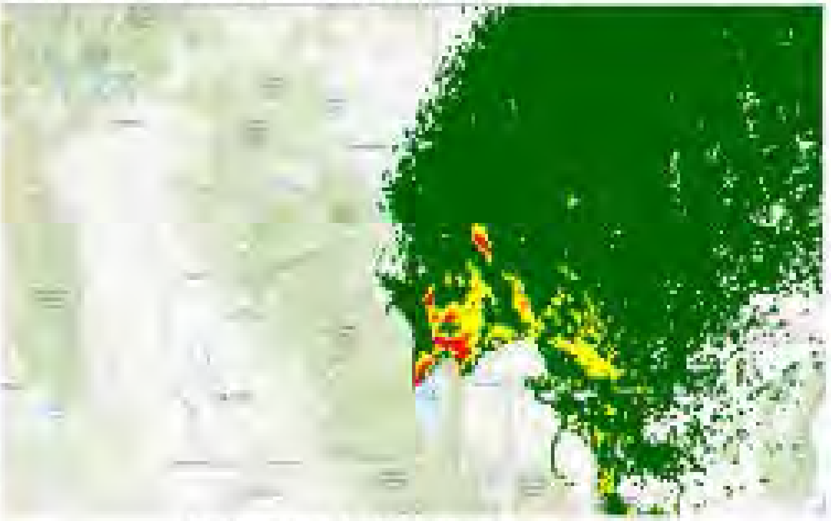
Scenario 1, Replicate 2



Scenario 2, Replicate 8



Scenario 3, Replicate 1

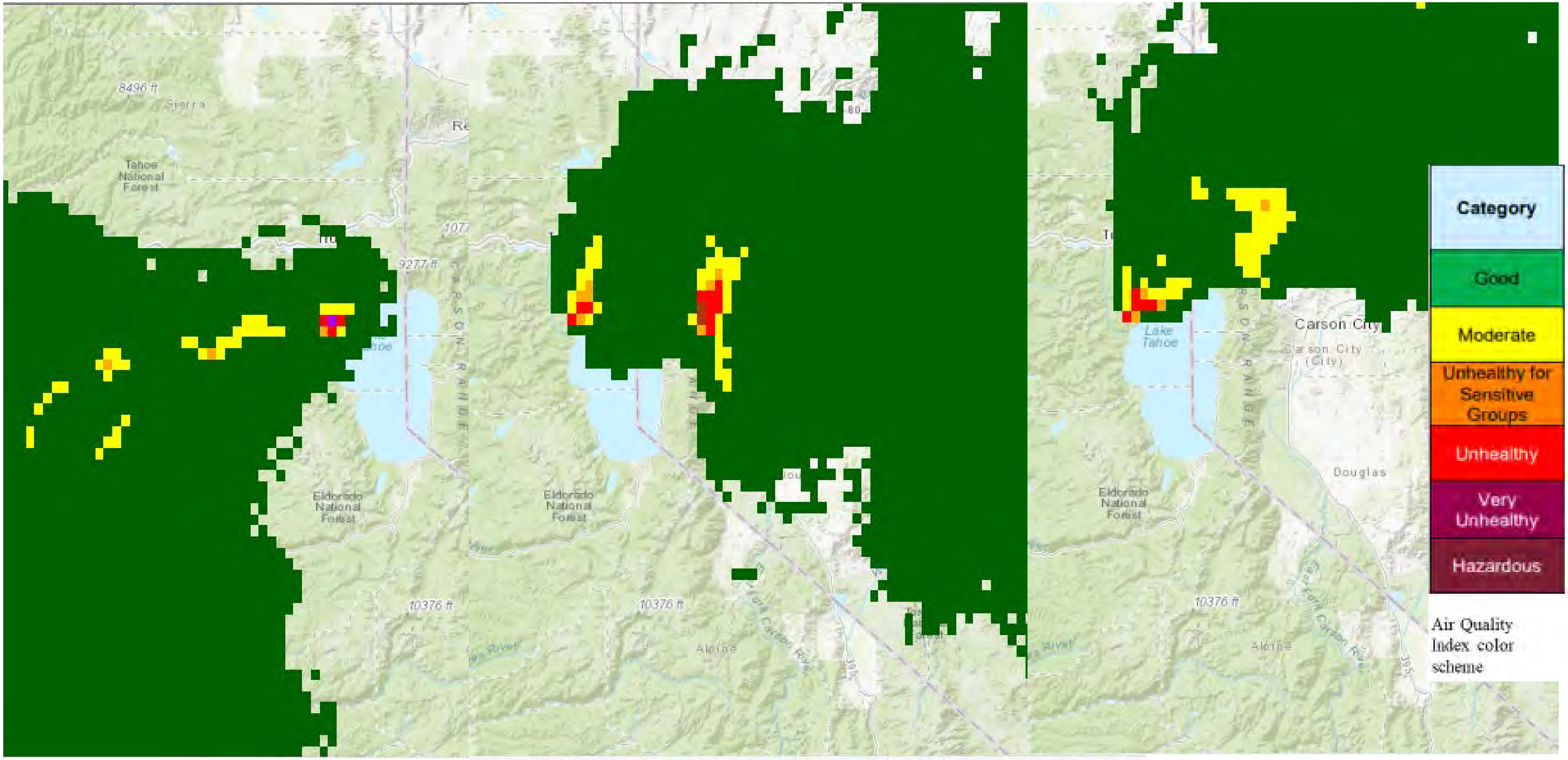


Scenario 4, Replicate 2

Category
Good
Moderate
Unhealthy for Sensitive Groups
Unhealthy
Very Unhealthy
Hazardous

Air Quality Index color scheme

Dispersion Analyses – Rx Fire



2018 2017 2016

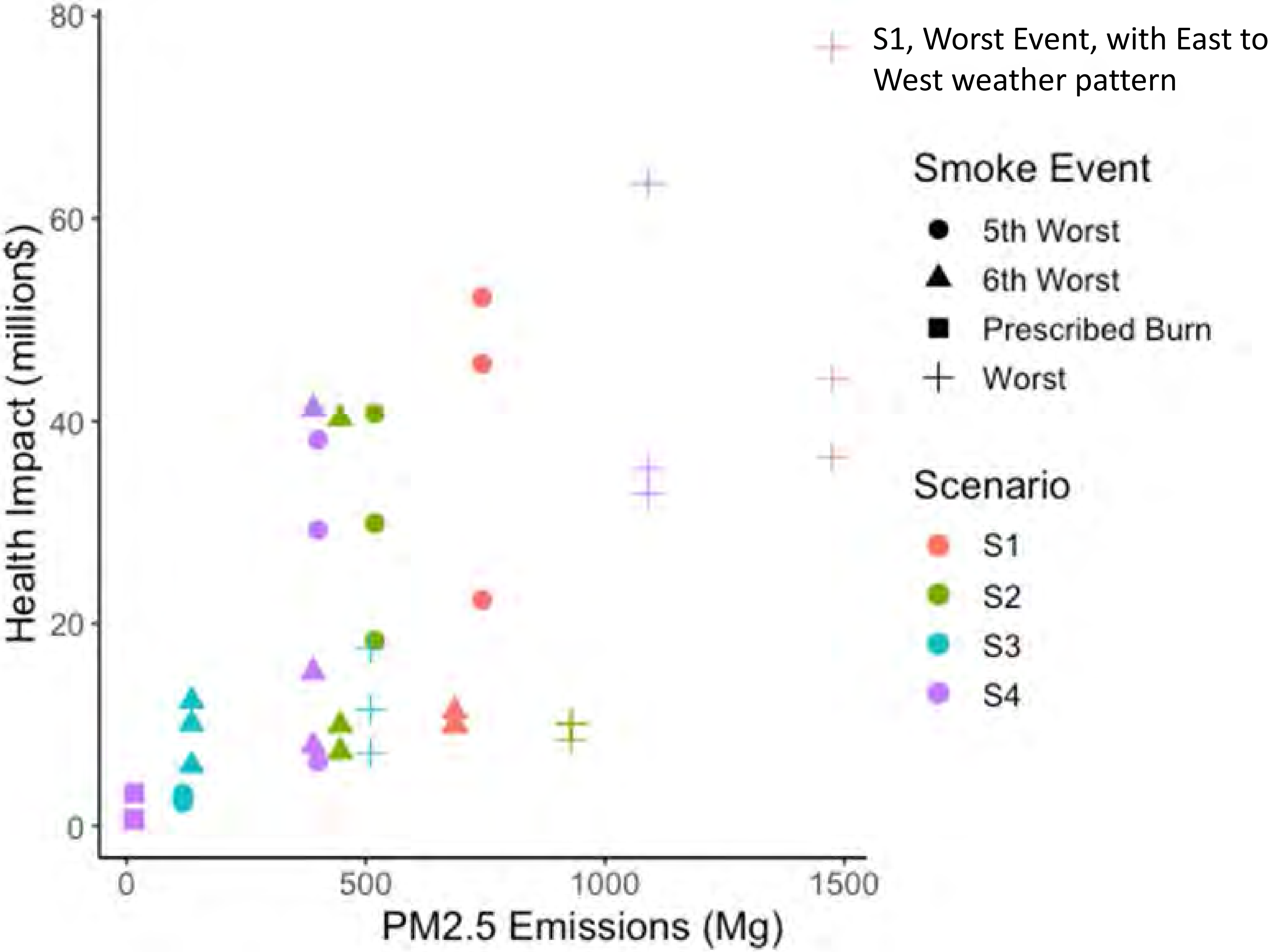
3) Economic Health Impacts of Smoke

- Evaluate health impacts
  - 36 wildfire events (4 scenarios X 3 replicates X 3 weather patterns)
  - 3 prescribed burns (1 replicate X 3 weather patterns)
- Health effects from smoke is measured as cumulative impact after **3 days**.

