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 mode
- Click on the **Q&A icon** to submit questions
- Use the **Chat feature** if you need technical assistance. Send a messages to Panelists
- We recommend joining through phone + computer if your audio or internet is poor

Introductions

Sarah Di Vittorio, Northern California Program Manager, National Forest Foundation
LTW Project Manager

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

Jonathan Long, Opening Remarks

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

Day 1: May 19

Lake Tahoe West Science Symposium

TIME	AGENDA ITEM	PRESENTER
9:00 am	**Welcome, Zoom Overview, Agenda Review, Introductions** **Opening Remarks**, Jonathan Long	**Sarah Di Vittorio,** National Forest Foundation **Jonathan Long,** Forest Service Pacific Southwest Research Station (PSW)
9:10 am	**Overview of Lake Tahoe West and Science** 10-minute presentation followed by 5-minute Q&A	**Nadia Tase**, CalFire
9:25 am	**Overview of LTW Modeling Effort** Overview of goals, scope, science products, and scenarios used in modeling	**Pat Manley,** PSW **Jonathan Long**, PSW
10:00 am	**BREAK (30 minutes)**	
10:30 am	**Results of Modeling Landscape Dynamics (Fire, Vegetation, Carbon)** 30-minute presentation followed by 10-minute Q&A	**Charles Maxwell** with **Rob Scheller**, North Carolina State University
11:10 am	**Wildlife Habitat Modeling** 25-minute presentation followed by 10-minute Q&A	**Angela White**, PSW
11:45 am	**LUNCH BREAK (60 minutes)**	
12:45 pm	**Economics** 20-minute presentation followed by 10-minute Q&A	**Sam Evans**, Mills College, with **Matthew Potts,** University of California, Berkeley
1:15 pm	**BREAK (15 minutes)**	
1:30 pm	**Group Discussion: Take-homes for landscape-scale social ecological resilience and for management** 30 minutes **Pat Manley**, Moderator	**All presenters** **LTW Staff:** **Stephanie Coppeto**, Forest Service Lake Tahoe Basin Management Unit (LTBMU) **Shana Gross**, LTBMU
2:00 pm	***ADJOURN***	

Day 2: May 29

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)**	
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***	

LAKE TAHOE WEST RESTORATION PARTNERSHIP

Lake Tahoe West Partnership & Science

Nadia Tase

CA Dep’t of Forestry and Fire Protection / Tahoe Fuels and Fire Team

N
Squaw Valley
Alpine Meadows
28
Burton Creek
State Park
Dollar Point
89
Tahoe City
California
Nevada
Granite Chief
Wilderness
LAKE TAHOE
Homewood
Homewood
Ski Area
Tahoma
Placer County
El Dorado County
Ed Z'berg
Sugar Pine Point
State Park
Meeks Bay
Rubicon
Bay
D L Bliss
State Park
Emerald Bay
State Park
Emerald Bay
Cascade
Lake
Upper Truckee
River
City of South
Lake Tahoe
Desolation
Wilderness
Fallen
Leaf Lake
LAKE TAHOE WEST
LANDSCAPE BOUNDARY
Planning Area (entirely within Lake Tahoe Basin)
USDA Forest Service, Other National Forests
USDA Forest Service, Lake Tahoe Basin Management Unit
California Tahoe Conservancy
California State Parks
Local
Private
Wilderness

Governance approach

- Collaborative
- Six convening organizations and agencies
- Multiple interagency teams
- Two stakeholder committees
- Science Team

Development of a Science-Based Restoration Strategy

The Lake Tahoe West partners wove together several key sources of scientific information to develop this Strategy. These sources include:

A Landscape Resilience Assessment completed by the Lake Tahoe West partners in 2017

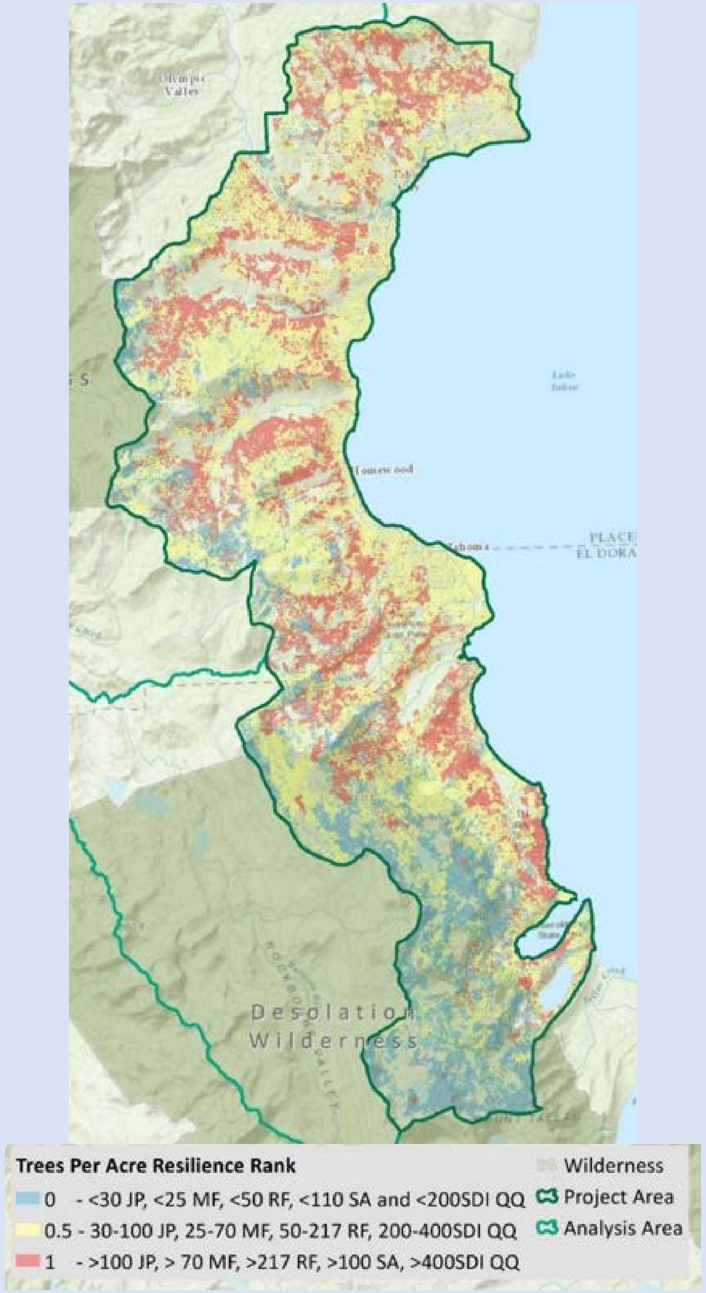
Existing scientific studies and reports, as well as professional expertise of the Interagency Design Team, Science Team, and Stakeholder Committees

An integrated landscape modeling analysis of the impacts of different management approaches on the west shore

Landscape Resilience Assessment
TPA example

Vegetation Type	Number of Trees per Acre and Resilience Rank[1]		
	Resilient (0)	Less Resilient (0.5)	Least Resilient (1)
Jeffrey pine	0-60	60-130	>130
White fir – mixed conifer	0-55	55-100	>100
Red fir	0-80	80-247	>247
Subalpine	<140	N/A	≥140
Aspen[2]	<200 SDI	200-400 SDI	>400 SDI

[1] Resilient = mean of historic and/or reference condition data for trees per acre.
Less Resilient = Greater than mean of historic and/or reference condition data but within upper range of trees per acre as described in the literature for that vegetation type.
Least Resilient = Trees per acre exceeds that which has been documented in the literature.
[2] Data for aspen is in Stand Density Index (SDI) and not Trees per acre.



Landscape Restoration Strategy

Goal 1 – Forests recover from fire, drought, and insect and disease outbreaks

Objective 1A

- Decrease tree density on 40,000 acres to move forests closer to within the range of natural variation for tree densities and to increase forest structural heterogeneity

Science Team Modeling

Scenarios:

1: Suppression-only

2: WUI focused

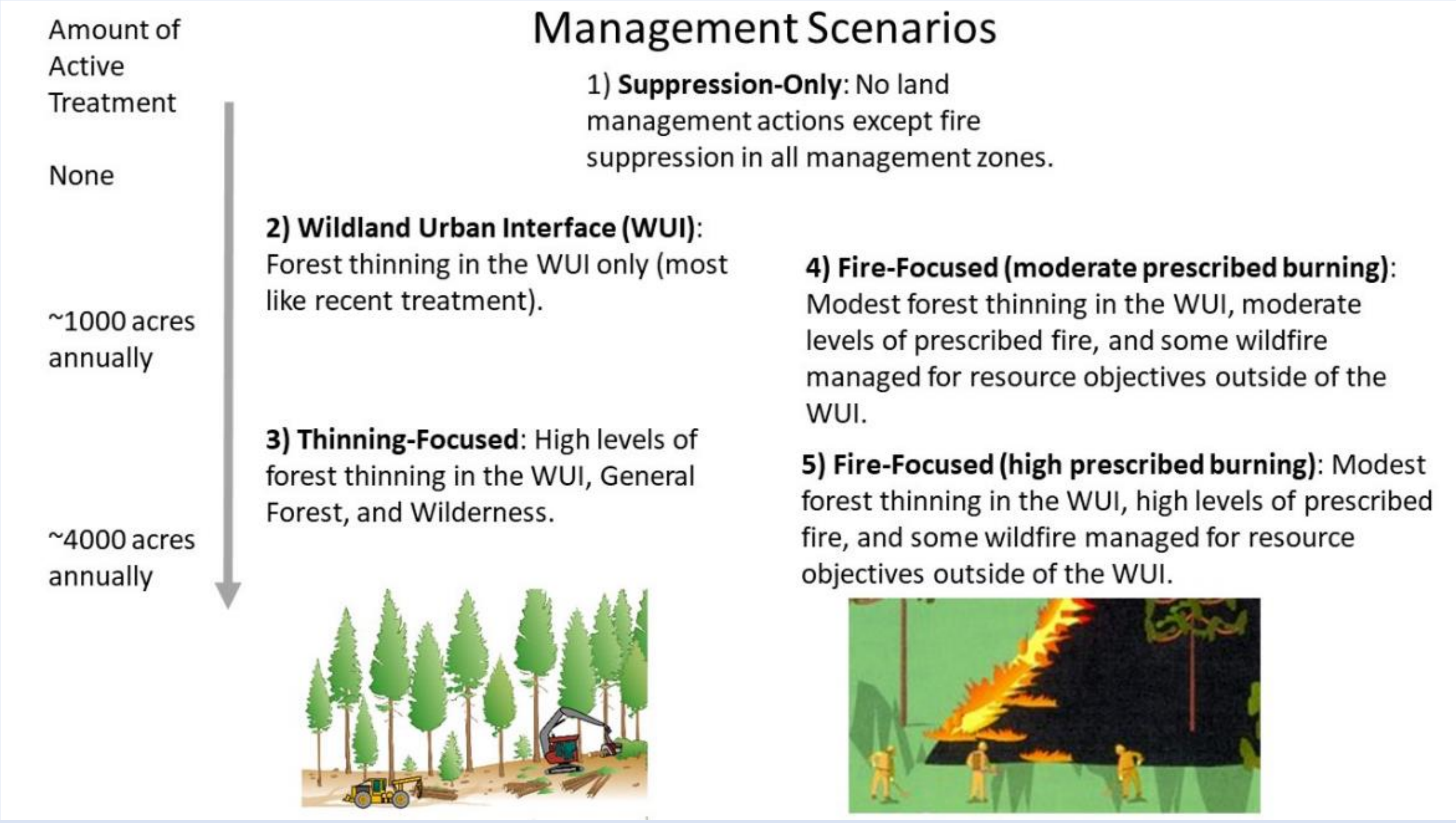
3: Thinning Focused

4: Fire Focused

***5 (formerly 4.2):** Fire-focused, expanded

*added to match the original intent from the IADT to rely on fire to treat as much area as was treated under scenario 3.