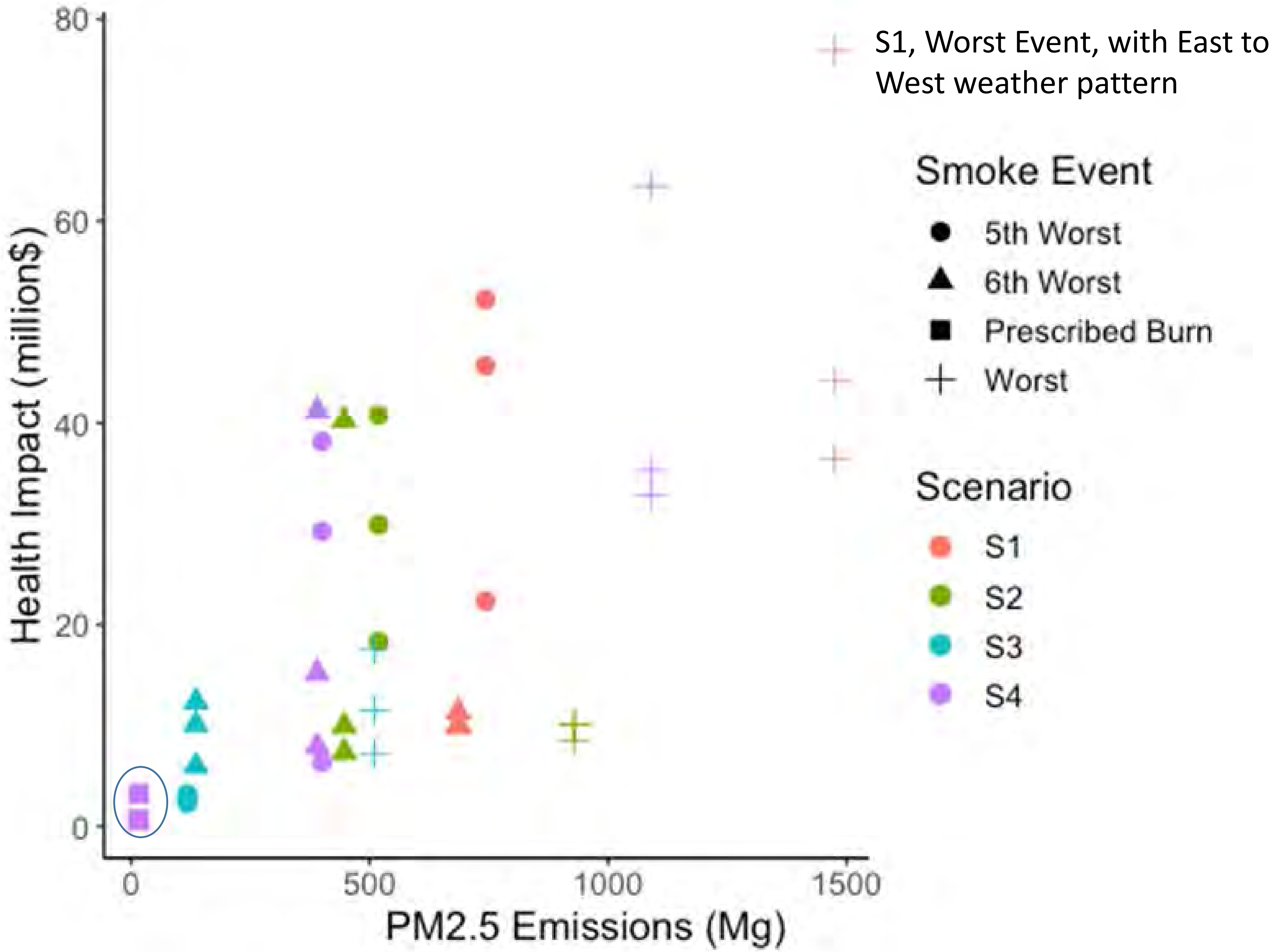
BenMAP Model

- Estimates the economic value of change in fine particulates based upon dose-response functions from wildfire epidemiology literature:
  - Cost of illness for respiratory outcomes (hospital admissions and ER visits)
  - Willingness-to-pay to avoid Minor restricted activity days (MRADs)
  - All-cause mortality valued at $9 million per statistical life

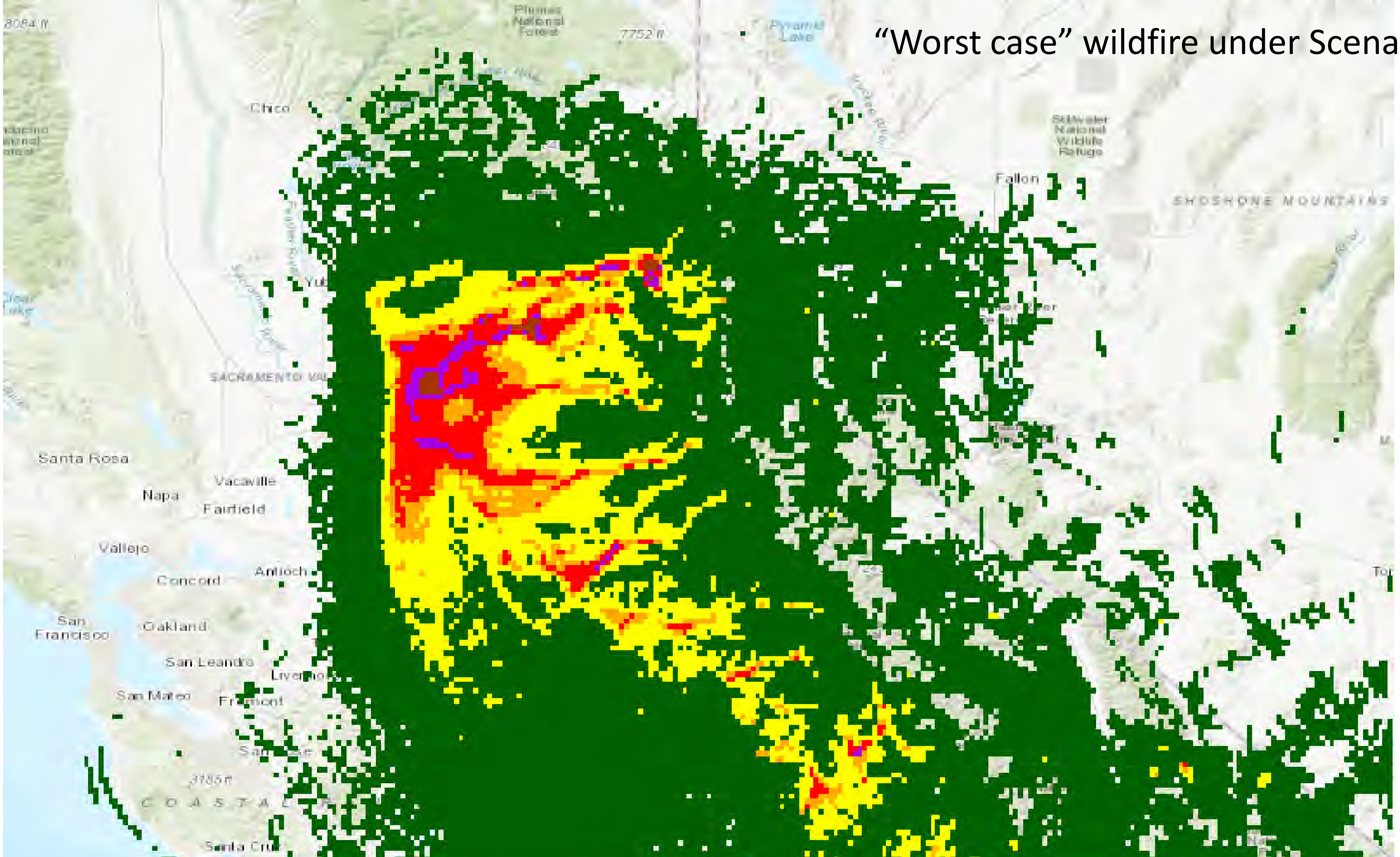
Mortality Effects of Individual Smoke Events