Modeled management scenarios vs. Proposed Action

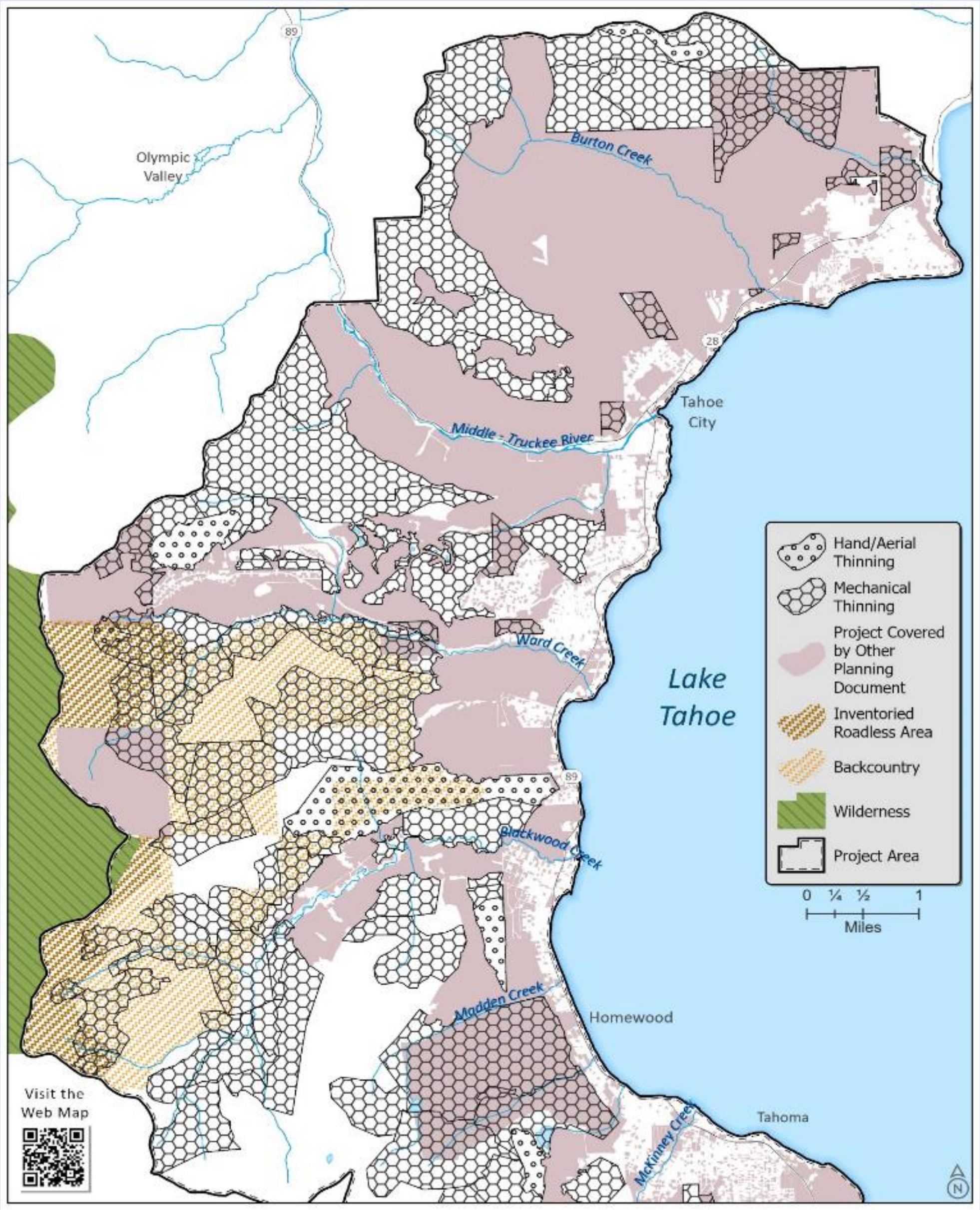


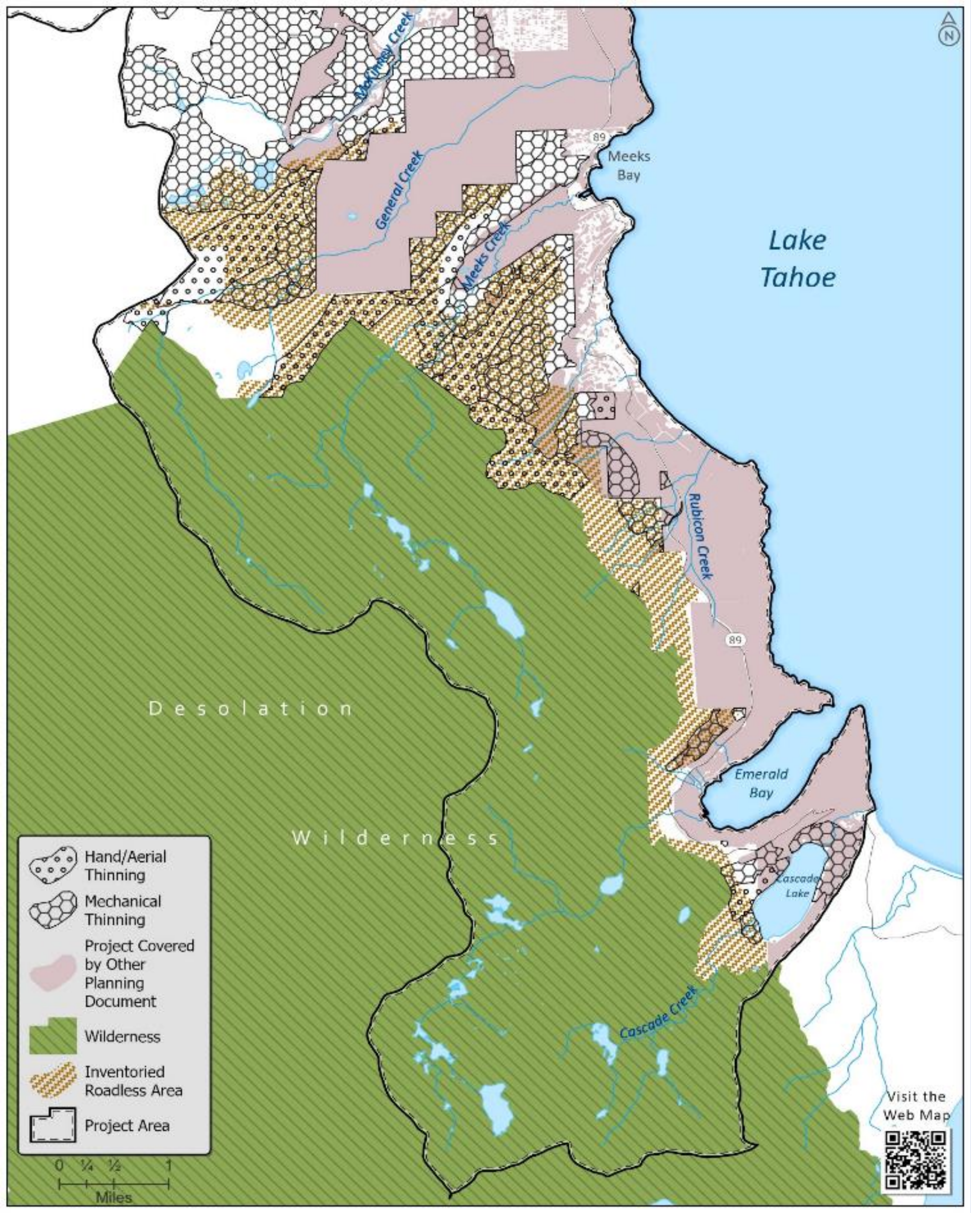
Annual treatments over 100 years

Proposed Action:

- 2500 acres/year thinning over 10 years
- 2000 acres/year RX fire over 10-20 years

Proposed Project





Incorporating Science Moving forward

Environmental Review

- Environmental Effects Analysis
- Project Design Features
- Resource Protection Measures
- Treatment Prioritization

Project Implementation

- Stand-by-stand prescription development

Enjoy the Symposium !

Lake Tahoe West Science: Introduction

Jonathan Long, Research Ecologist

U.S. Pacific Southwest Research Station

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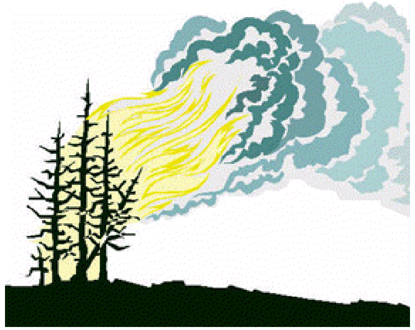
Patricia Manley, Research Program Manager

U.S. Pacific Southwest Research Station

pat.manley@usda.gov



Why engage scientists?

- The Lake Tahoe West Restoration Partnership wanted to manage the forests to be resilient under current and expected future conditions
- Restoration options depend upon our best estimates of future climate and take into consideration the interactions and interdependence of resource conditions over time
- Coordination between science and management teams help to integrate assessment, modeling, monitoring, treatment design, and stakeholder engagement
- Opportunity builds upon and add to the deep investment in prior research in the Lake Tahoe Basin
-

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

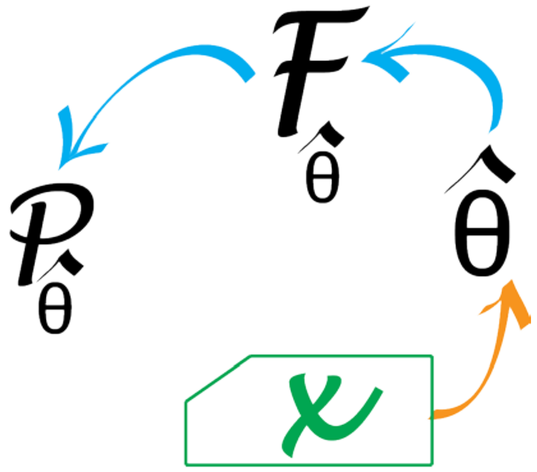
USDA Forest Service Research Stations:

- 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

Why model?



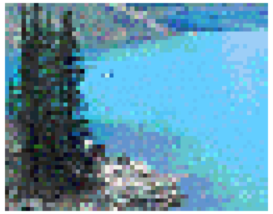
- Resilience is a characteristic that describes how systems respond to disturbance
- Resilience is the capacity of a system to absorb or withstand perturbations, like fire or drought or thinning, and other stressors, like climate change, such that the system maintains or recovers its characteristic composition, structure and functions
- Dynamics are inherent to resilience, so modeling is needed to estimate or project how systems will respond to disturbance
  - Individual disturbance responses
  - Disturbance regimes over time (e.g., management approaches)

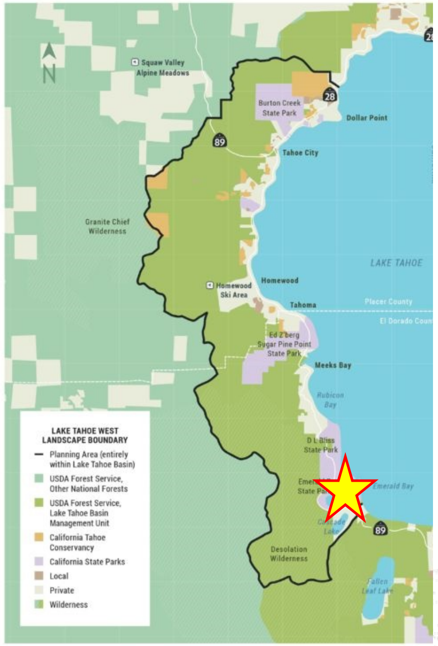
Dimensions of Modeling

- Broad suite of system elements
- Short-term responses
- Long-term dynamics
- Interactions and interrelationships among elements over time
- Effectiveness of management in producing outcomes

Indicators used in evaluation

Broad Scope: Socio-ecological responses and outcomes evaluated

1) Community Values 	WUI fire risk Threats to property Air quality (daily emissions) Cultural resource quality Carbon sequestration Restoration by-products
2) Environmental Quality 	"Functional" fire regime Upland vegetation health Wildlife conservation Water quality Water quantity
3) Operational Feasibility 	Net Treatment Costs Suppression Costs Staffing Days of Intentional Burning



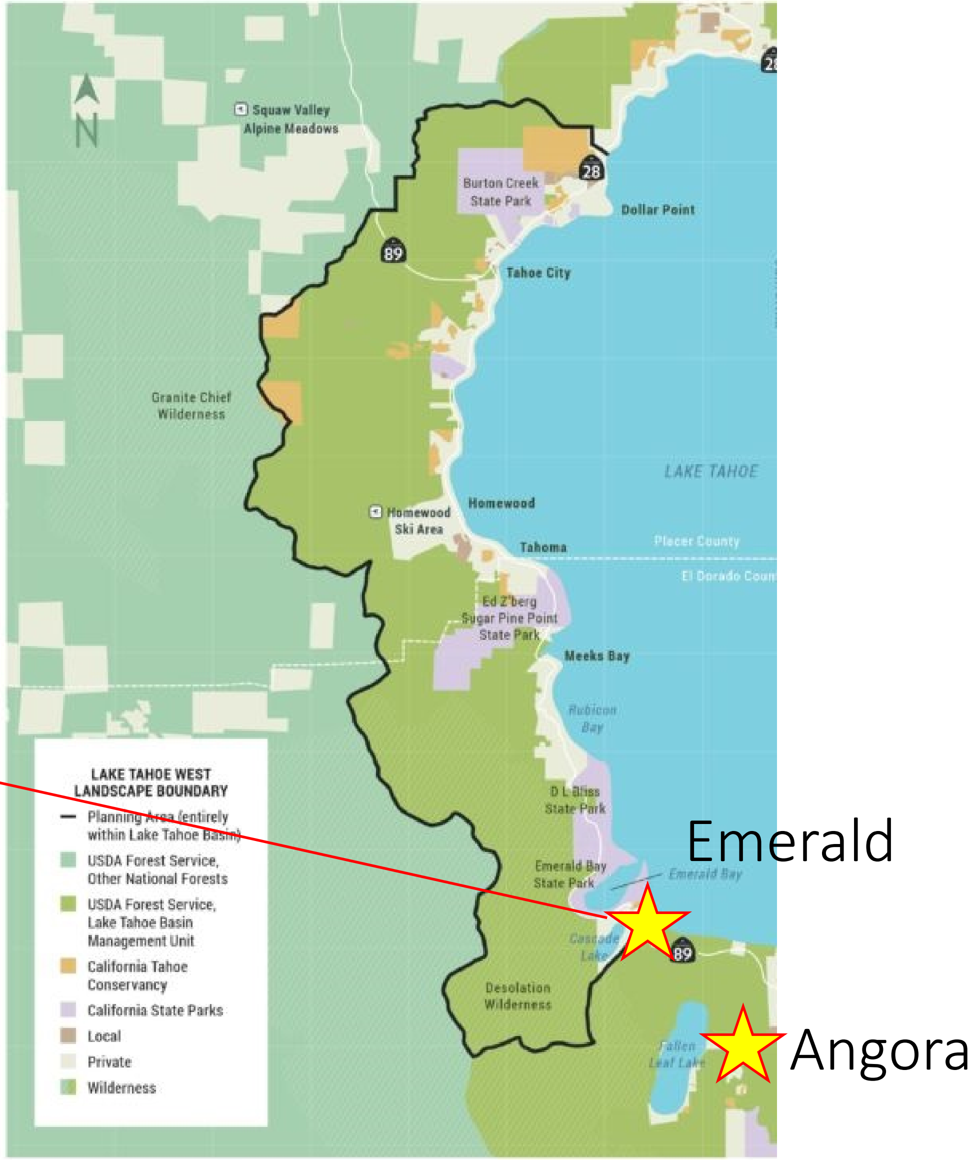
Lake Tahoe West

Following heavy logging starting in the mid-19th century, forests regrown to become increasingly dense.

1873 Emerald Bay and Cascade Lake 1994

Emerald Fire 2016

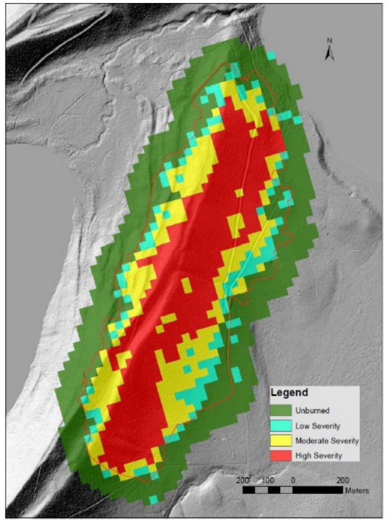
Only one large recent wildfire in the project area



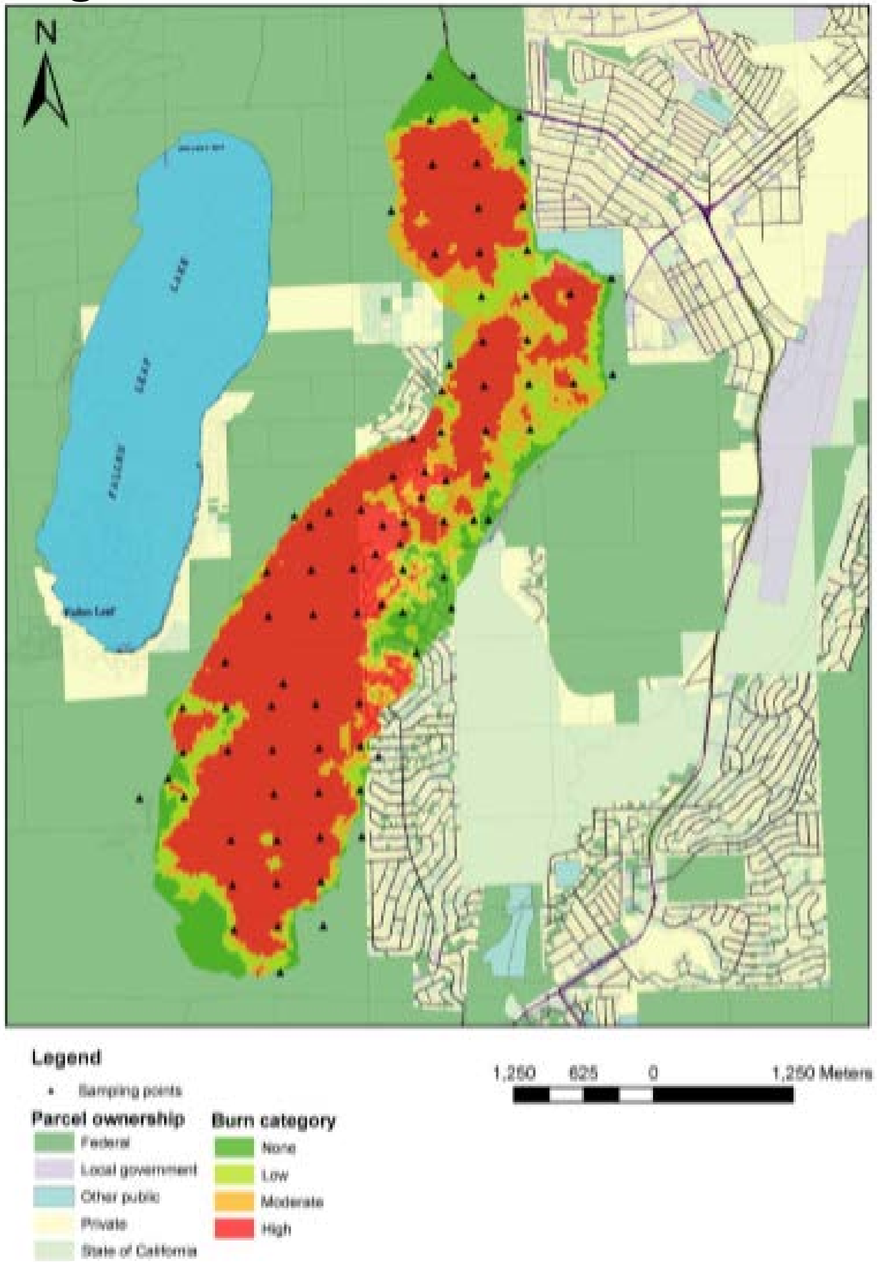
Historical Fire Severity

Wildfire	Gondola	Angora	Emerald
Year	2002	2007	2016
% high severity	29%	34%	53%
% moderate severity		42%	34%
% low severity		24%	13%
Total acreage	**673**	**3072**	**152**
Total hectares	272	1,243	62

Emerald

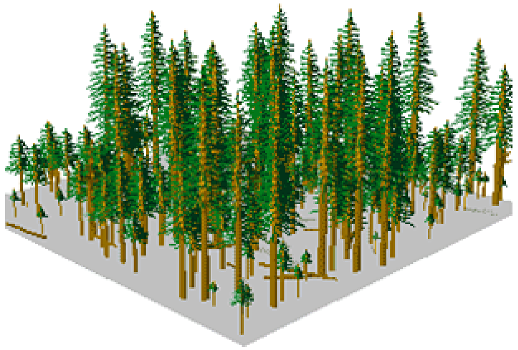


Angora



Multiple Scales of Modeling

Short-term "Event" Modeling → **Long-term "Regime" Modeling**

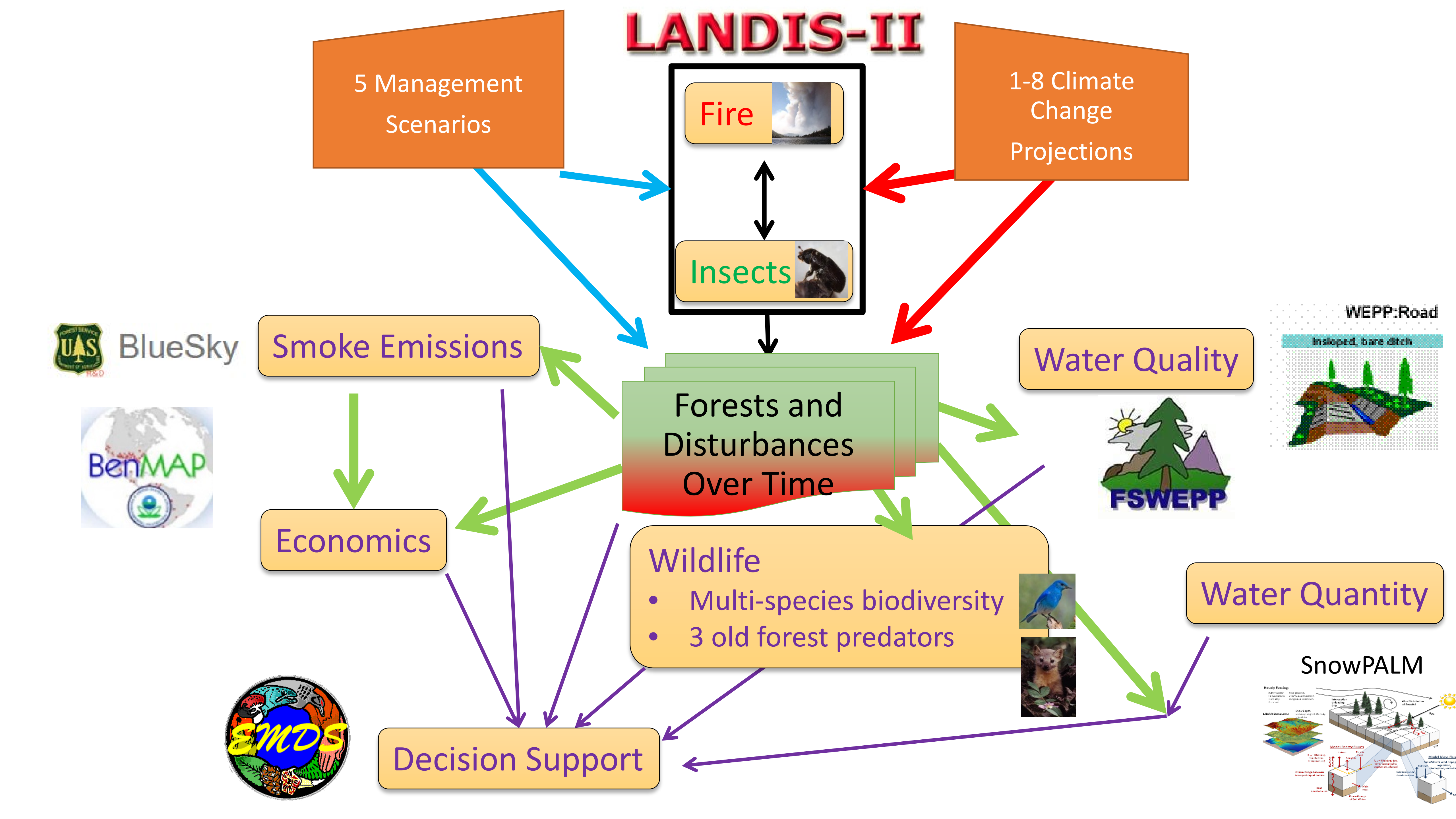


- Fire behavior in aspen stands
- Smoke impacts of fire events →
- Hydrologic effects of thinning →
- Water quality effects of disturbances →

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

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


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

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).

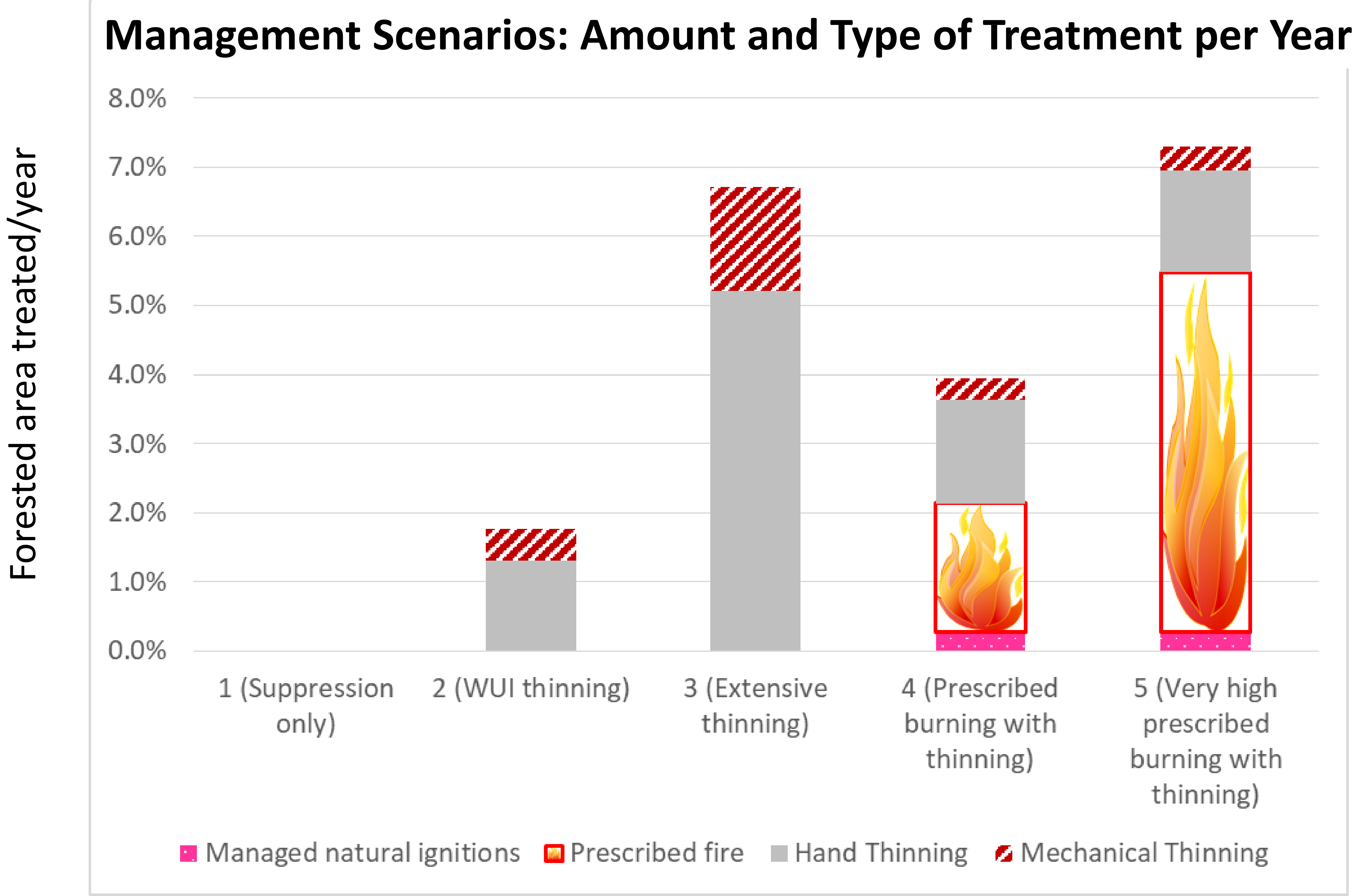
~1000 acres annually

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

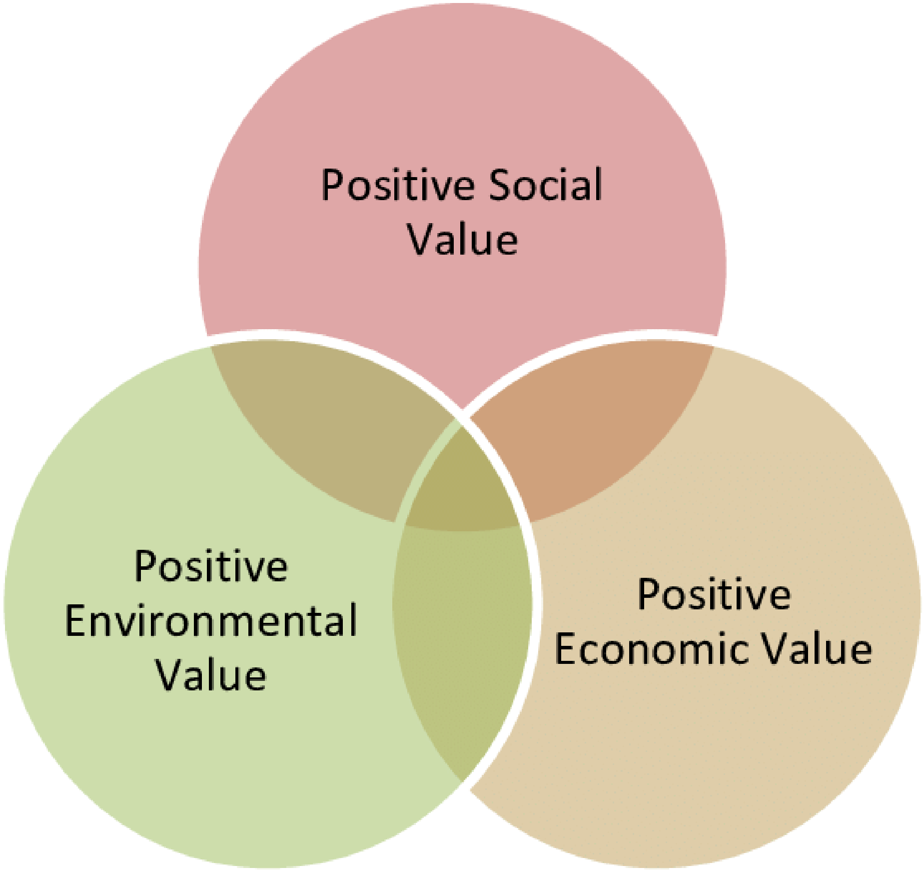

Management Scenarios: Amount and Type of Treatment per Year
Forested area treated/year
8.0%
7.0%
6.0%
5.0%
4.0%
3.0%
2.0%
1.0%
0.0%
1 (Suppression only)
2 (WUI thinning)
3 (Extensive thinning)
4 (Prescribed burning with thinning)
5 (Very high prescribed burning with thinning)
Managed natural ignitions
Prescribed fire
Hand Thinning
Mechanical Thinning

Climate Scenarios

- Initial landscape modeling (used for overall decision support analysis) based upon single climate projection (“Round 1”)
- Additional modeling conducted based upon multiple climate projections and updates to model assumptions, including responses of individual tree species (“Round 2”)
- Different climate projections did influence overall performance of key indicators, but generally did not affect relative performance of management scenarios
- Note that the water modeling did not directly account for climate change, which is expected to increase erosion and decrease snow

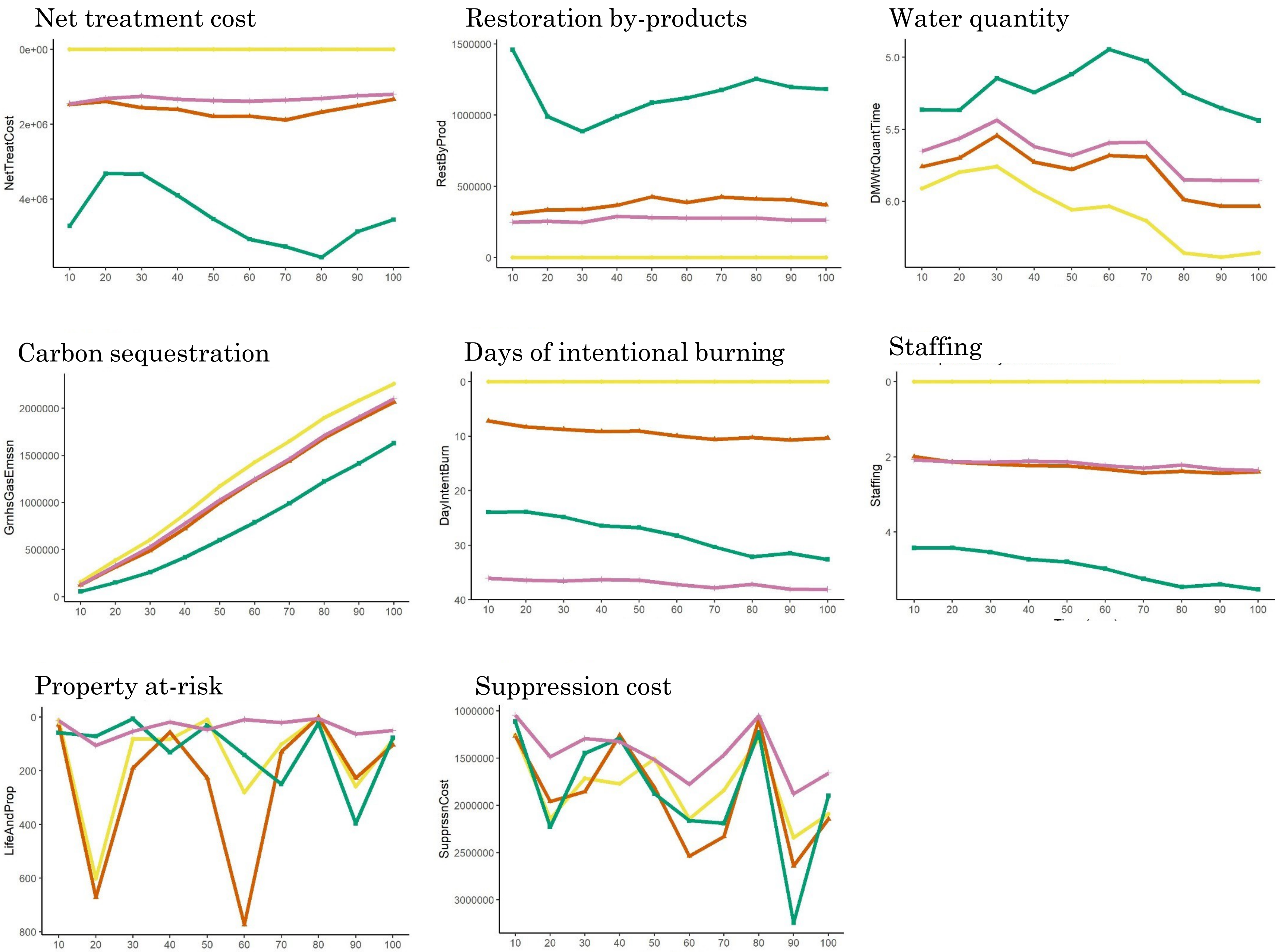
Integrated Evaluation of Social and Ecological Values

- 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



Management Effectiveness: Example Output for Key Indicators

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
- Smoke and feasibility
- Decision support

Previous Research in the Basin

Stevens, J. T., B. M. Collins, J. W. Long, M. P. North, S. J. Prichard, L. W. Tarnay, and A. M. White. 2016. Evaluating potential trade-offs
among fuel treatment strategies in mixed-conifer forests of the Sierra Nevada. Ecosphere 7(9):e01445. 10.1002/ecs2.1445

Treatments targeting the WUI area or areas vulnerable to high flame length were effective in reducing risks from wildfire in a “snapshot” (single event) analysis

Loudermilk, E.L., R.M. Scheller. P.J. Weisberg, A.M. Kretchun. 2016. Bending the carbon curve: fire management for carbon resilience under climate change. Landscape Ecology 1-12.