Mortality Effects of Individual Smoke Events

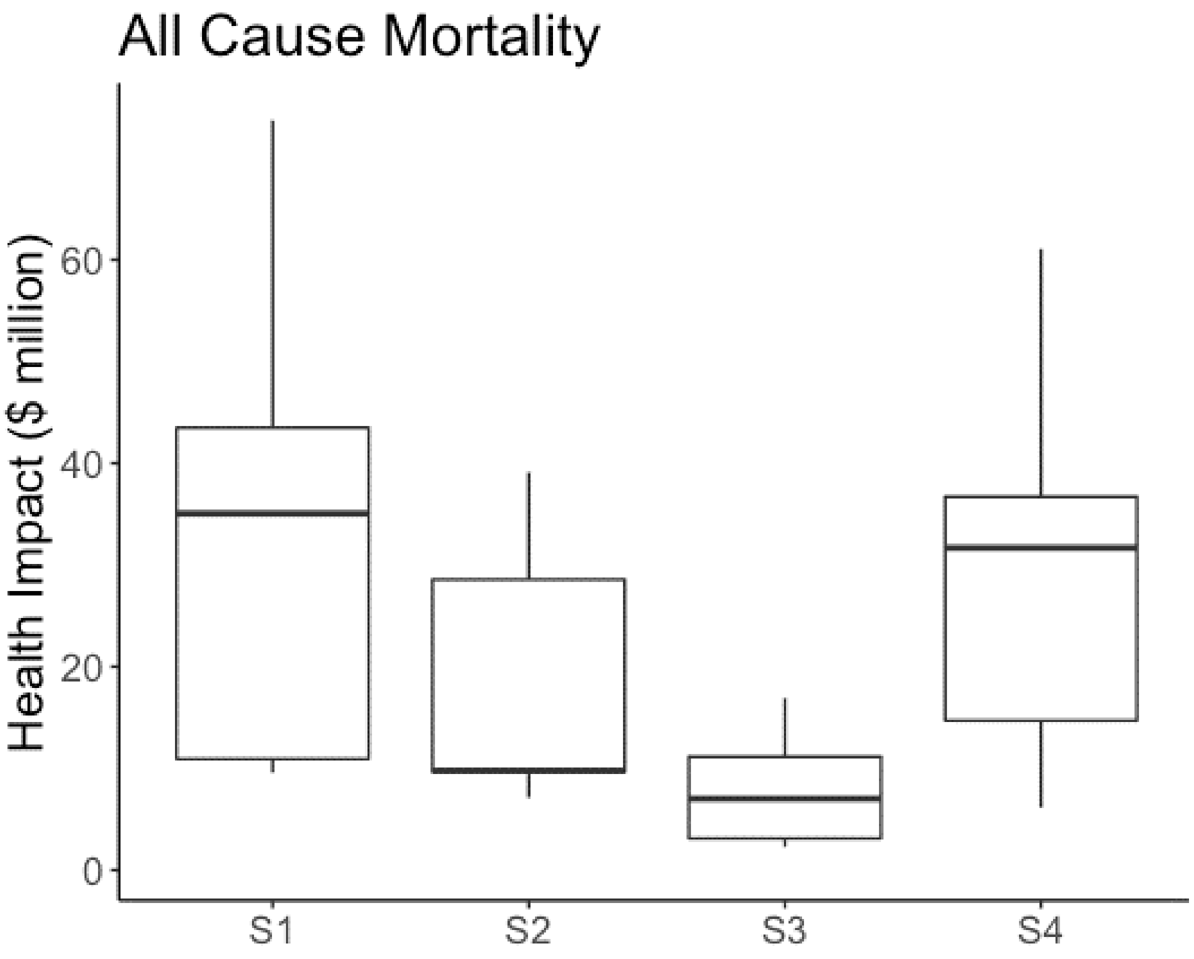


“Worst case” wildfire under Scenario 1

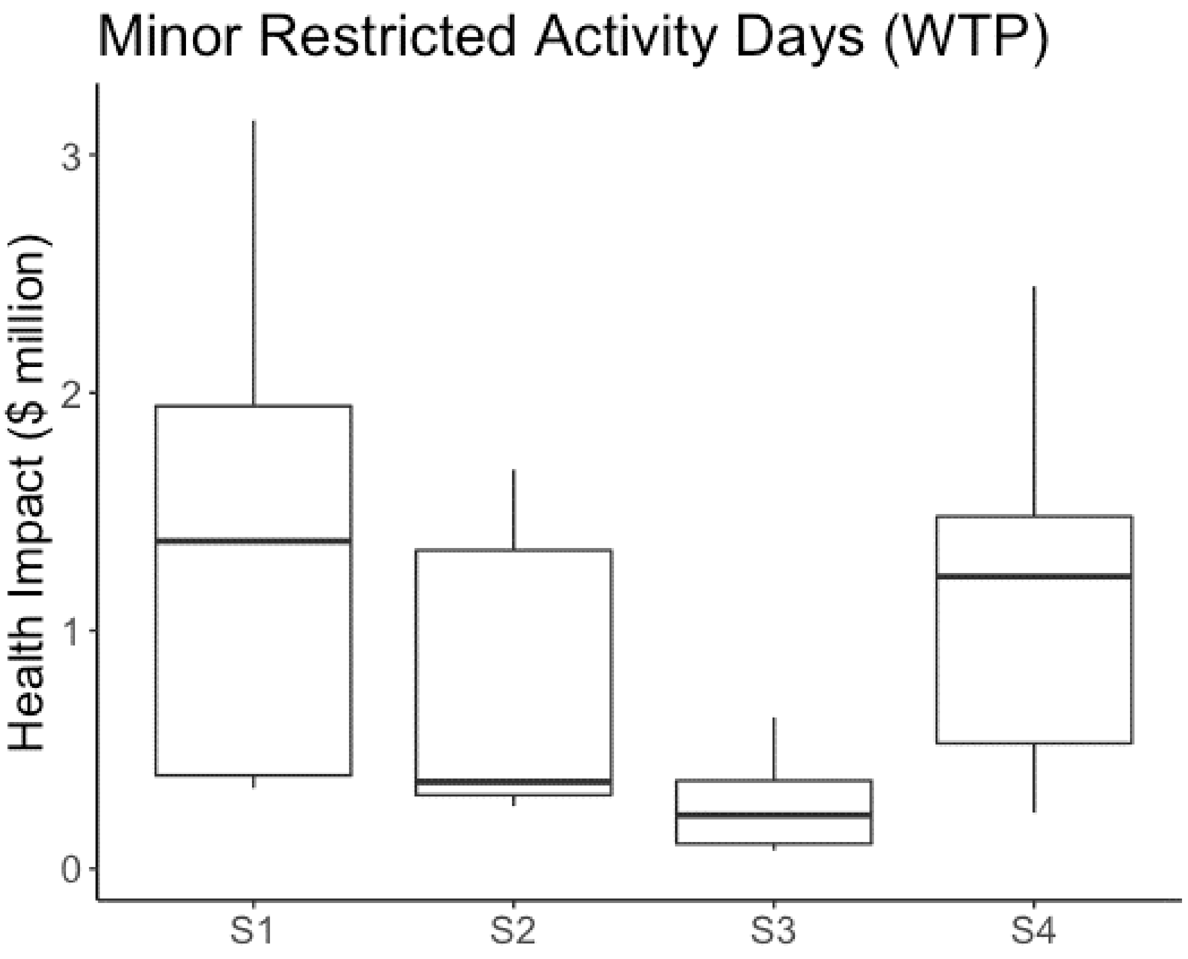


Impacts from 3 day extreme wildfire smoke events under each scenario

Mortality values (10s of Million$)



Willingness to Pay to Avoid (Million$)



Key Findings

- Forest thinning treatments are expected to substantially reduce economic impacts of smoke from extreme wildfires
- Increased use of prescribed fire would reduce peak impacts from wildfires while increasing overall particulate emissions
- Dispersion and resulting impacts vary greatly with weather conditions
- The framework illustrates how we can evaluate tradeoffs, but more comprehensive computations (within a year and across years) would help to fully evaluate the fire-focused regimes in particular

Feasibility Indicators

Scenario	Annual area (acres) of understory burning*	Annual days of intentional burning*	Staffing Required
1	0	0	0
2	0	7.2-10.3	2.0-2.5
3	0	23.9-32.6	4.6-5.7
4	1182-1454	36.1-38.1	2.1-2.4
5	3284-3792	88.1-104.2	3.5-3.8

Modeled average daily rates of prescribed understory burning (not including pile burning):

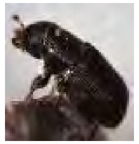
Scenario 4: 40 acres/day X 30 days
Scenario 5: 72 acres/day X 90 days

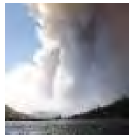
Overview of Indicators by Management Scenario

Lake Tahoe West Science Symposium

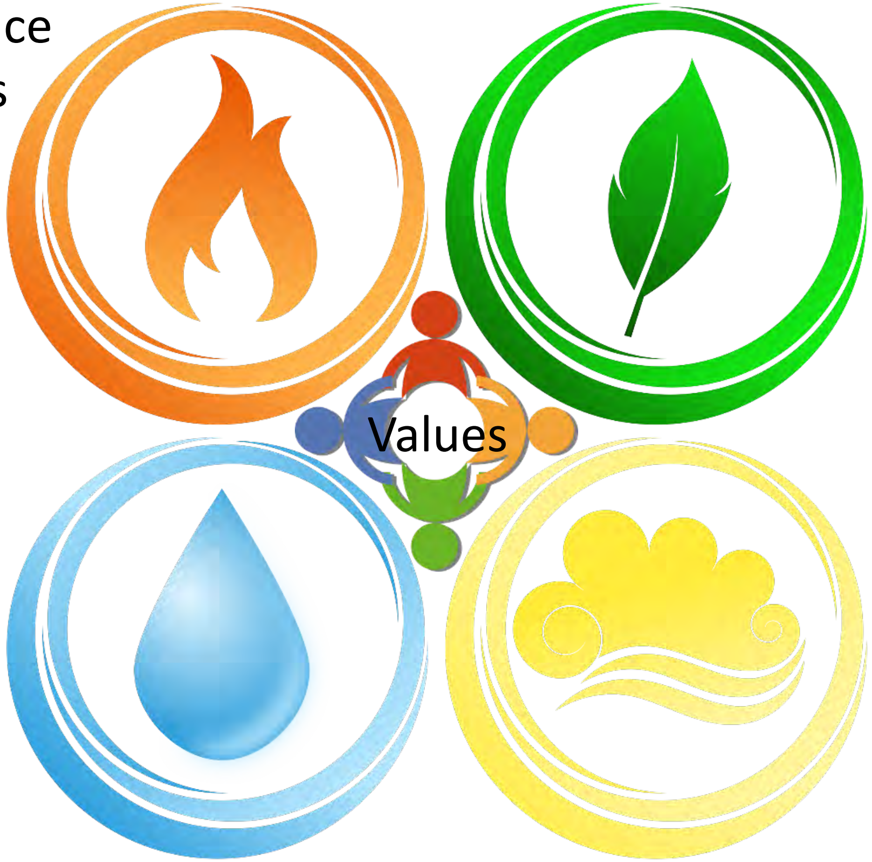
5/29/2020

Presented by Jonathan Long

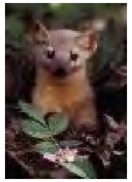




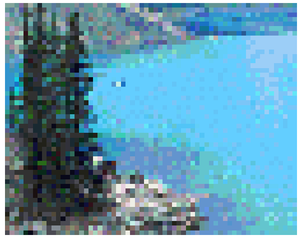
Disturbance regimes



Vegetation and wildlife habitat



Water



Air

Evaluation Criteria	1) Community Values	**WUI fire risk**
		Threats to property (Day 1: Economics)
		Air quality (**Day 2: Air quality**)
		Cultural resource quality
		Carbon sequestration (Day 1: Economics)
		Restoration by-products (Day 1: Economics)
	2) Environmental Quality	**“Functional” fire regime**
		Upland vegetation health
		Wildlife habitat quality (See Day 1: Wildlife)
		Water quality (**Day 2**)
		Water quantity (**Day 2**)
	3) Operations	Net Treatment Costs (Day 1: Economics)
		Suppression Costs (Day 1: Economics)
		Staffing (**Day 2: Air Quality**)
		Days of Intentional Burning (**Day 2: Air Quality**)

"Functional" Fire Regime Indicators

- Initial Design Team guidance
  - 1) Highlighted % burn at different severities and size of high severity patches as performance indicators
  - 2) Used Fire Return Interval Departure to inform the assessment
- Using % burn severity alone, or FRID and % burn severity together as *performance indicators* can lead to odd outcomes
  - For example, two large wildfires with uncharacteristic burn severity might score the same or better than a single small one
- So, we devised scoring systems for % of **total landscape area burned at different severities**, adjusted by management zone

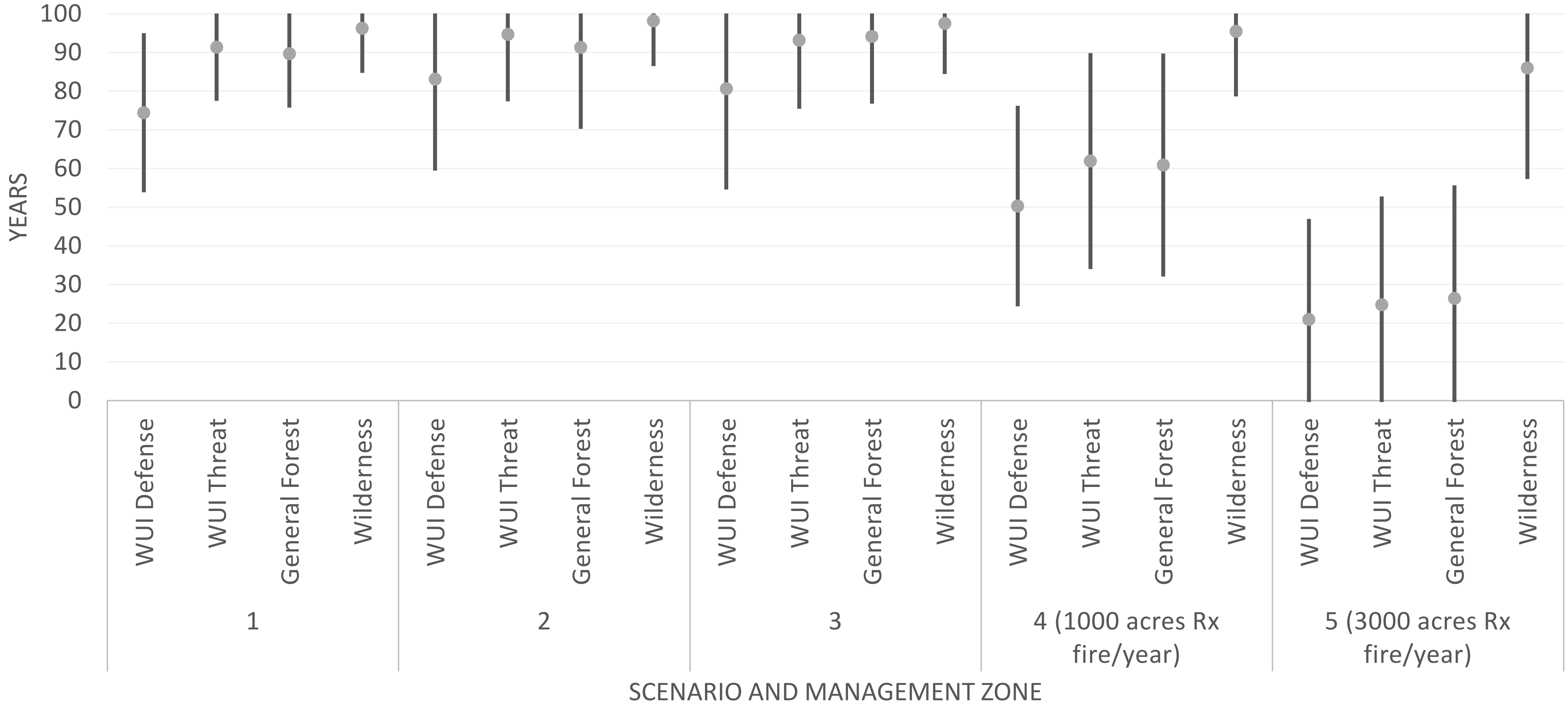
Scoring Fire Regime Indicators

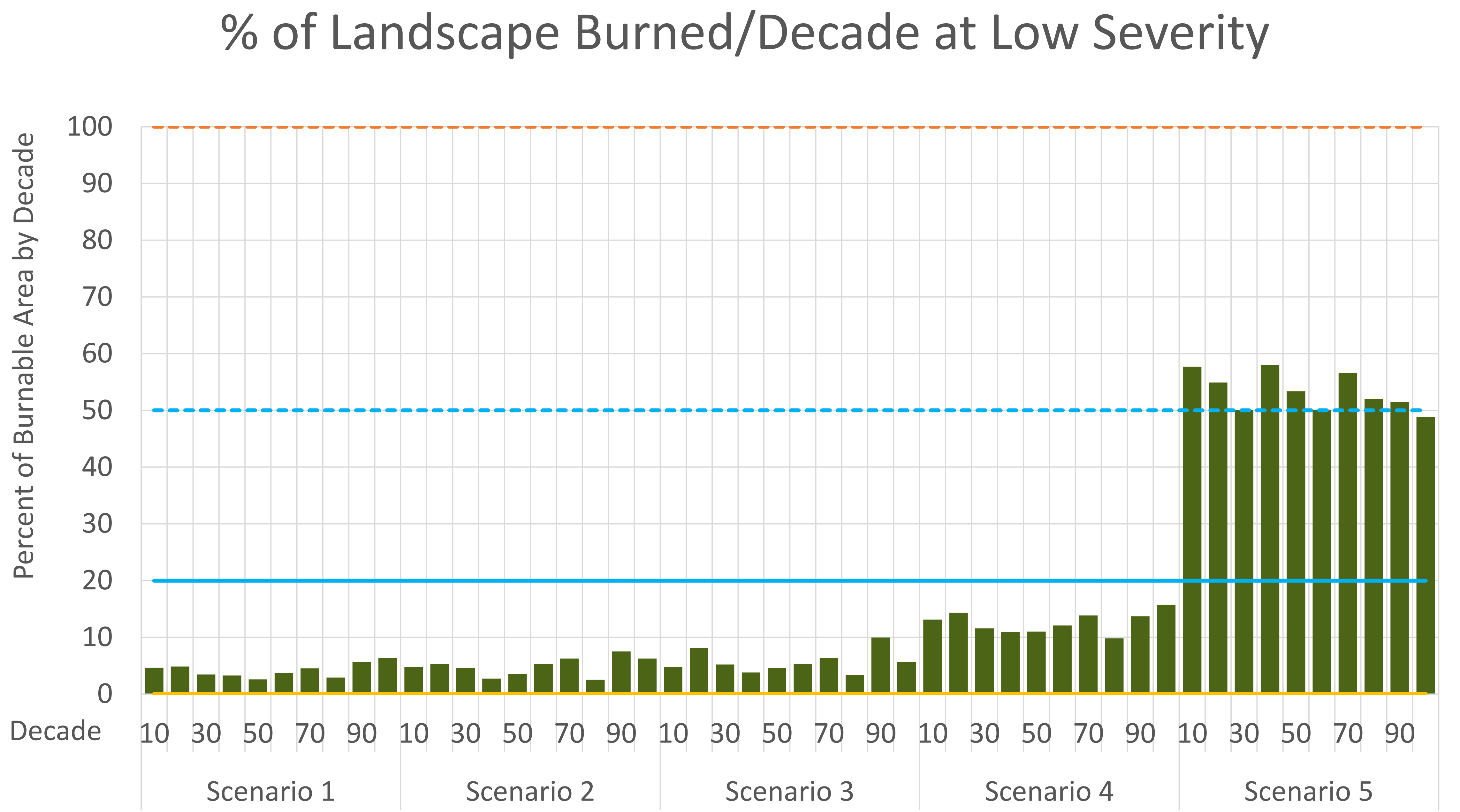
Amount of fire associated with favorable conditions was related to reference fire return intervals for lower and upper elevation types within each management zone

Wilderness Zone: wildfire is more socially tolerable but is expected to be less frequent than in lower elevation areas

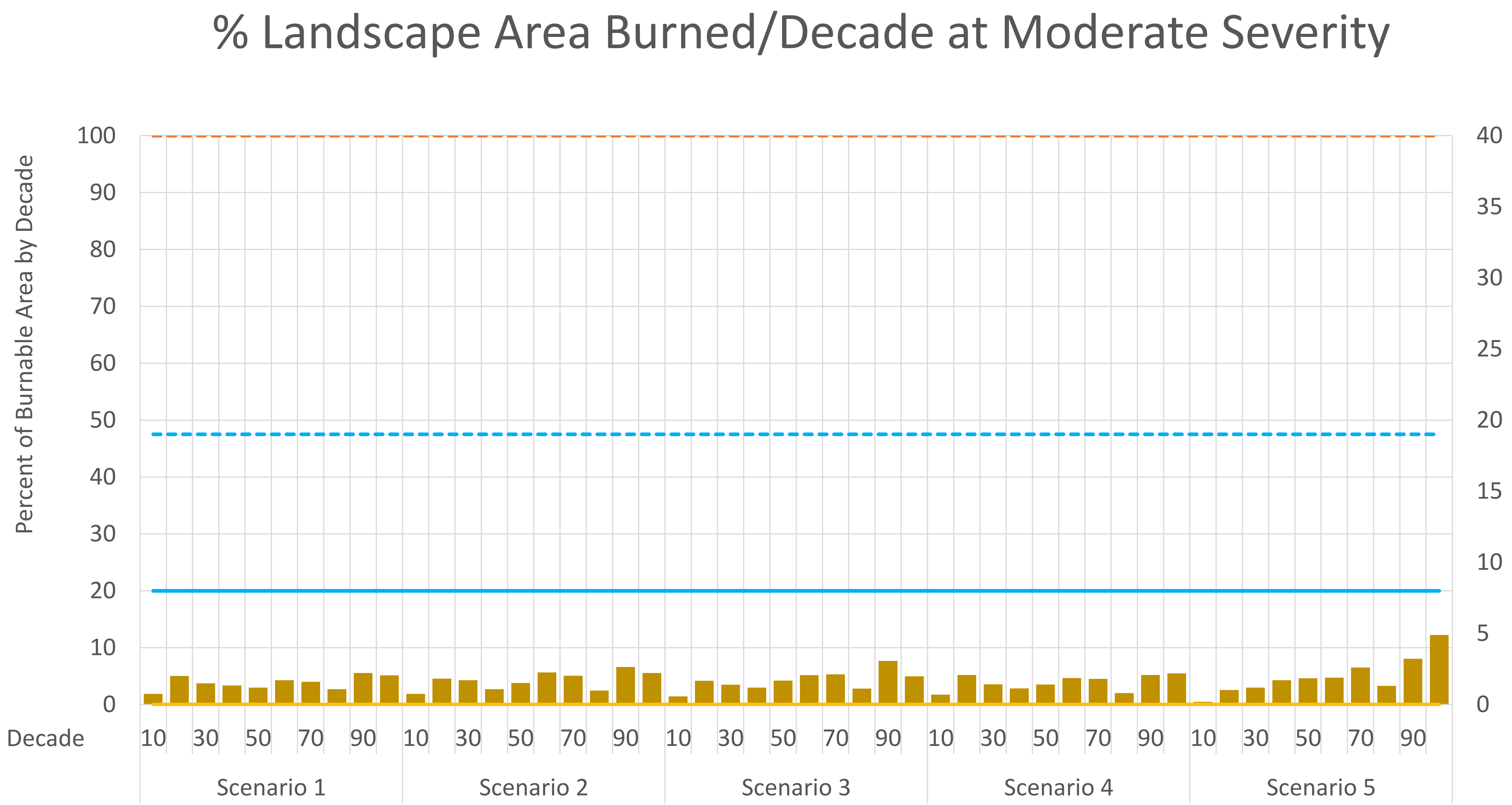
WUI Zones: due to focus on threats to life and property, there were no scoring penalties for a lack of high or moderate severity fire in the threat zone, and a penalty for any such fires in the defense zone