Long-term analysis using LANDIS suggested potential to promote resilience and fire and drought, with potential to achieve a net gain in carbon after several decades or centuries

Key Findings from Lake Tahoe West Modeling

- There is considerable momentum in the system—so more carbon will be stored, and areas of large trees and “late seral” vegetation will expand under any management scenario
- Expect more wildfire, but less severe fire with treatment
- Increased treatment promoted resilience based upon most indicators
  - Suppression-only is least expensive to implement and sequesters the most carbon, but entails high risks to communities
  - The most extensive and intensive thinning scenario appeared effective by many indicators, especially in reducing risk of property loss and extreme emissions
- Prescribed burning is also effective at reducing risk of wildfire, and cost-effective compared to thinning, but could have higher impacts to air, water quality, and older trees

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 carbon	• Wildlife habitat overall • Area of old forest • Social value of carbon
	• Treatment cost	• Suppression cost

Integration of Findings

- Further analysis of results can help refine approaches, for example:
  - Water quality analysis for steep slopes
  - Hydrological analysis to determine greater return from thinning
  - Erosion risks from current and abandoned road segments
- Fire-focused approach involves more uncertainty regarding actual effects of burn treatments
  - Illustrates importance of adaptive management in ramping up both prescribed fire and managed wildfire over time
  - Planned analysis of fire strategy using the PODs analysis framework

Pros and Cons of Modeled Scenarios

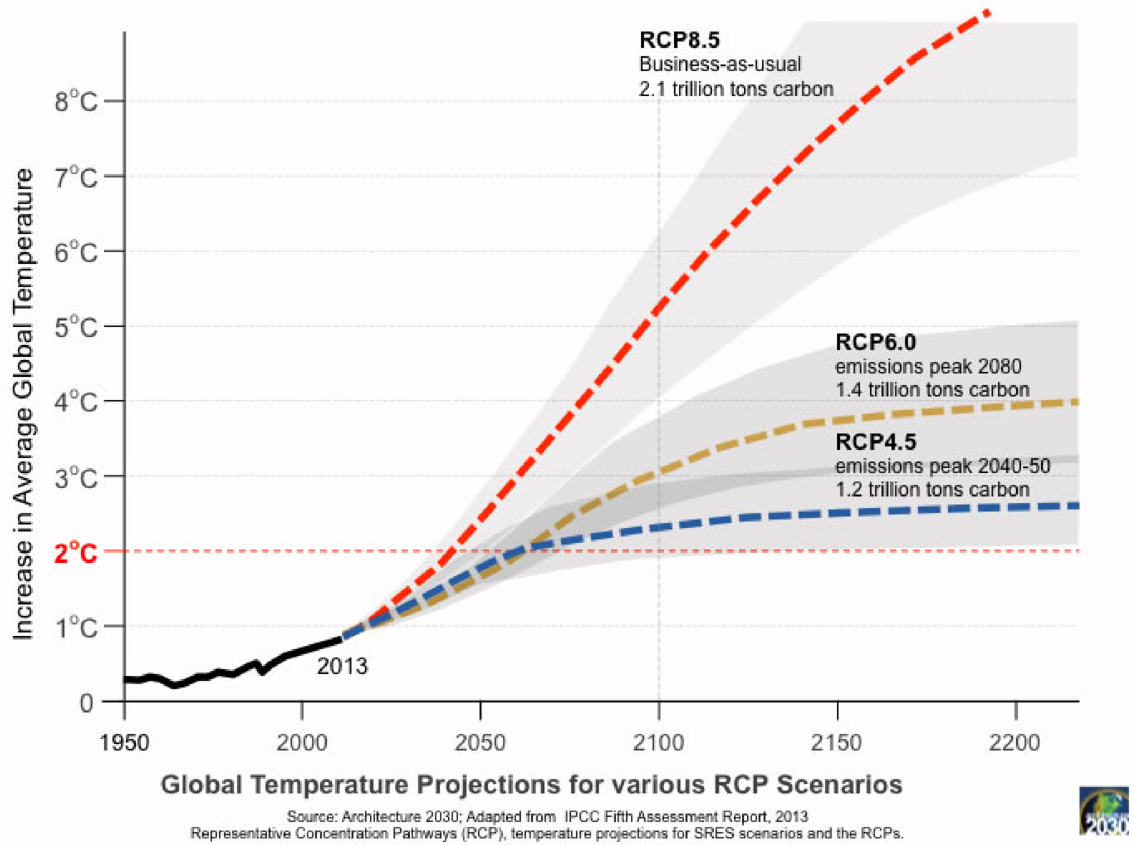
- Suppression-only
  - Low implementation cost, but high risk from severe wildfire
  - Stored more carbon
- Increased thinning
  - Reduced risk of wildfire in WUI areas and associated property loss
  - Reduced high severity and extreme wildfire events including very high emission days
  - Increased potential water yield
- Fire-focused
  - Prescribed burning costs less to implement than thinning
  - Promoted many of the same outcomes as thinning
  - Had somewhat higher impacts to water quality and increased fine particle emissions to air
  - Reduced carbon, and areas with older trees over the very long term
  - Favored more fire tolerant trees (e.g., aspen, pines) relative to less tolerant ones

Supplemental Slides


Disturbance regimes
Vegetation conditions and wildlife habitat
Water system: quality and quantity
Air system

Considering Climate Change Projections

- Primary landscape modeling results were based upon a single climate change projection (based upon RCP 4.5).
- This reflects a shift in climate from the recent historical record—especially higher winter minimum temperatures and longer growing seasons.
- Supplemental modeling used RCP 8.5 climate change projections (higher levels of emissions and warming).



Topic Area	Products
Overall Integration	*Draft report in revision*, to be produced as a General Technical Report
Vegetation, Forest Carbon, and Disturbances	Draft report: LANDIS validation and assumptions **Published article**: A landscape model of variable social-ecological fire regimes Manuscript in review: *Influence of management versus climate change and disturbance*
Fine-scale Fire Modeling (Aspen/Conifer Stands)	Draft manuscript: *Modeling fire behavior and fine-scale forest structure following conifer removal in aspen—conifer forests of the Lake Tahoe Basin*
Wildlife Habitat	*Planned manuscript* on wildlife habitat for biodiversity Draft manuscript: Landscape management effects on old forest-associated predators
Water Quality Modeling	*Planned reports and manuscripts on WEPP analyses* **Report**: *Erosion Analysis of the Road Network in Lake Tahoe West* **Report**: *Modeling the effect of reopening abandoned roads on hydrology and soil loss* **Report**: *Estimates of Surface and Mass Erosion Following the 2016 Emerald Wildfire*
Hydrology and Snow Modeling	**Published articles**: *Using Process Based Snow Modelling and Lidar to Predict the Effects of Forest Thinning on the Northern Sierra Nevada Snowpack*, https://doi.org/10.3389/ffgc.2020.00021 *Increasing the efficacy of forest thinning for snow using high-resolution modeling: A proof of concept in the Lake Tahoe Basin, California, USA, Ecohydrology* (2020). DOI: 10.1002/eco.2203
Smoke Impacts	*Planned manuscript*
Economics	*Planned manuscript*
Decision Support	*Planned manuscript*

LTW: Forecasting Vegetation, Disturbance, Management

Charles Maxwell, Post-doctoral Associate

Robert Scheller, Professor

NC STATE UNIVERSITY

Goals

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

- Modeled forest, fire, and beetle dynamics over 100 years
- Potential climate futures evaluated – 2 pathways, multiple models
- Outputs pertain to forest conditions, fire dynamics, beetle mortality
- Outputs used as inputs to other models, such as wildlife, smoke, water quality and economics

Goals

Evaluate social and ecological values

- Possibility of tradeoffs among values
- Consider potential net benefits of different courses of action and which values are most important
- Therefore, need to capture many metrics of landscape response

Model Selection: LANDIS-II

- Designed for large landscapes with interacting components
- Simulates:
  - Succession
  - Wildfire
  - Insect outbreaks
  - Forest management: Rx fire, thinning, harvesting

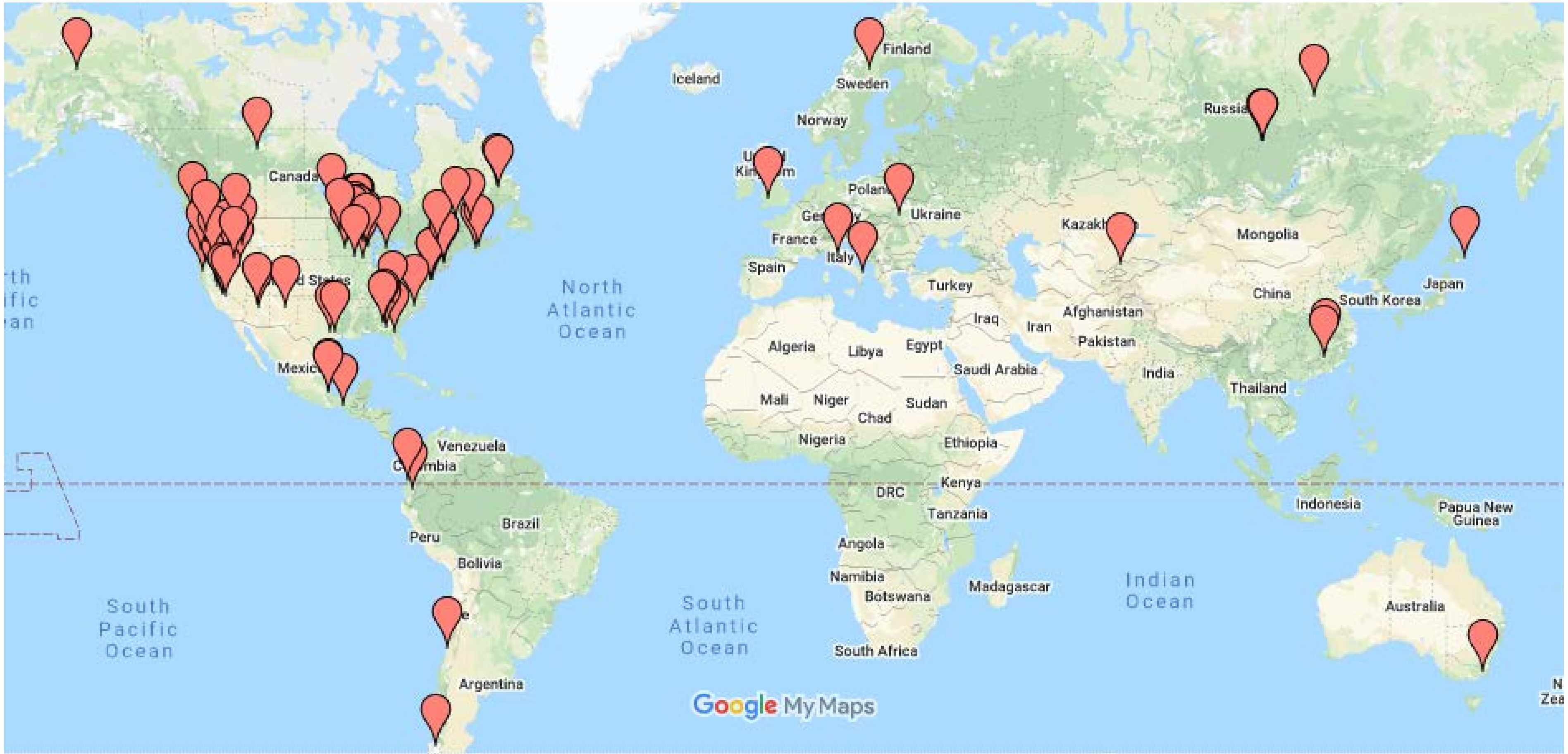
Model Selection: LANDIS-II

- Succession and Disturbance respond dynamically to climate change
- Provides outputs that serve our goals:
  - Tree and shrub species change through time
  - Forest demographics: the age of species and stands
  - Maps of areas burned and burn severity
  - Landscape Carbon (above and belowground C)
  - Smoke emissions

Model Selection: LANDIS-II

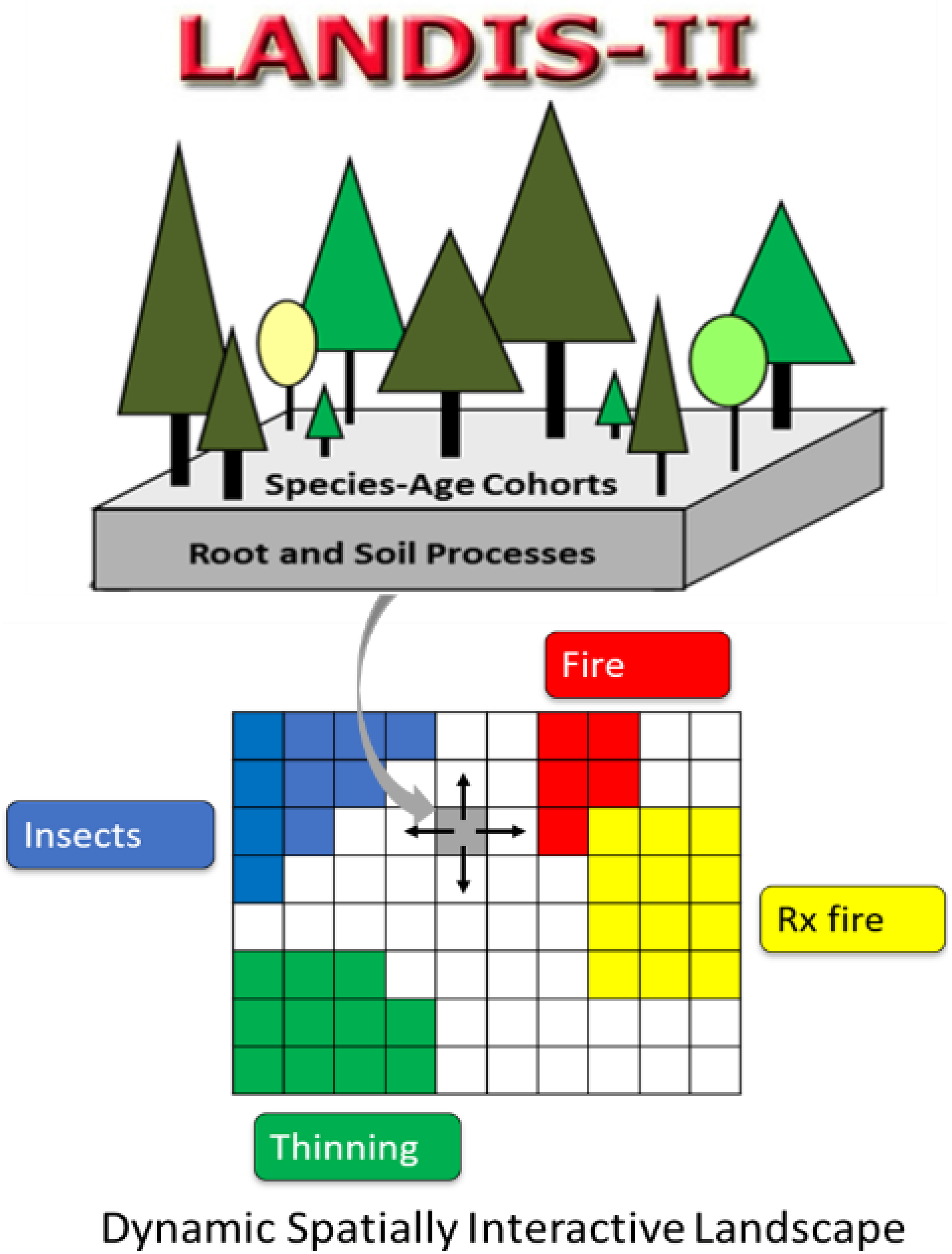
- 20+ years of development
- Open-source
- Widely used for forecasting and planning
- Previously parameterized for LTB and Sierra Nevada

LANDIS-II Applications

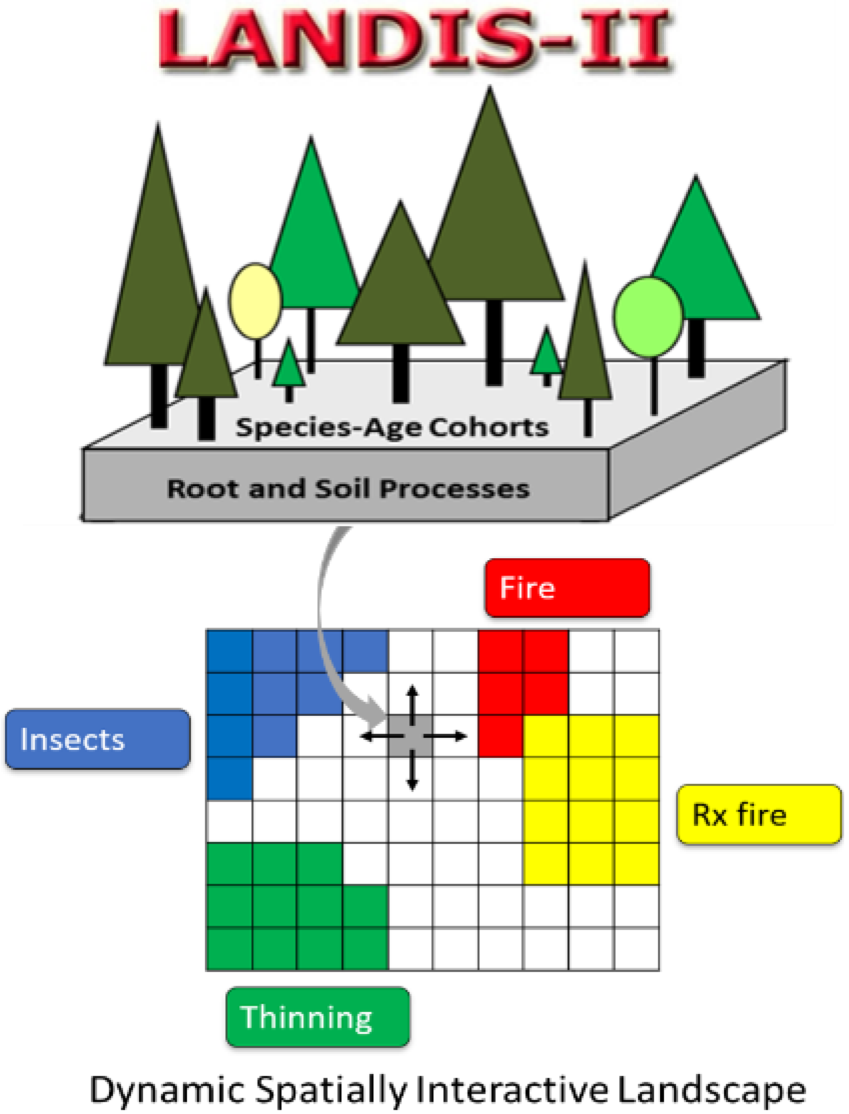


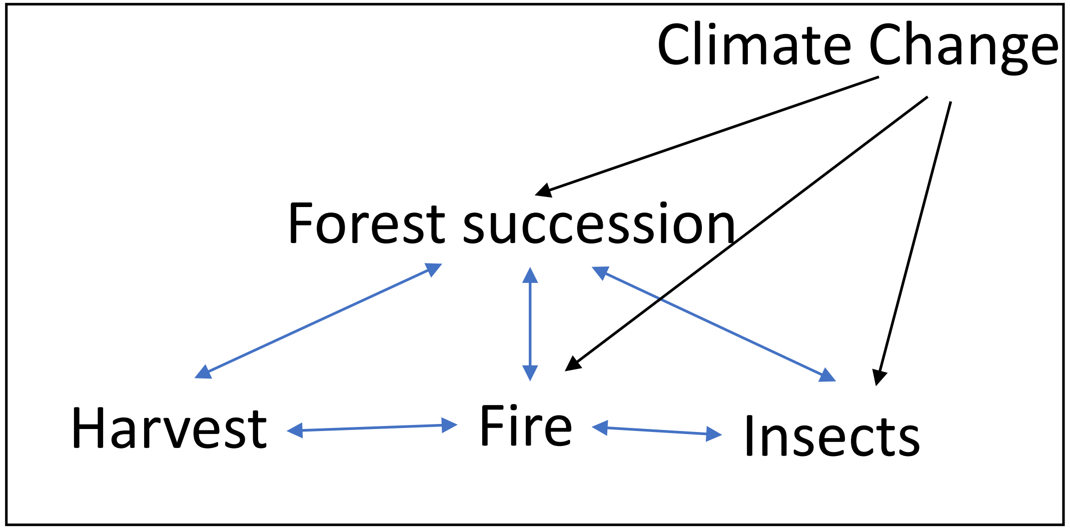
How the model works

- Trees are grouped into cohorts based on species and age
- Cohorts compete for light, nutrients, and water
- Each tree species is modeled individually (13 unique species for the Basin)
- Landscape composition based on observed (field/satellite) data



How the model works

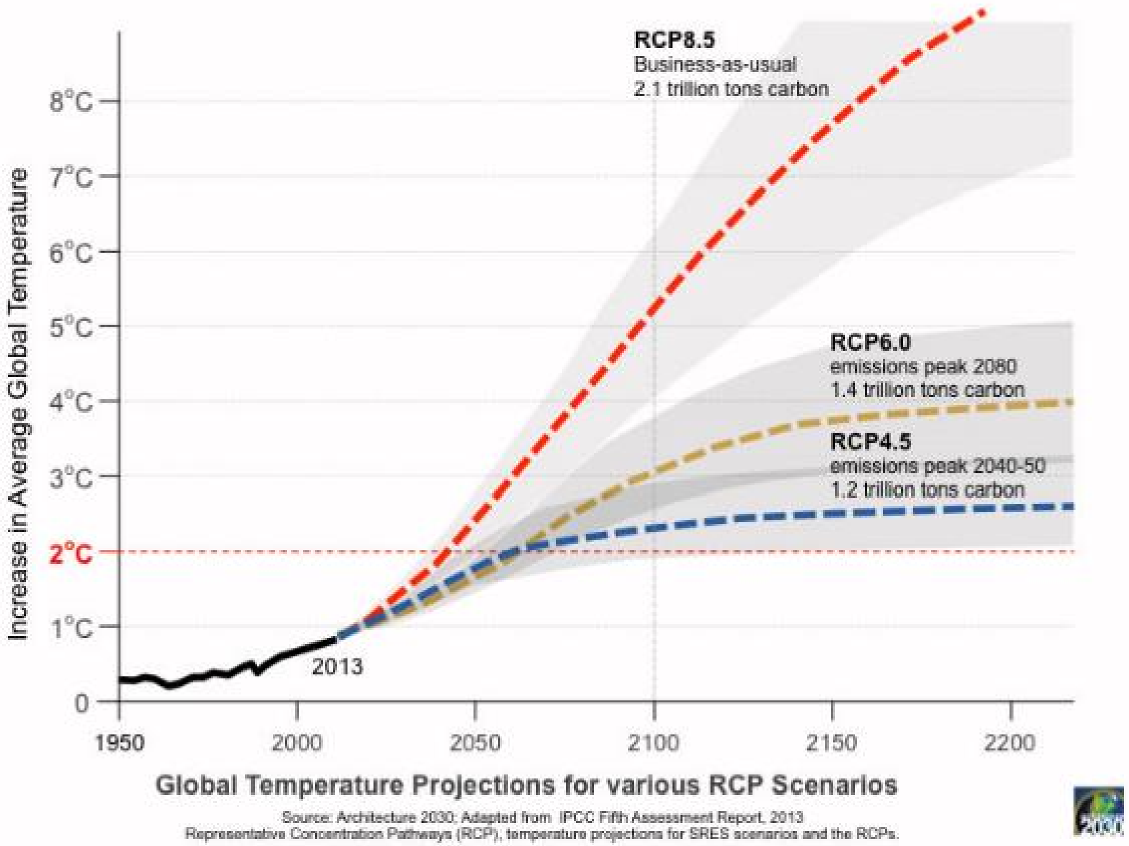




- Climate change drives disturbance processes:
  - Fire spread determined by weather conditions
  - Insect outbreaks triggered by drought and warm winters
- Climate change influences forest growth and succession:
  - Water and specific temperature ranges are necessary for growth and successful regeneration

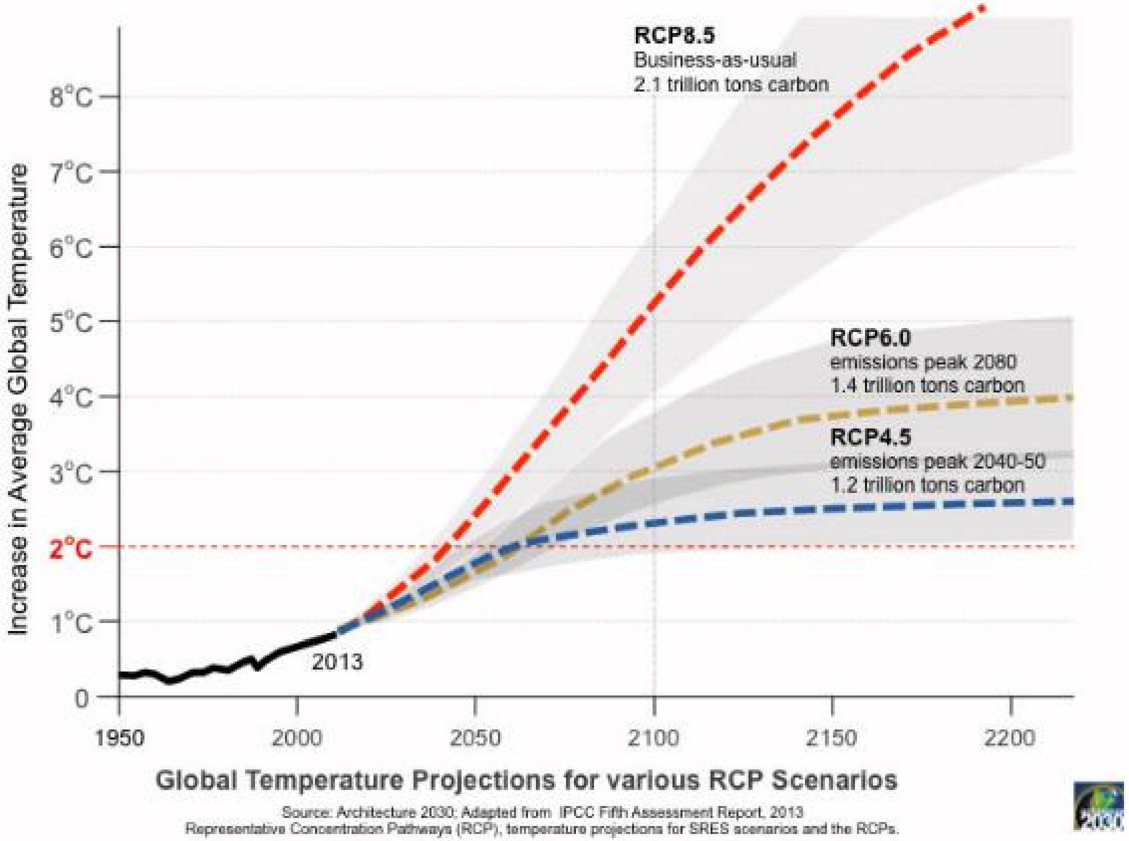
Considering Climate Change Projections

- Primary landscape modeling results were based upon a single climate change projection (based upon RCP 4.5).
- This reflects a shift in climate from the recent historical record—especially higher winter minimum temperatures and longer growing seasons.
- Supplemental modeling used RCP 8.5 climate change projections (higher levels of emissions and warming).

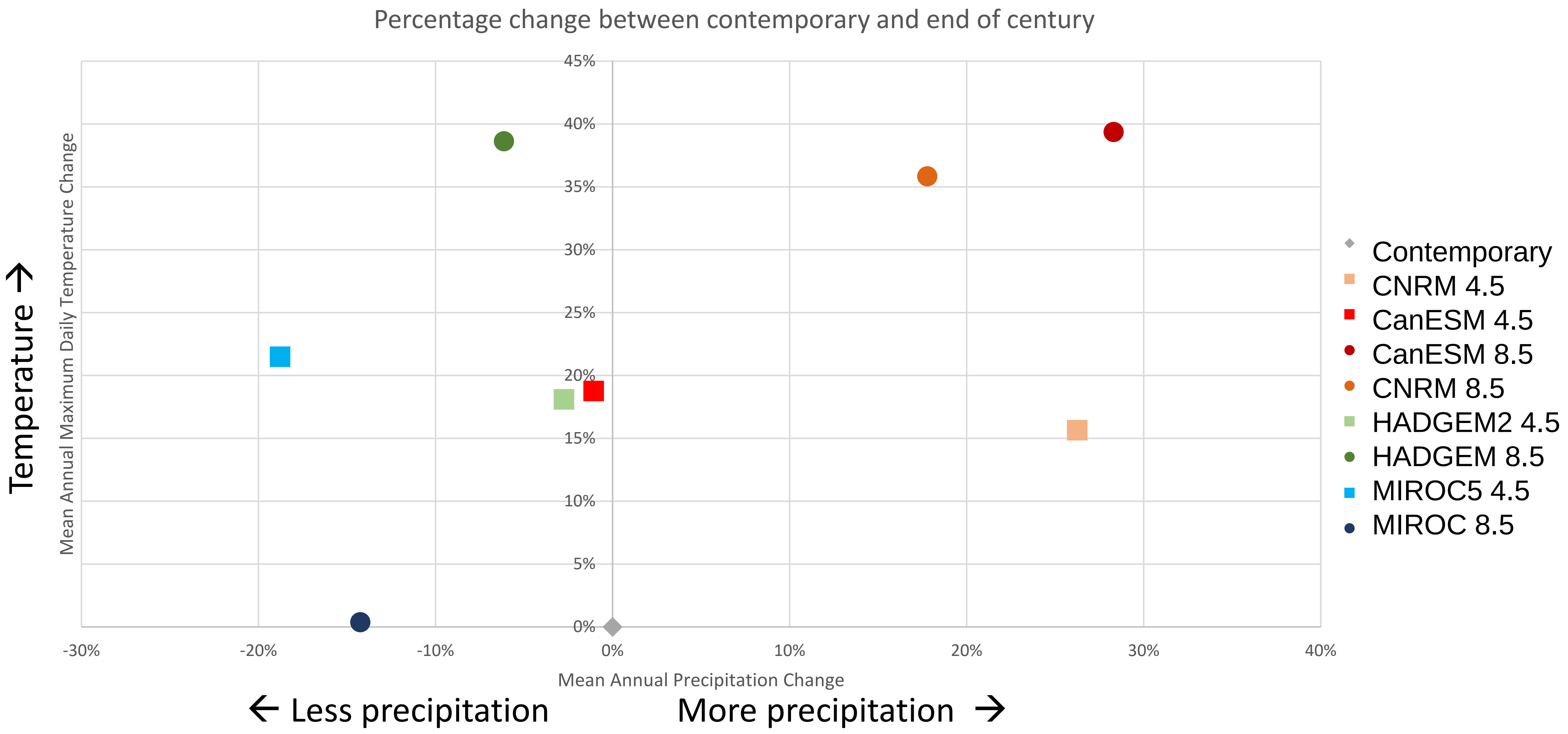


Considering Climate Change Projections

- The results shown in this presentation are based on second round of modeling that utilized projections from RCP4.5 and RCP8.5 emissions trajectories