Approximate Fire Return Intervals by Zone

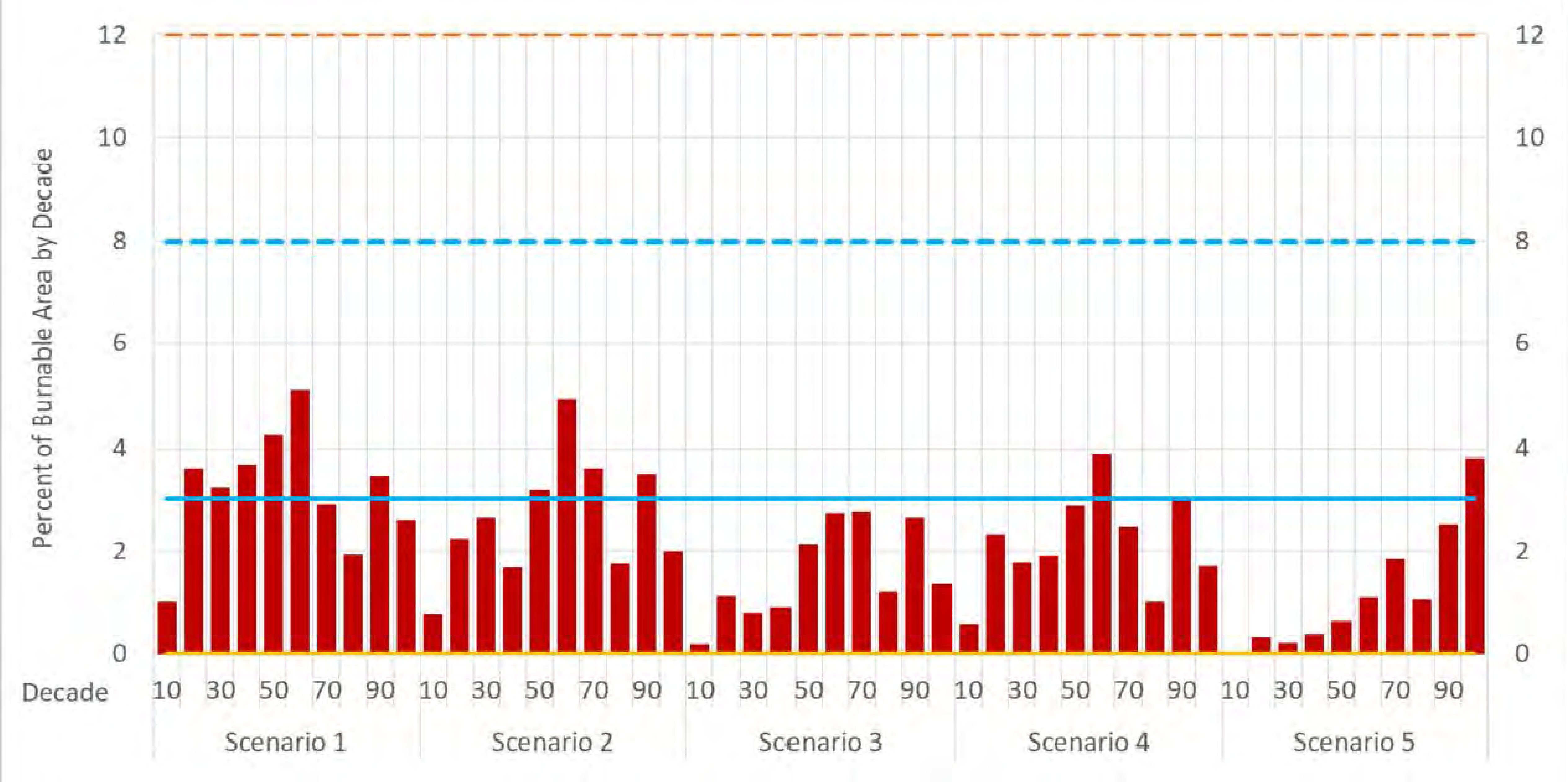




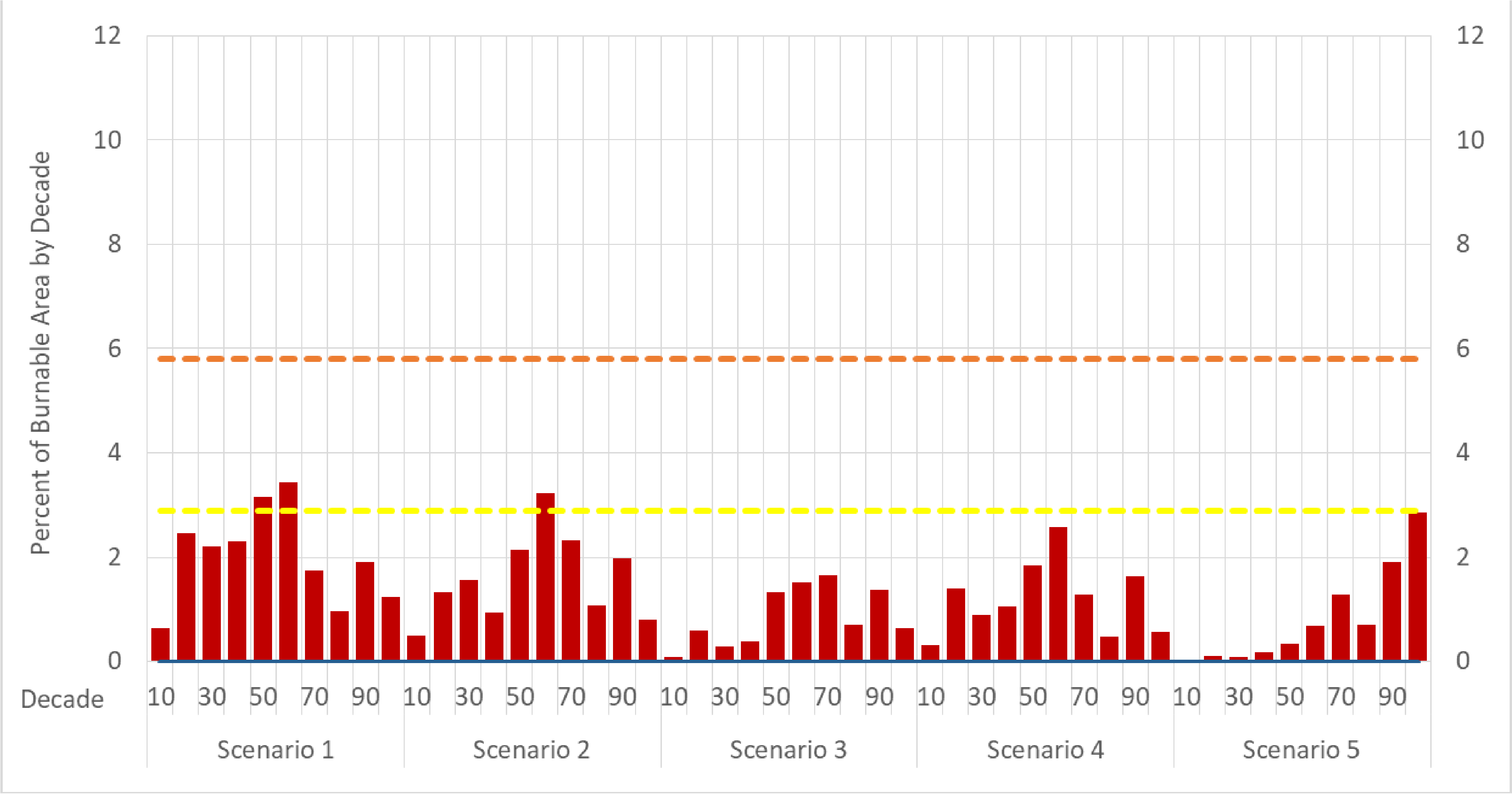
% of Landscape Burned/Decade at Low Severity
Percent of Burnable Area by Decade
100
90
80
70
60
50
40
30
20
10
0
Decade
10 30 50 70 90 10 30 50 70 90 10 30 50 70 90 10 30 50 70 90 10 30 50 70 90
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5


% Landscape Area Burned/Decade at Moderate Severity
Percent of Burnable Area by Decade
100
90
80
70
60
50
40
30
20
10
0
40
35
30
25
20
15
10
5
0
Decade
10 30 50 70 90 10 30 50 70 90 10 30 50 70 90 10 30 50 70 90 10 30 50 70 90
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5

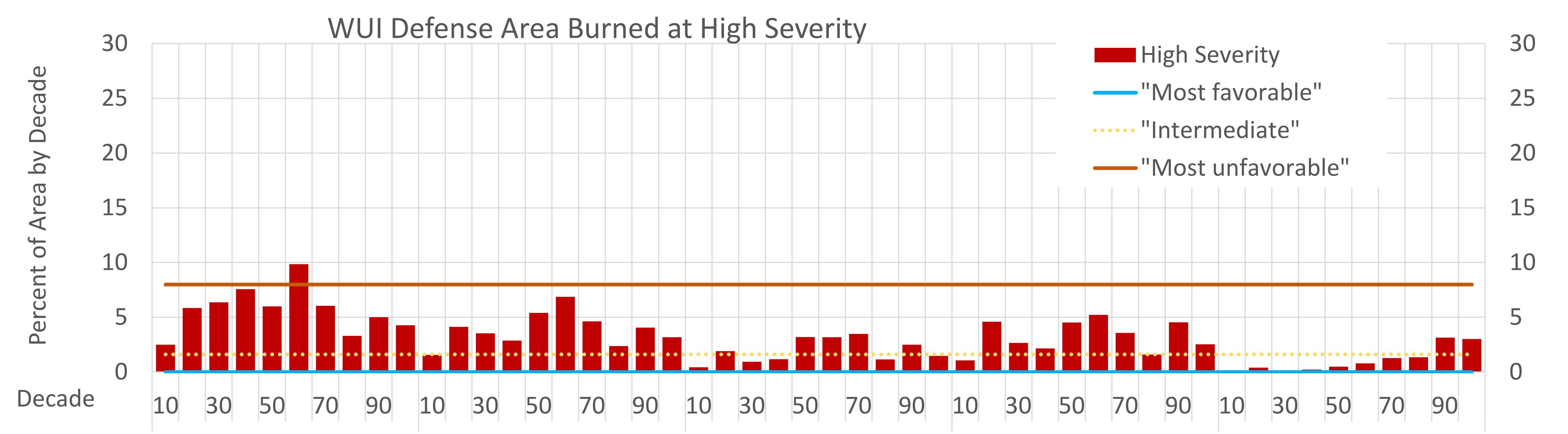
% Landscape Area Burned/Decade at High Severity