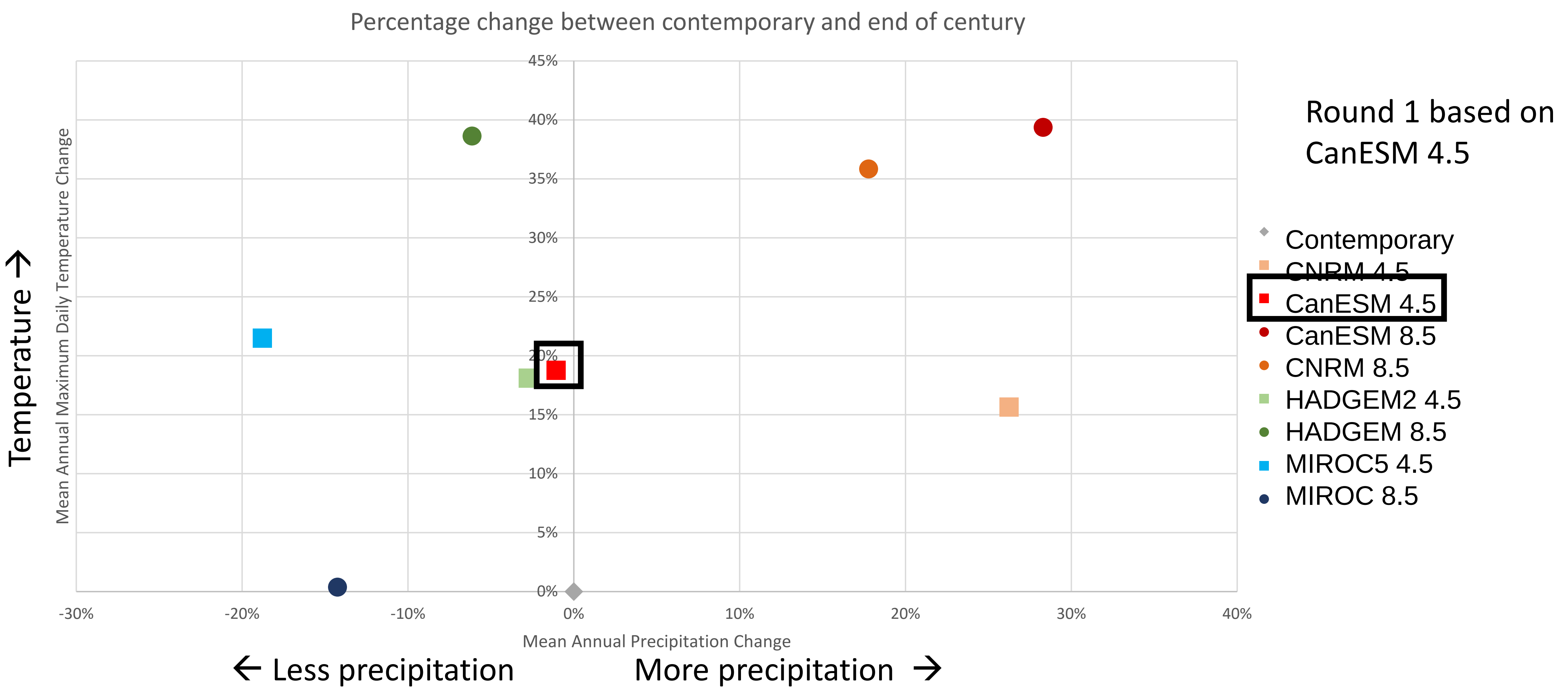


Future climate of the Basin



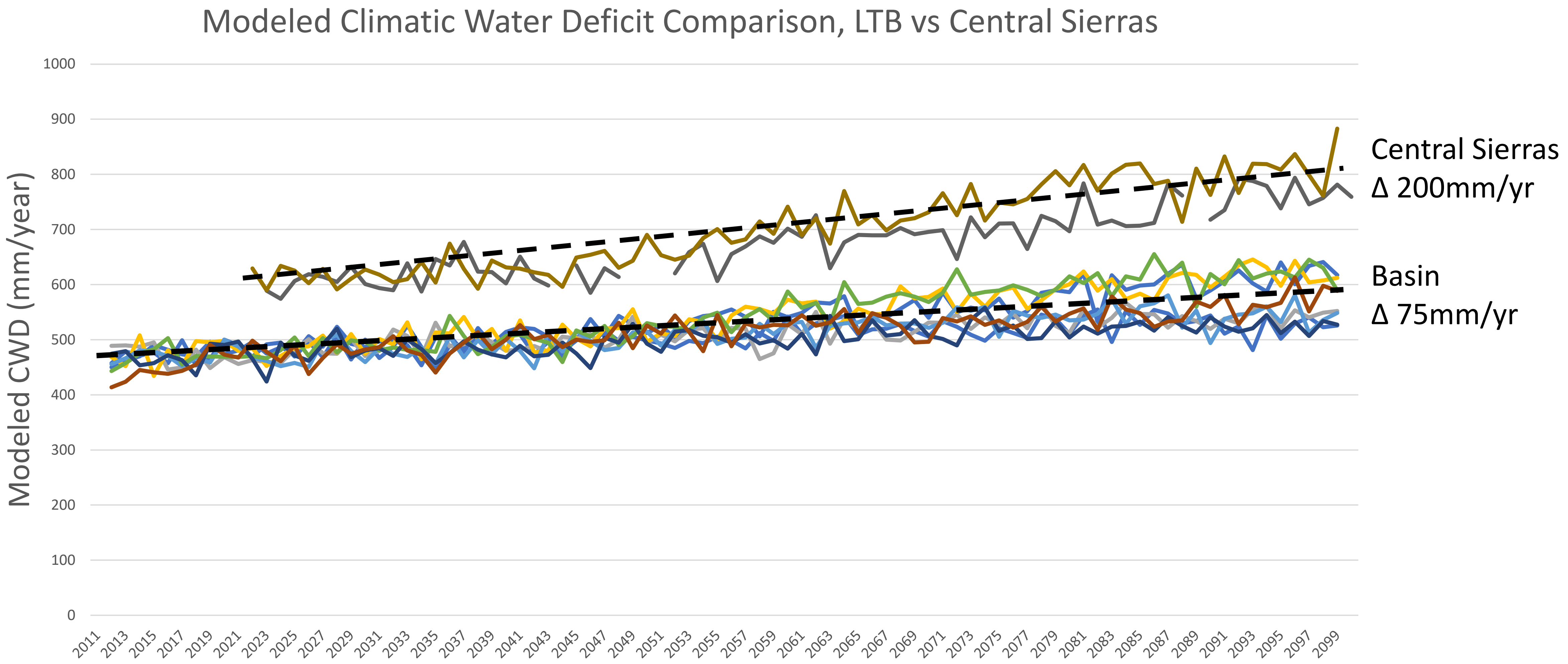
- Projected temperature increase of +1-5°C by end of century
- Projected precipitation change of -20% to +30% compared to end of century

Future climate of the Basin

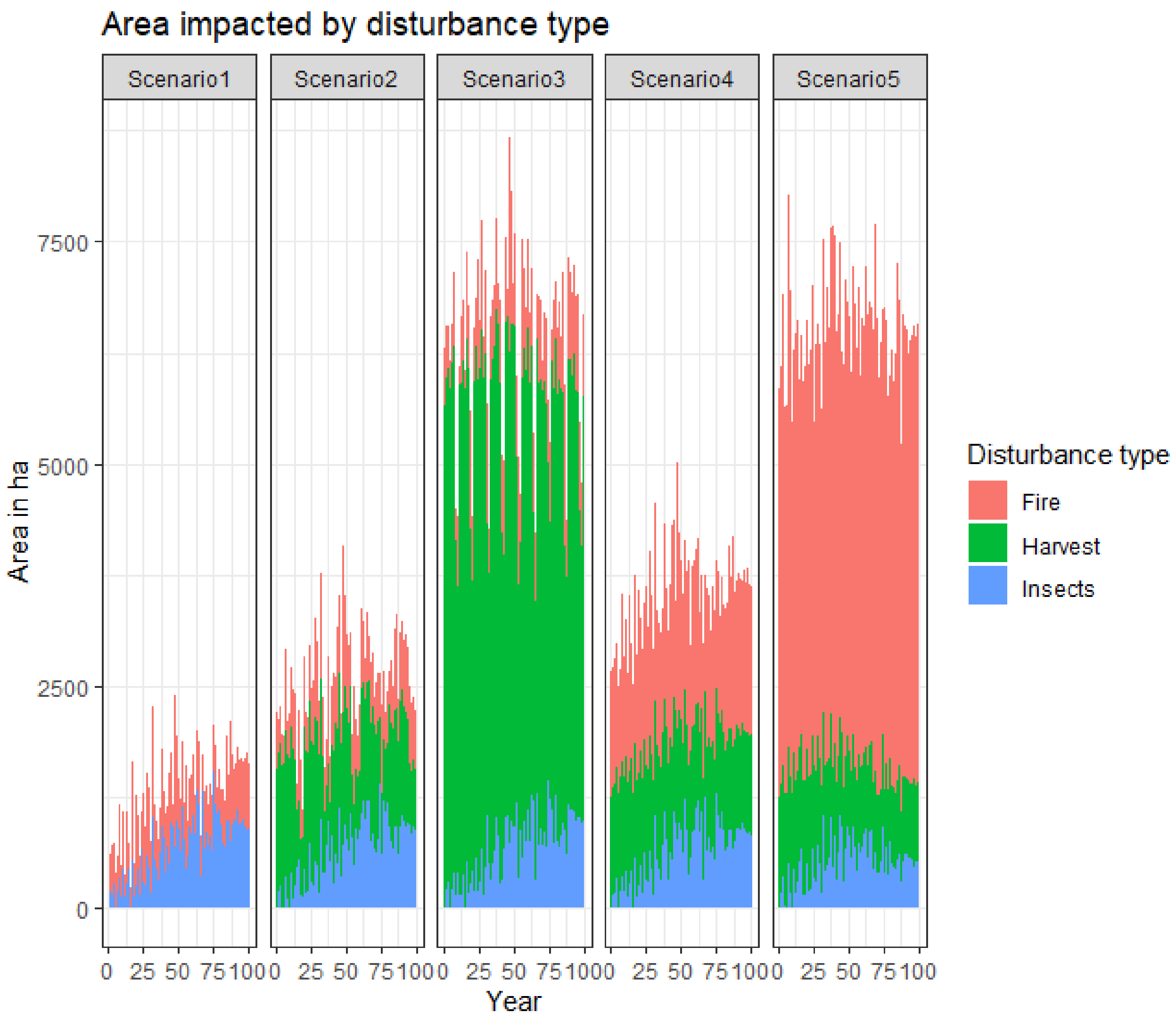


- Projected temperature increase of +1-5°C by end of century
- Projected precipitation change of -20% to +30% compared to end of century

Future drought stress

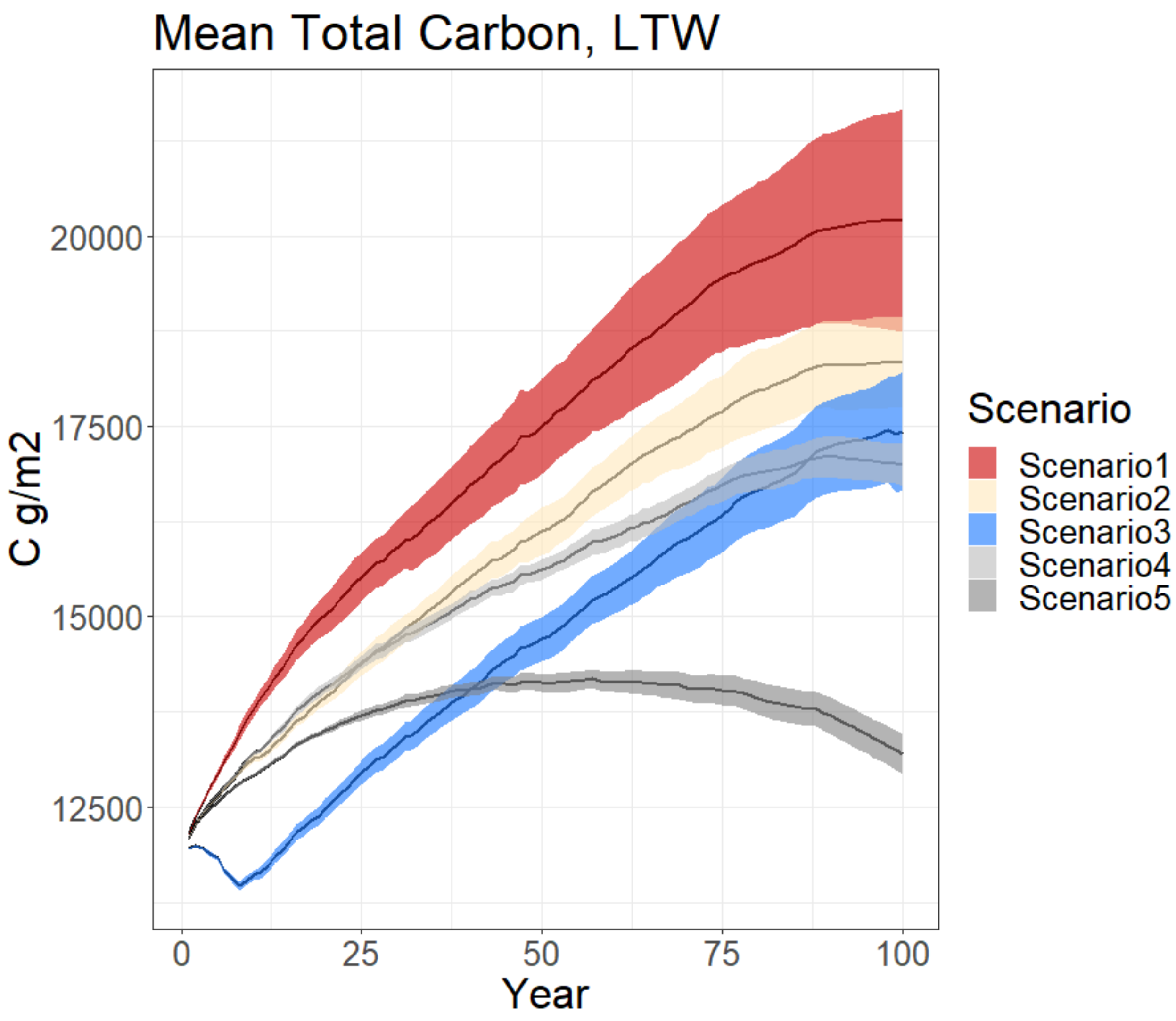


Disturbance footprint



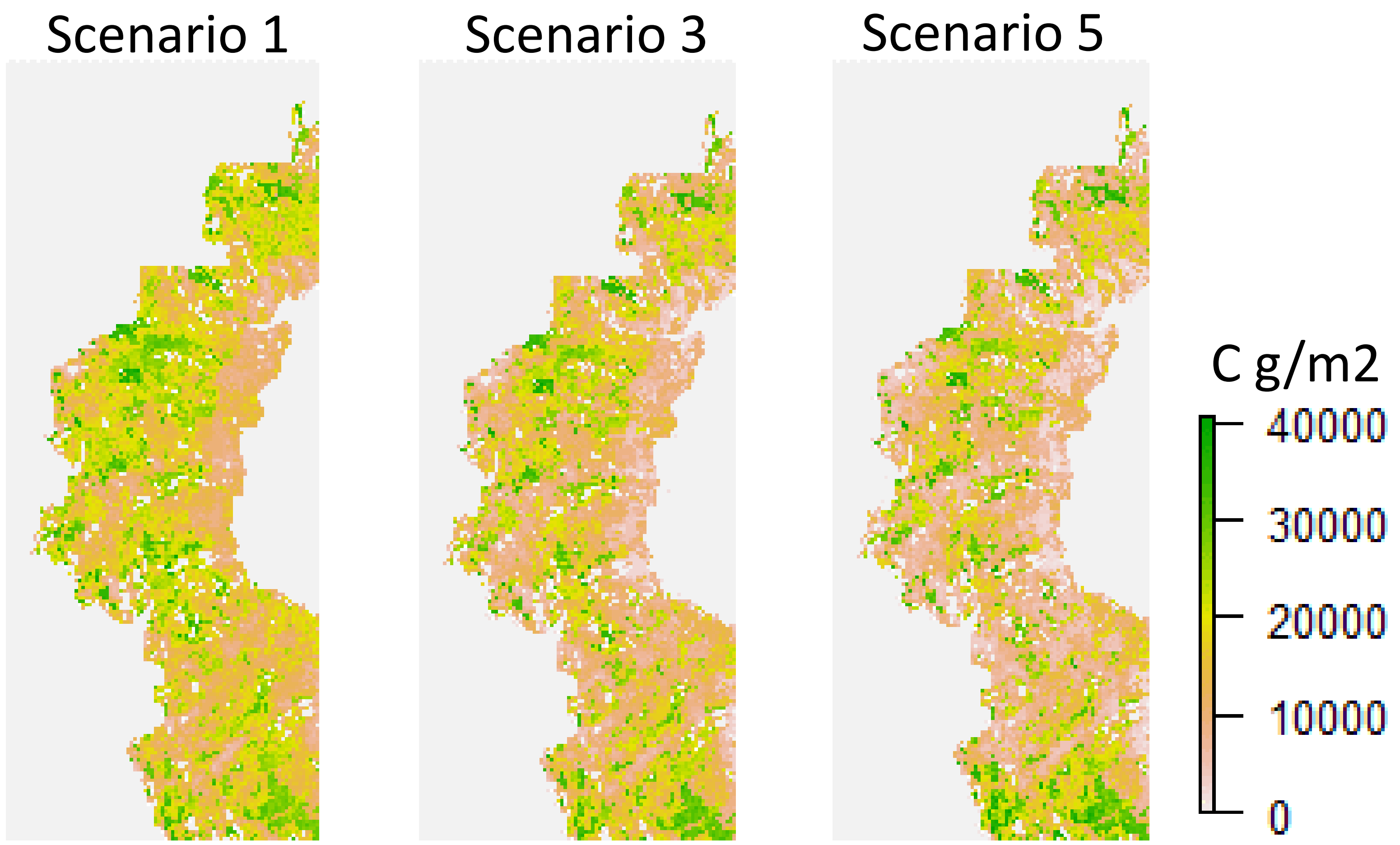
- Insect impacts should not be underrated but there is greater uncertainty in future effects
- Insect-related mortality affected even more area than wildfires
- Area burned by wildfire didn’t vary much across scenarios
- Human disturbances (including prescribed fire in Scenario 4 and 5) are additive, and designed to move the landscape to resilient conditions