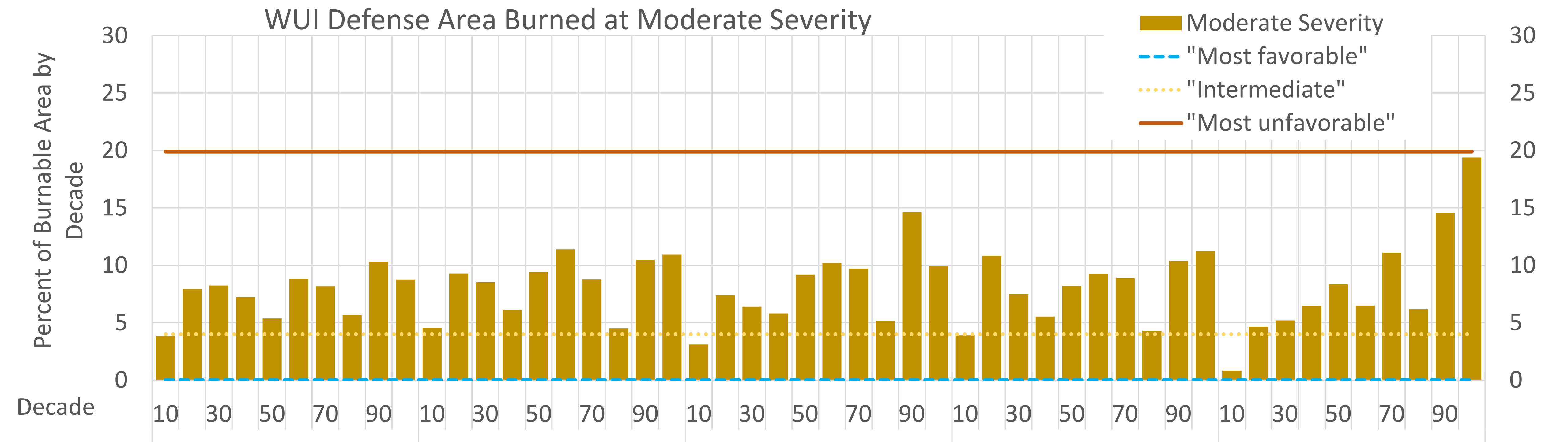


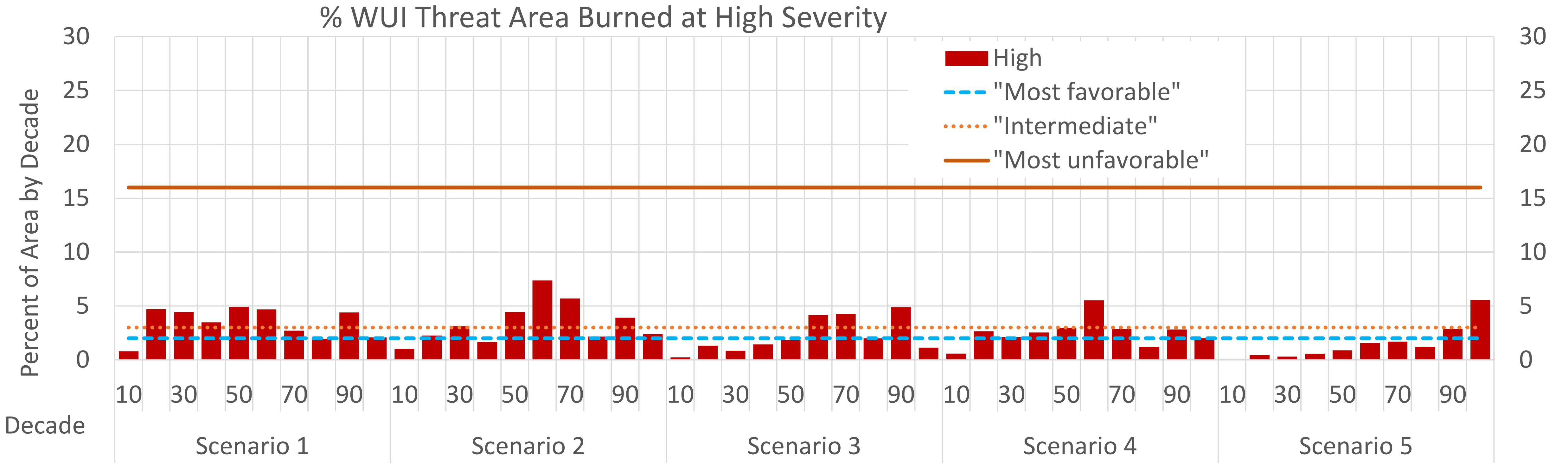
% of Landscape Burned in High Severity Patches



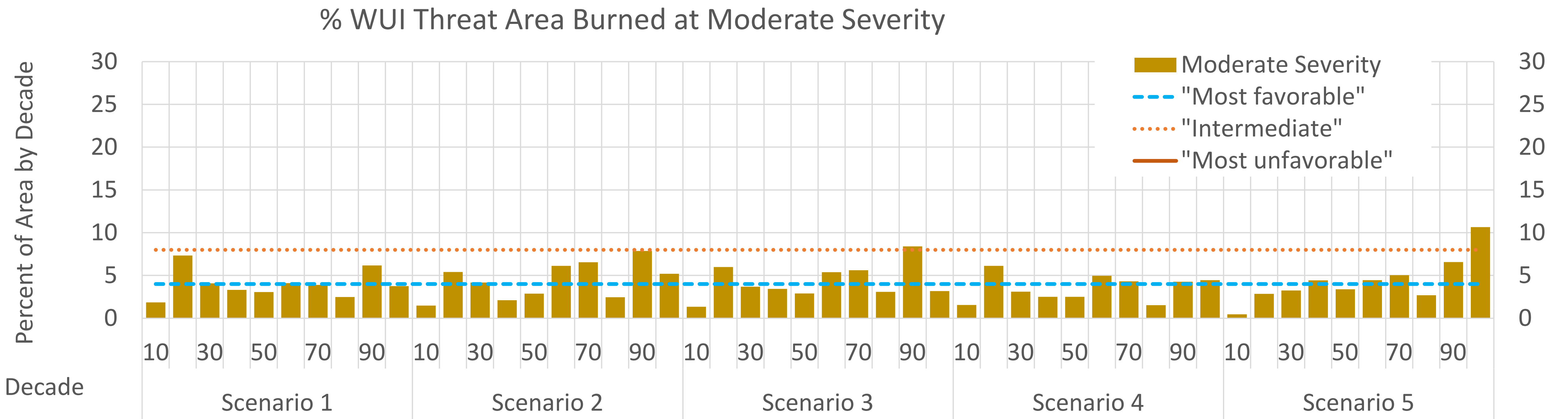
WUI Fire Risk Indicators


WUI Defense Area Burned at High Severity
High Severity
"Most favorable"
"Intermediate"
"Most unfavorable"
Percent of Area by Decade
Decade
0
5
10
15
20
25
30
10
30
50
70
90


WUI Defense Area Burned at Moderate Severity
Moderate Severity
"Most favorable"
"Intermediate"
"Most unfavorable"
Percent of Burnable Area by Decade
Decade
0
5
10
15
20
25
30
10
30
50
70
90

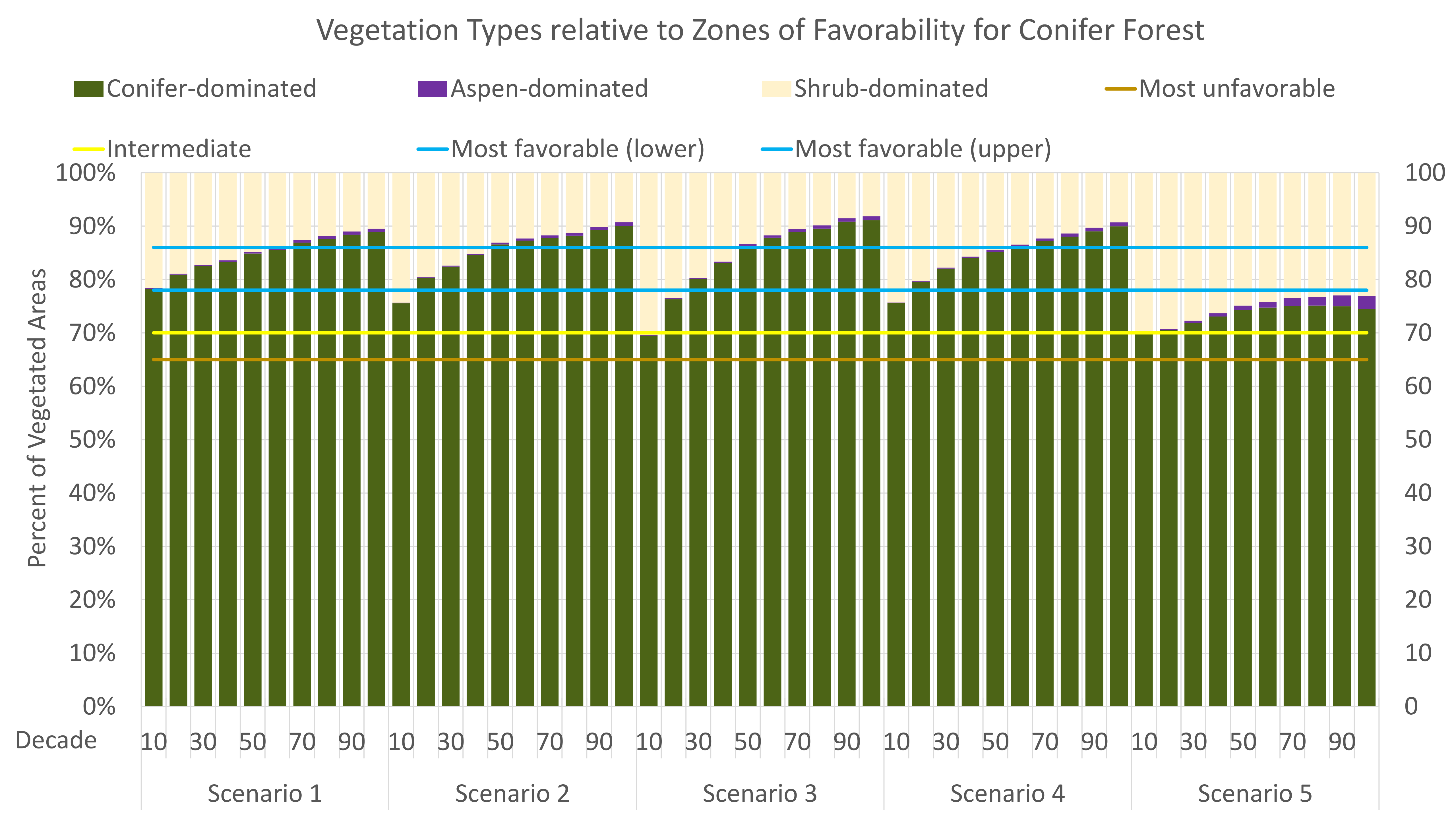


% WUI Threat Area Burned at High Severity
High
"Most favorable"
"Intermediate"
"Most unfavorable"
Percent of Area by Decade
0
5
10
15
20
25
30
10
30
50
70
90
Decade
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5