Carbon



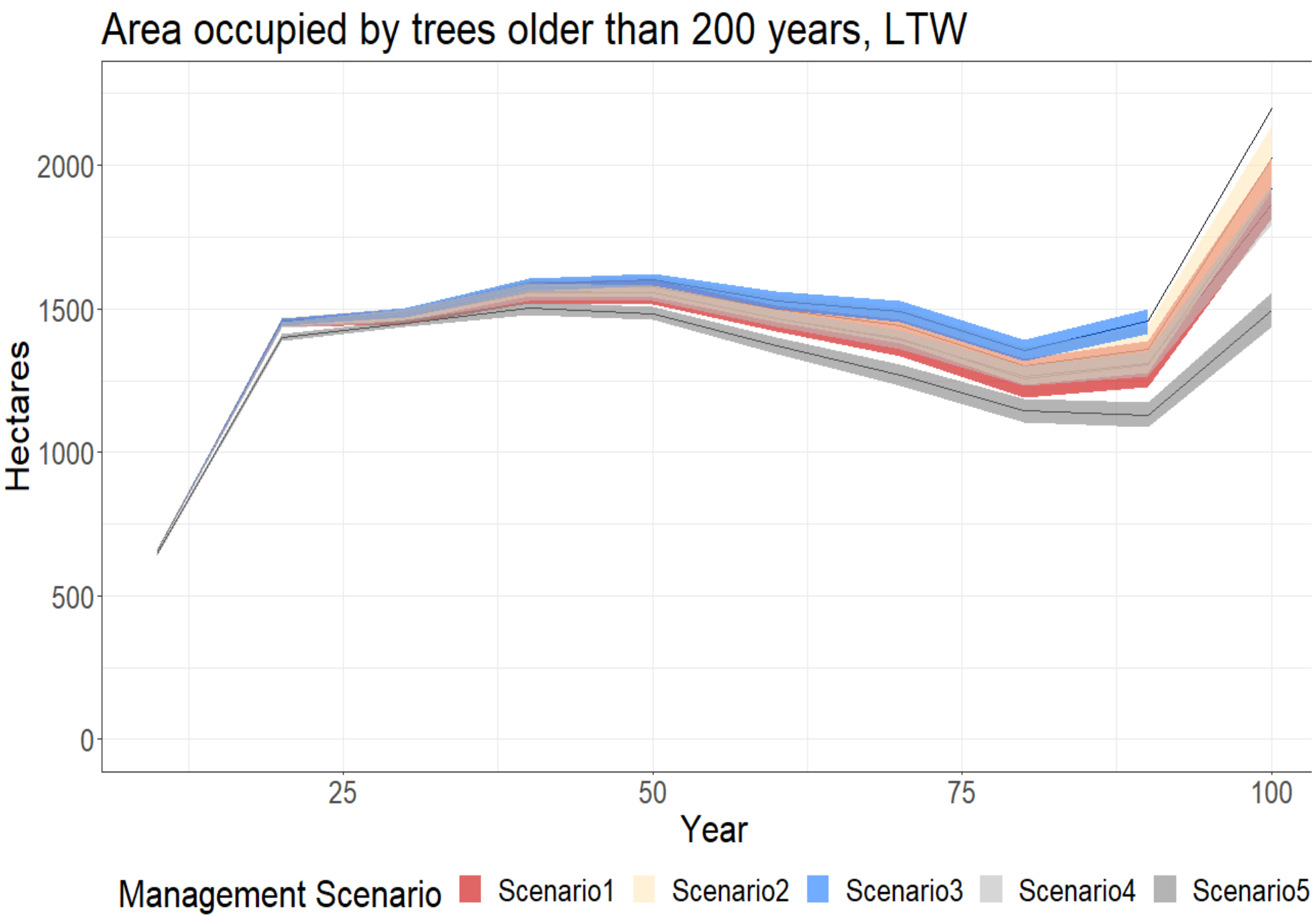
- Carbon increases through time except for Scenario 5
- Highest variability with Scenario 1

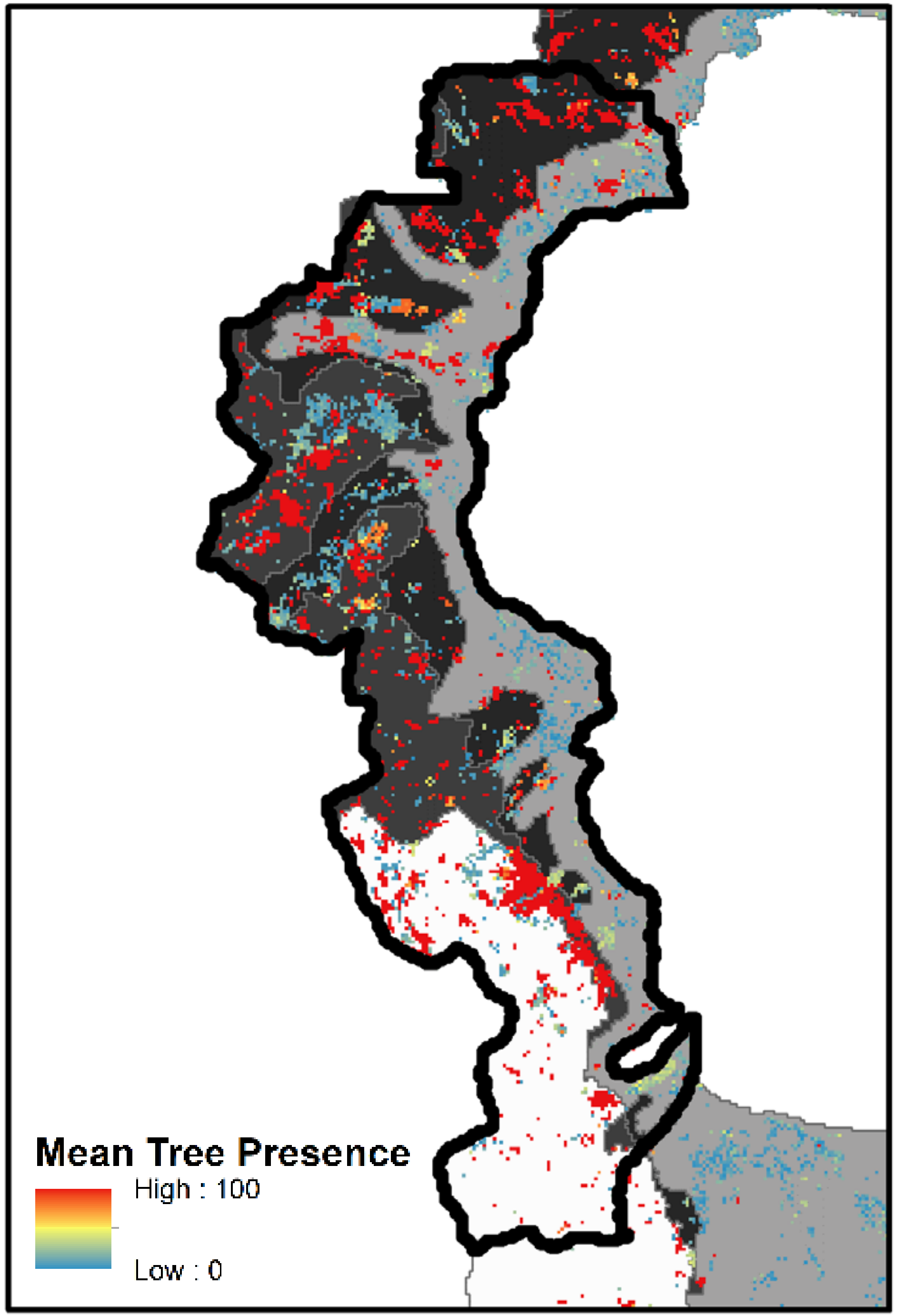
Carbon



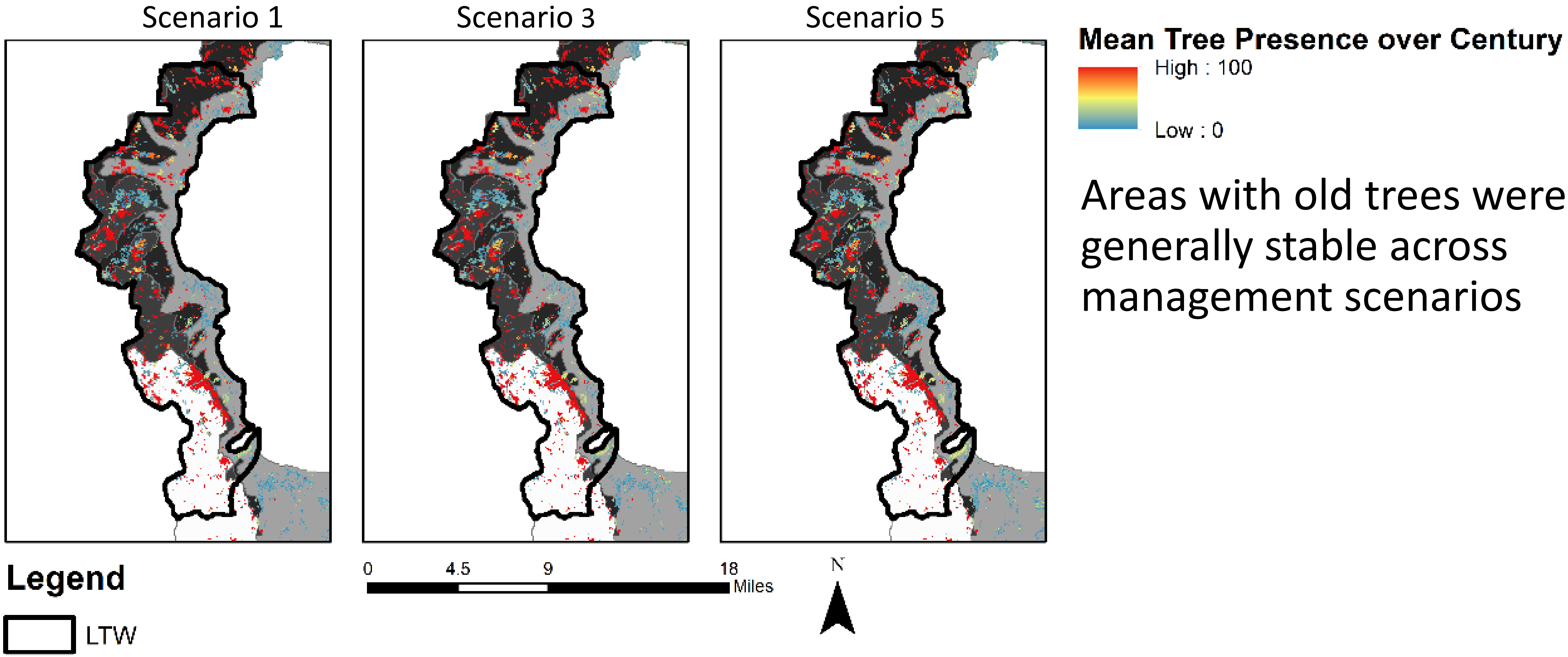
- Decadal mean for years 2090-2100 averaged across replicates and climates
- High carbon areas generally line up with areas that have older trees