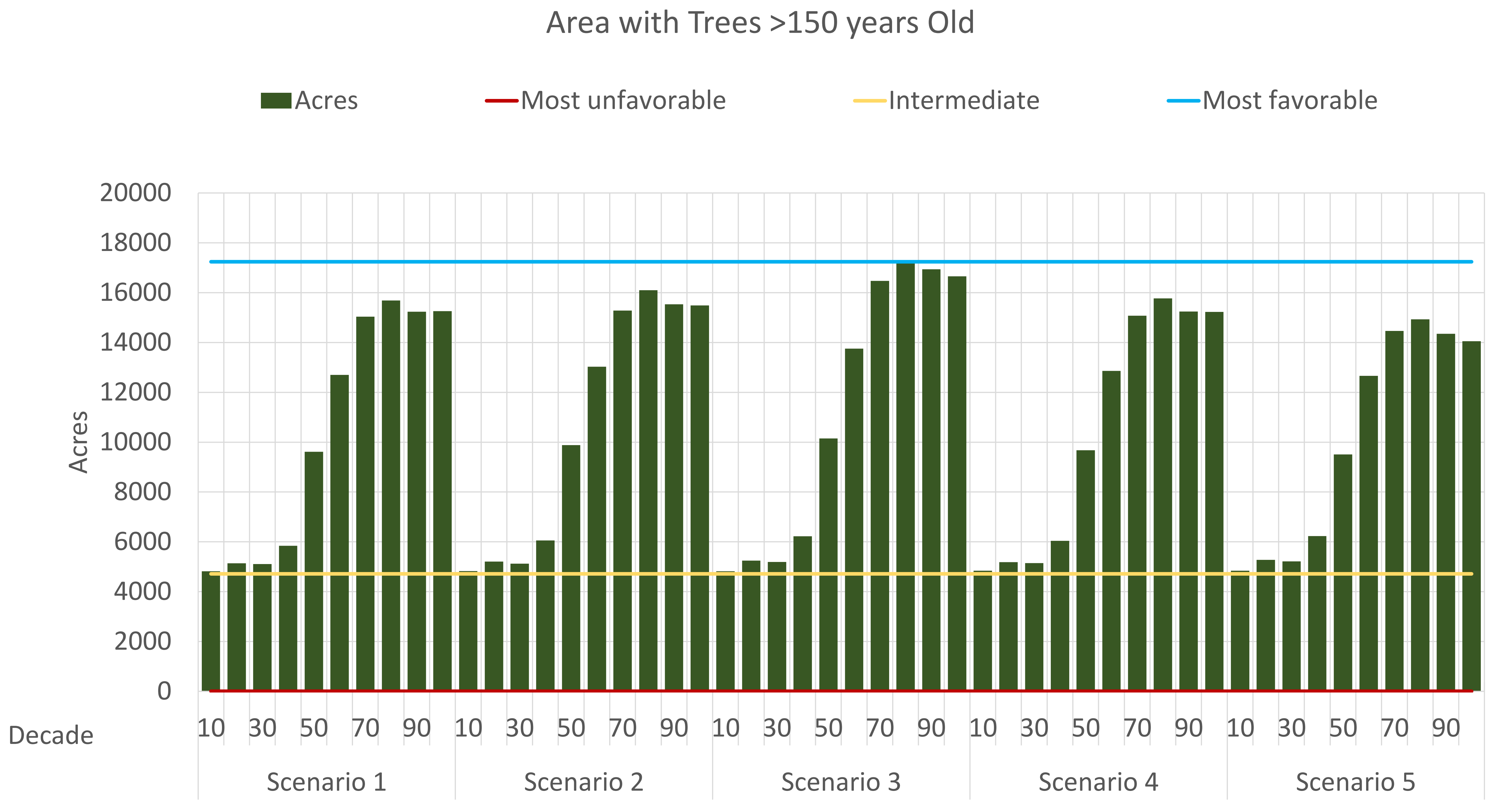


% WUI Threat Area Burned at Moderate Severity
Moderate Severity
"Most favorable"
"Intermediate"
"Most unfavorable"
Percent of Area by Decade
0
5
10
15
20
25
30
10
30
50
70
90
Decade
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5

Healthy Upland Vegetation Indicators

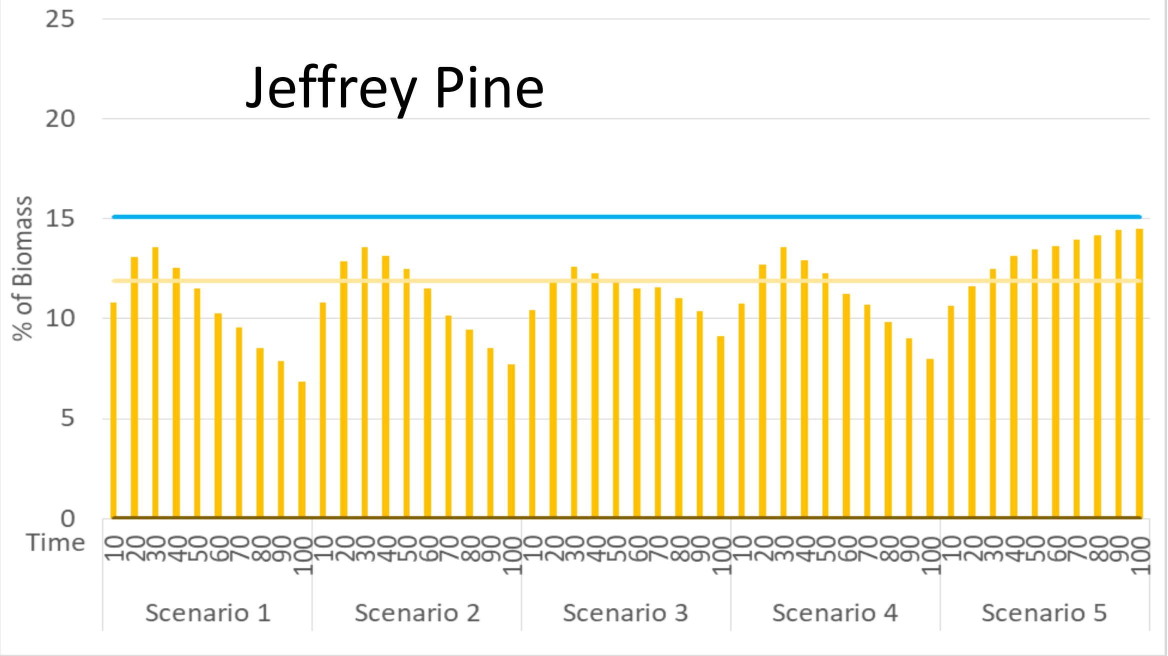


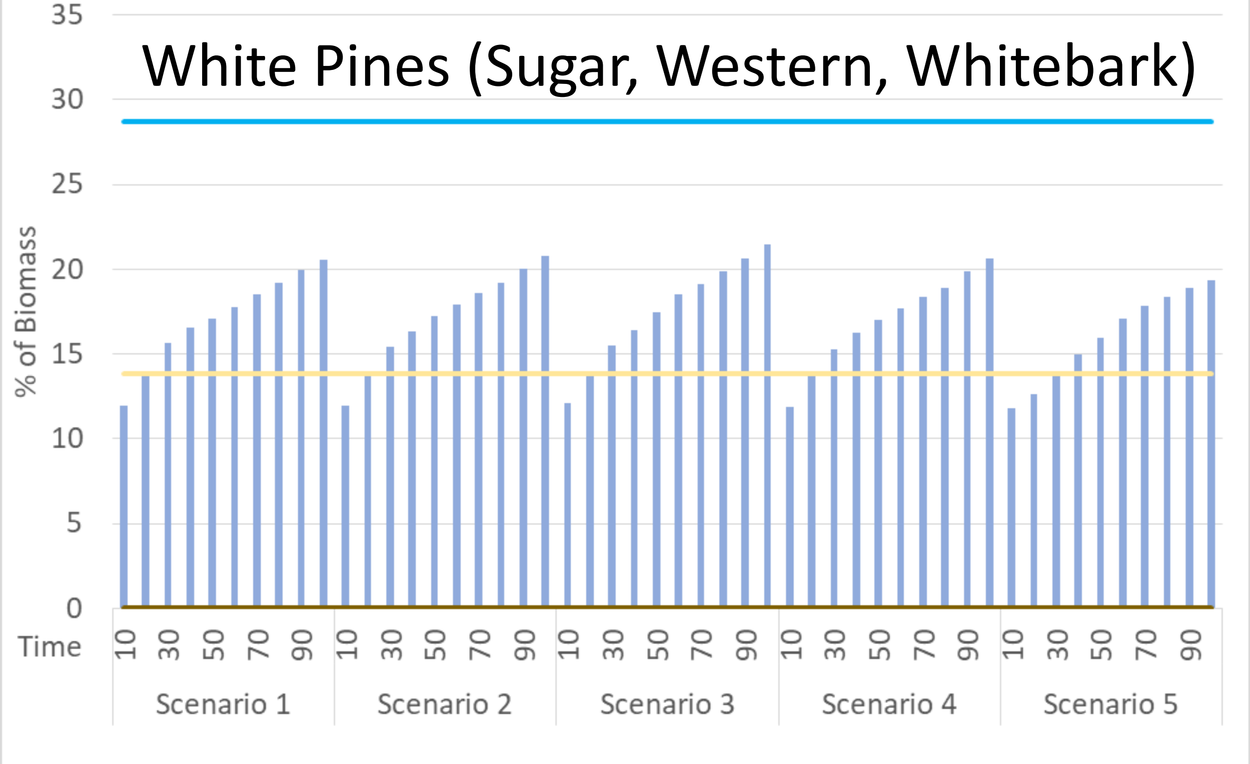
Vegetation Types relative to Zones of Favorability for Conifer Forest
Conifer-dominated
Aspen-dominated
Shrub-dominated
Most unfavorable
Intermediate
Most favorable (lower)
Most favorable (upper)
Percent of Vegetated Areas
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
100
90
80
70
60
50
40
30
20
10
0
Decade
10 30 50 70 90
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5

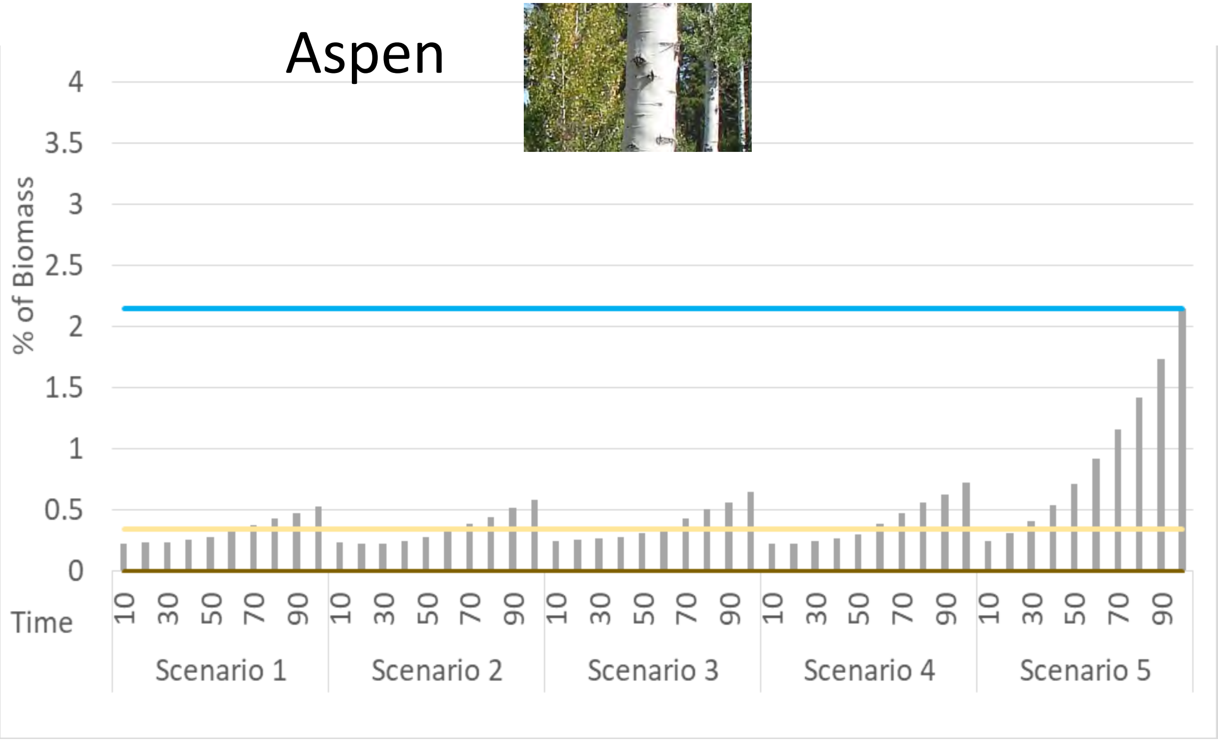


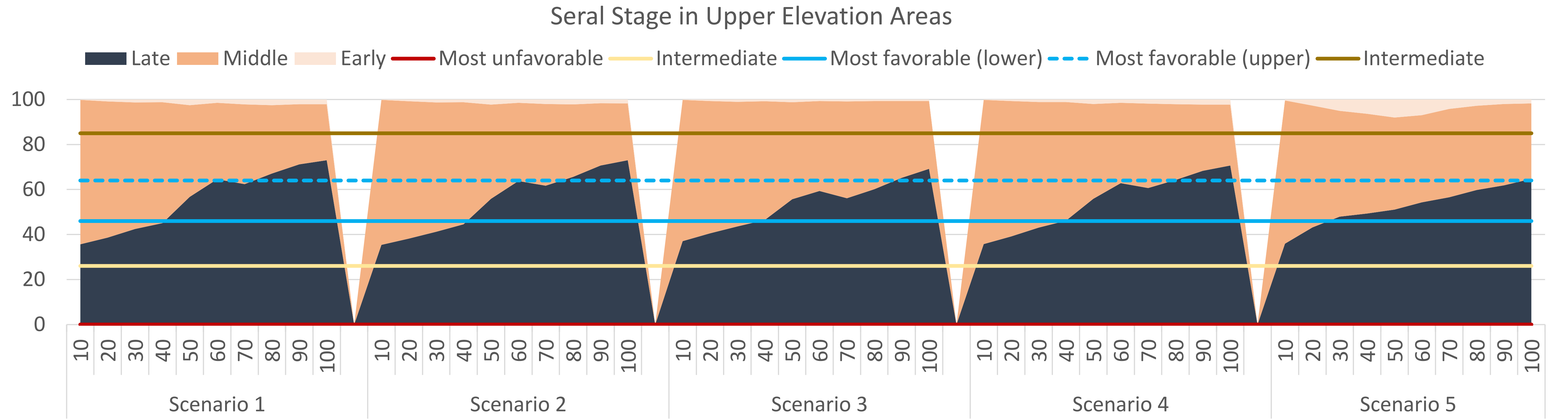
Area with Trees >150 years Old
Acres
Most unfavorable
Intermediate
Most favorable
Acres
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Decade
10 30 50 70 90
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5

Species Composition

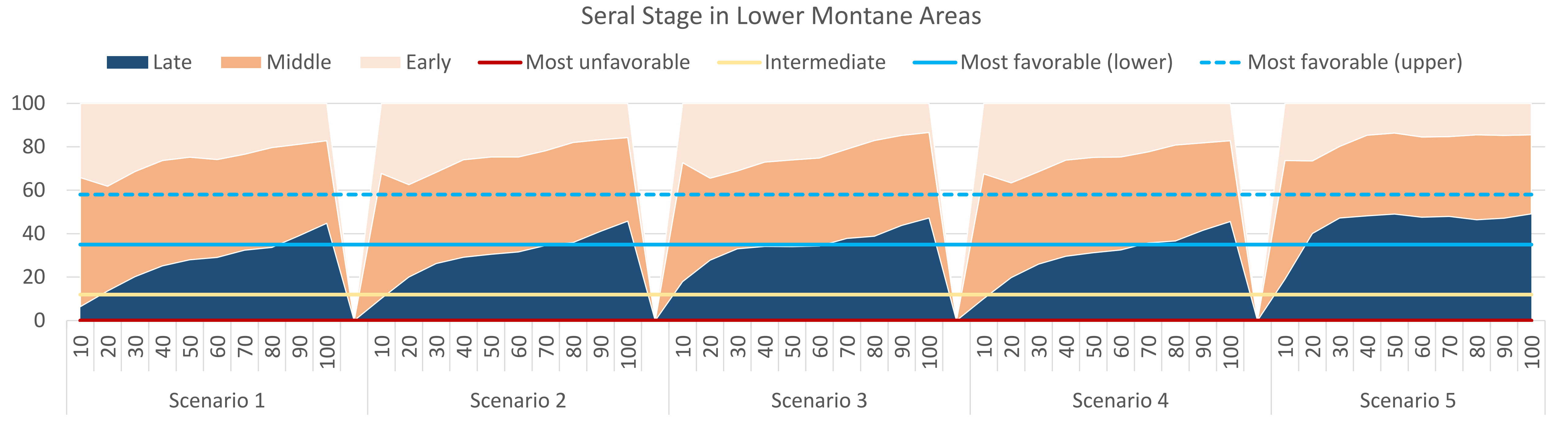






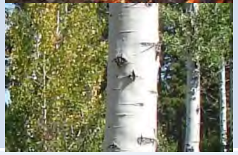
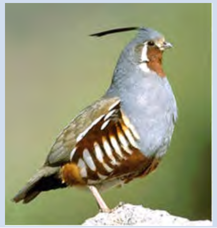


Seral Stage in Upper Elevation Areas
Late
Middle
Early
Most unfavorable
Intermediate
Most favorable (lower)
Most favorable (upper)
Intermediate
0
20
40
60
80
100
10 20 30 40 50 60 70 80 90 100
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5



Seral Stage in Lower Montane Areas
Late
Middle
Early
Most unfavorable
Intermediate
Most favorable (lower)
Most favorable (upper)
0
20
40
60
80
100
10 20 30 40 50 60 70 80 90 100
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5

Cultural Resources Quality

		Scenario				
Indicator		1	2	3	4	5
% area burned at low-intensity		4.20	4.90	5.70	**12.60**	**53.30**
% Aspen-dominated area		0.38	0.37	0.41	0.40	**1.09**
Mule deer high quality reproductive habitat		21.00	22.40	**24.50**	22.20	21.10
% Mountain quail high quality reproductive habitat		32.40	32.60	32.20	32.40	**24.30**
% Northern flicker high quality reproductive habitat		22.80	23.70	**24.30**	23.30	**20.70**

Responsiveness of Indicators

	Highly Responsive to Management Scenario	Not Highly Responsive to Management Scenario
	• Fire risk to property in WUI areas • Area burned at high severity and in large patches at high severity • Area burned at low severity (including prescribed fire)	• Total area burned by wildfire
	• Days of very high or extreme emissions of particulate matter and smoke impacts	
	• Leaf area index as proxy for increased water availability	• Water quality
	• Relative abundance of certain species (e.g., aspen) • In-forest and overall carbon storage (although not very sensitive in terms of dollar value)	• Wildlife habitat overall • Area of old forest
	• Up-front treatment cost and suppression costs	• Net cost of suppression and treatment