Old Trees, LTW



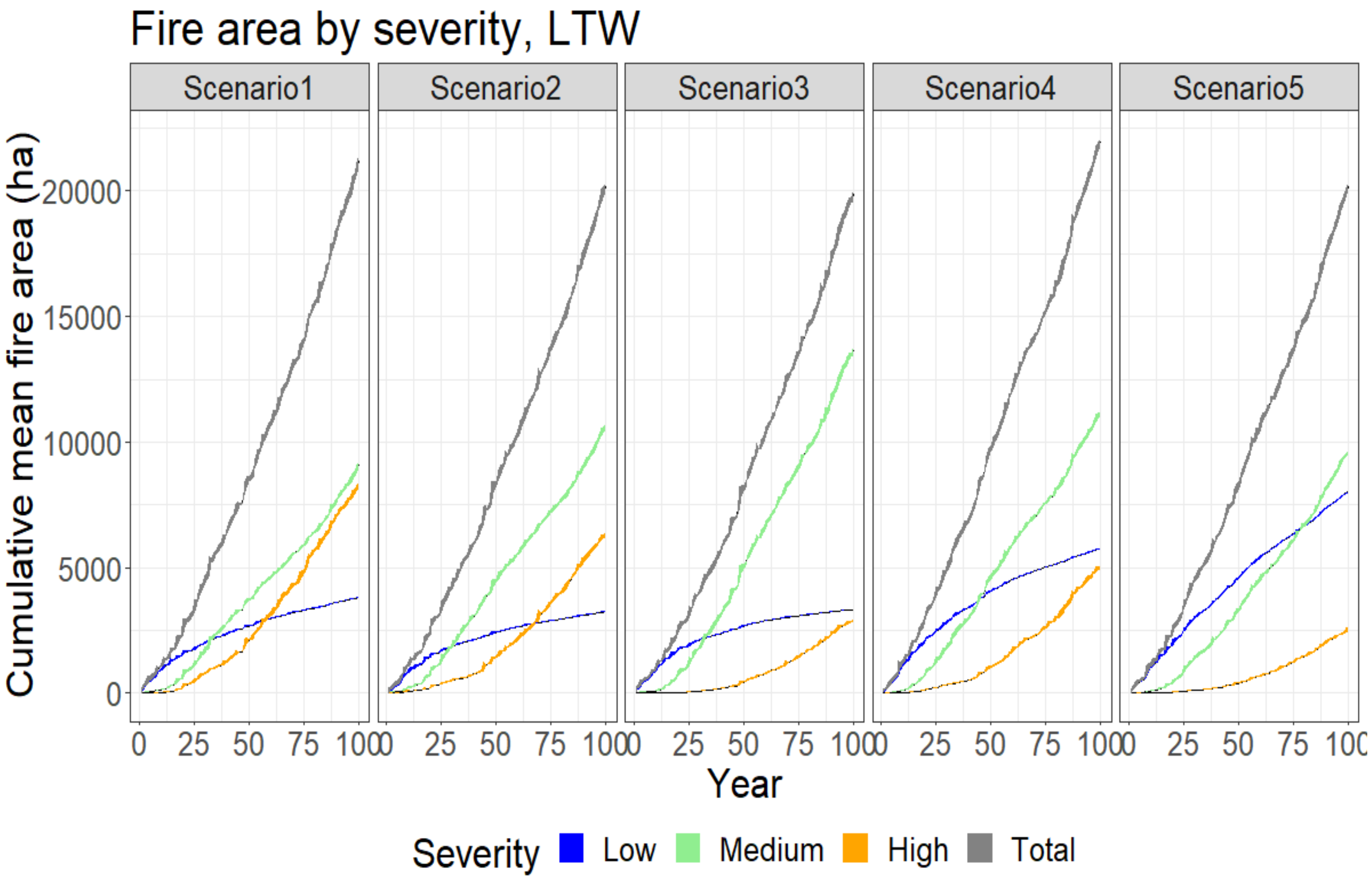


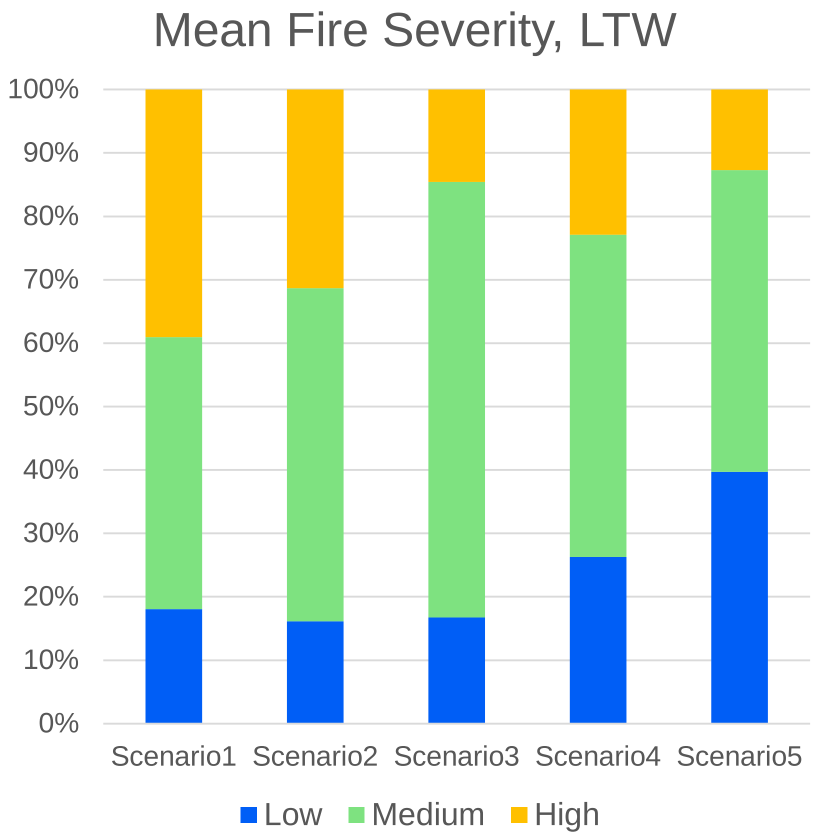
Old trees, LTB



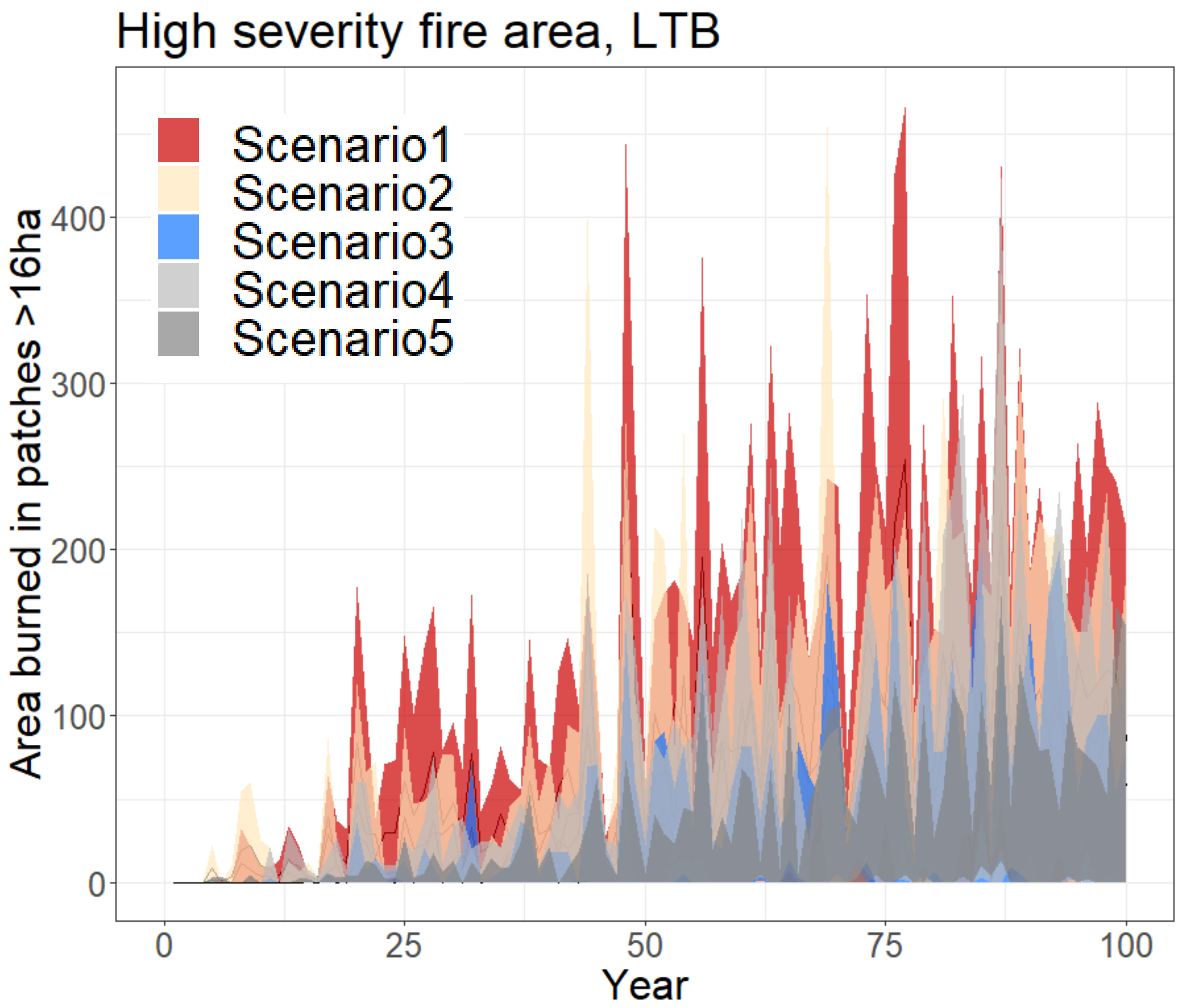
Areas with old trees were generally stable across management scenarios

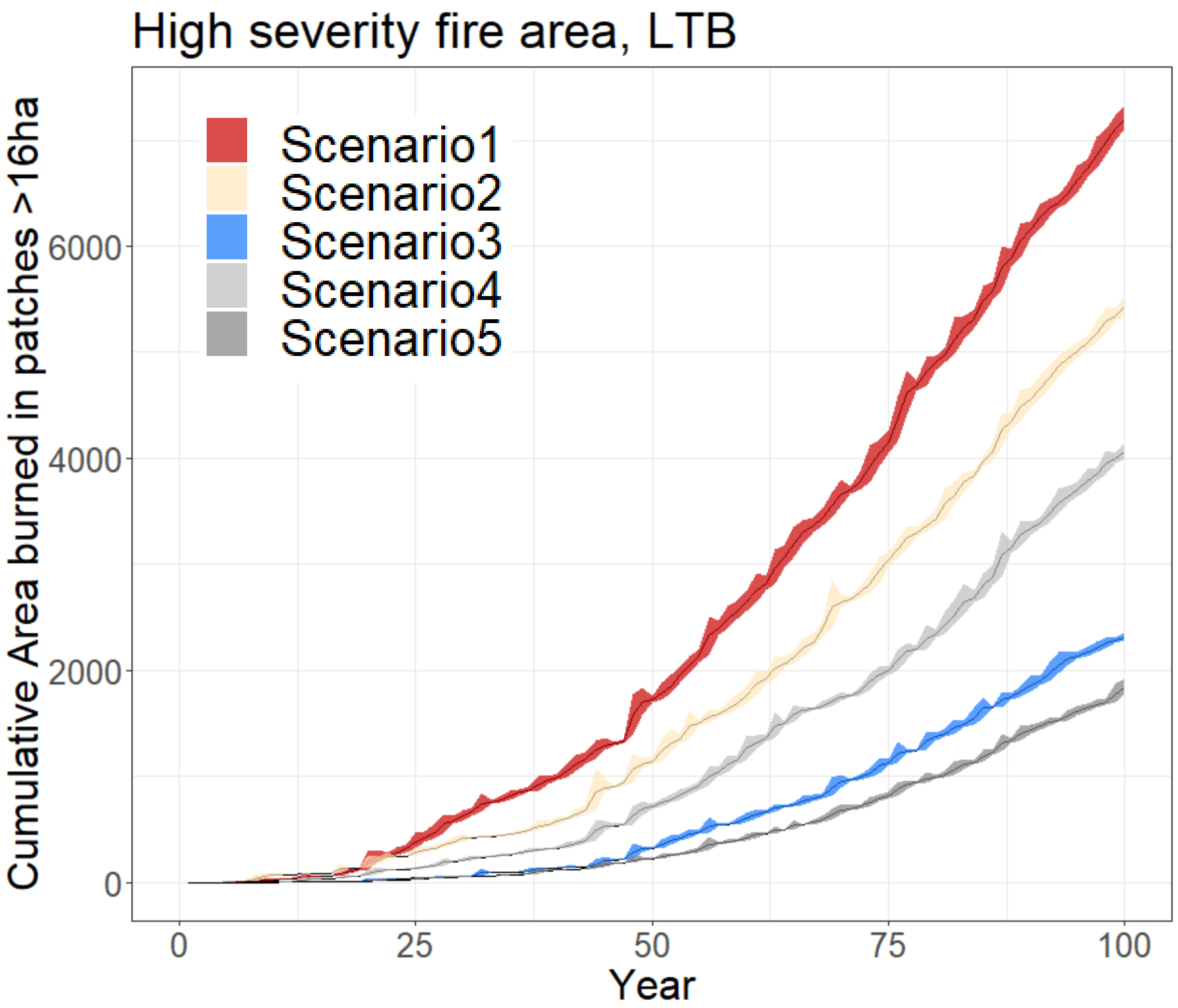
Wildfire by severity



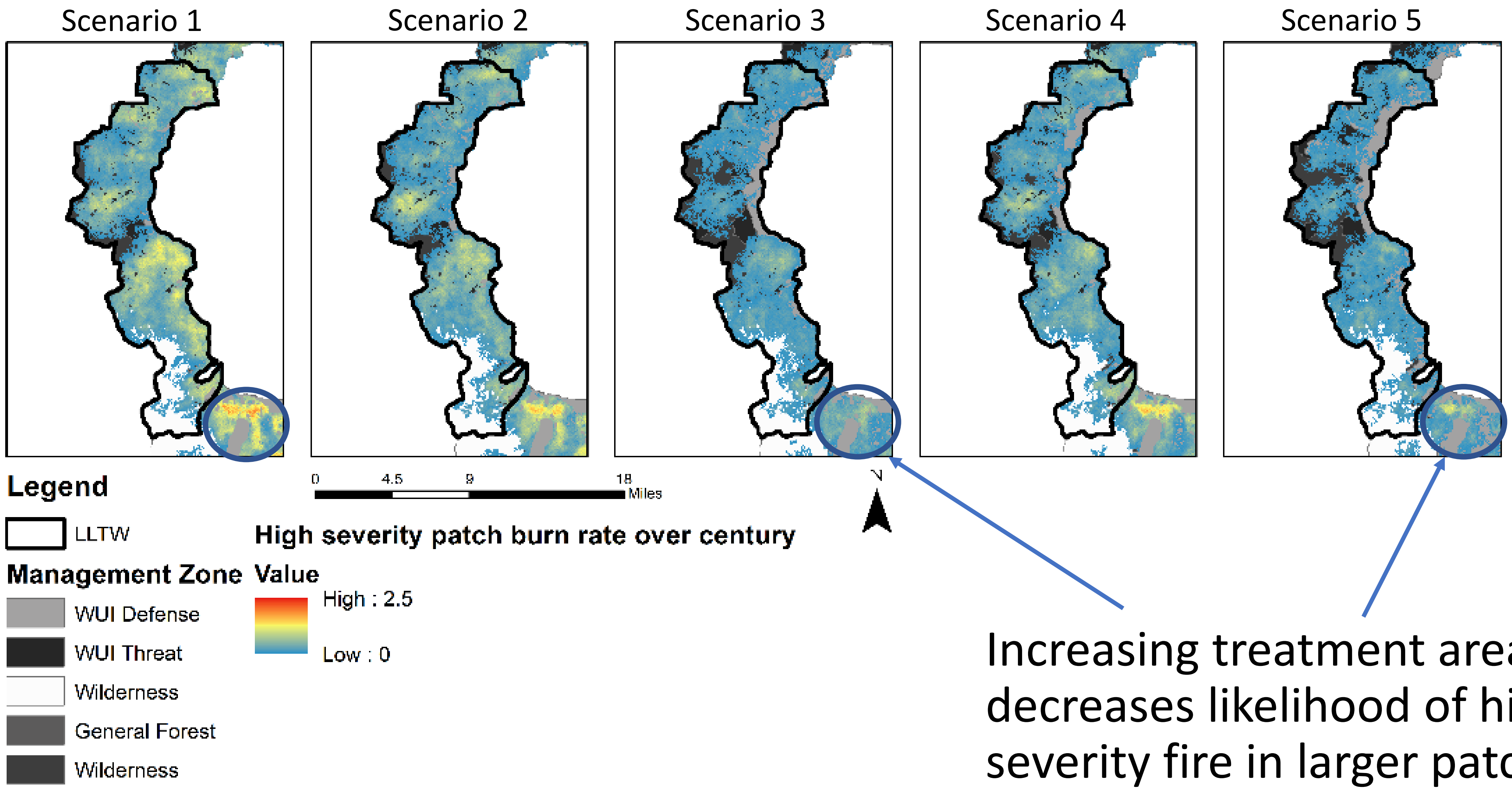


High severity fires in large patches



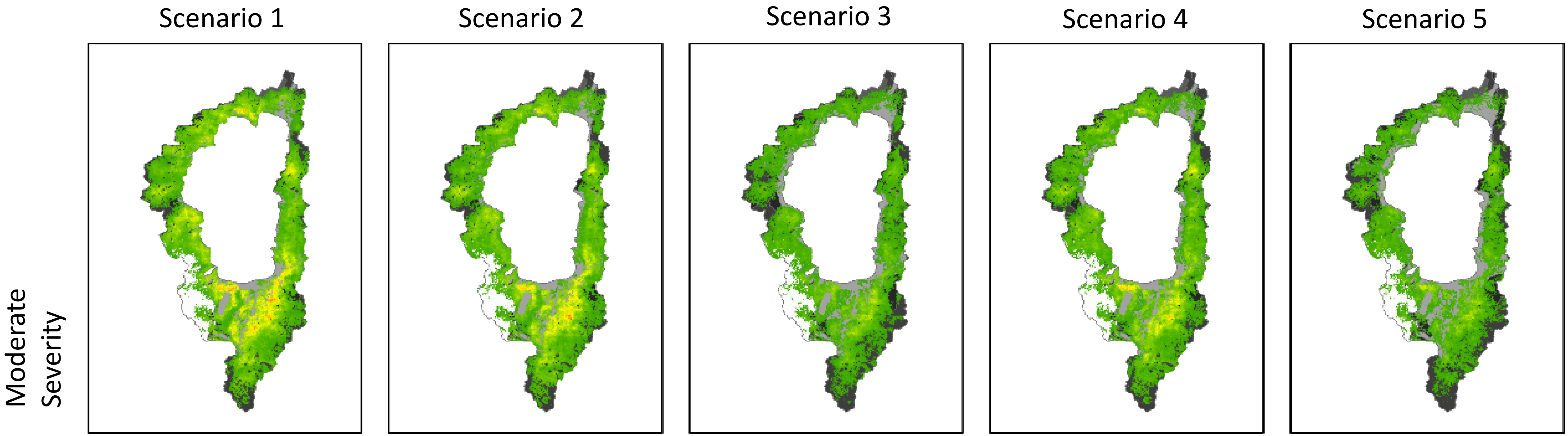


High severity fires in large patches



Increasing treatment area decreases likelihood of high severity fire in larger patches

Wildfire mean reburn



Legend

Management Zone

- WUI Defense
- WUI Threat
- Wilderness
- General Forest
- Wilderness

High severity

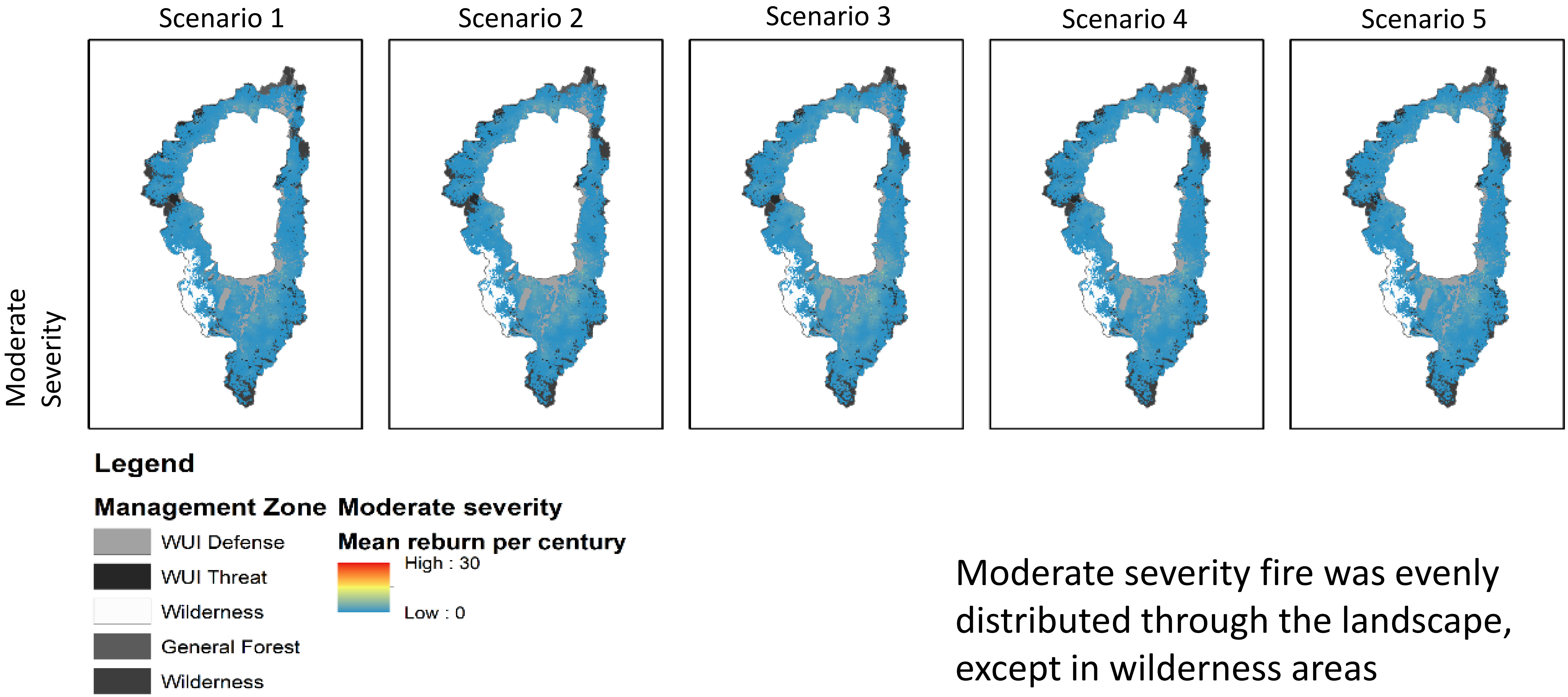
Mean reburn per century

High : 3

Low : 0

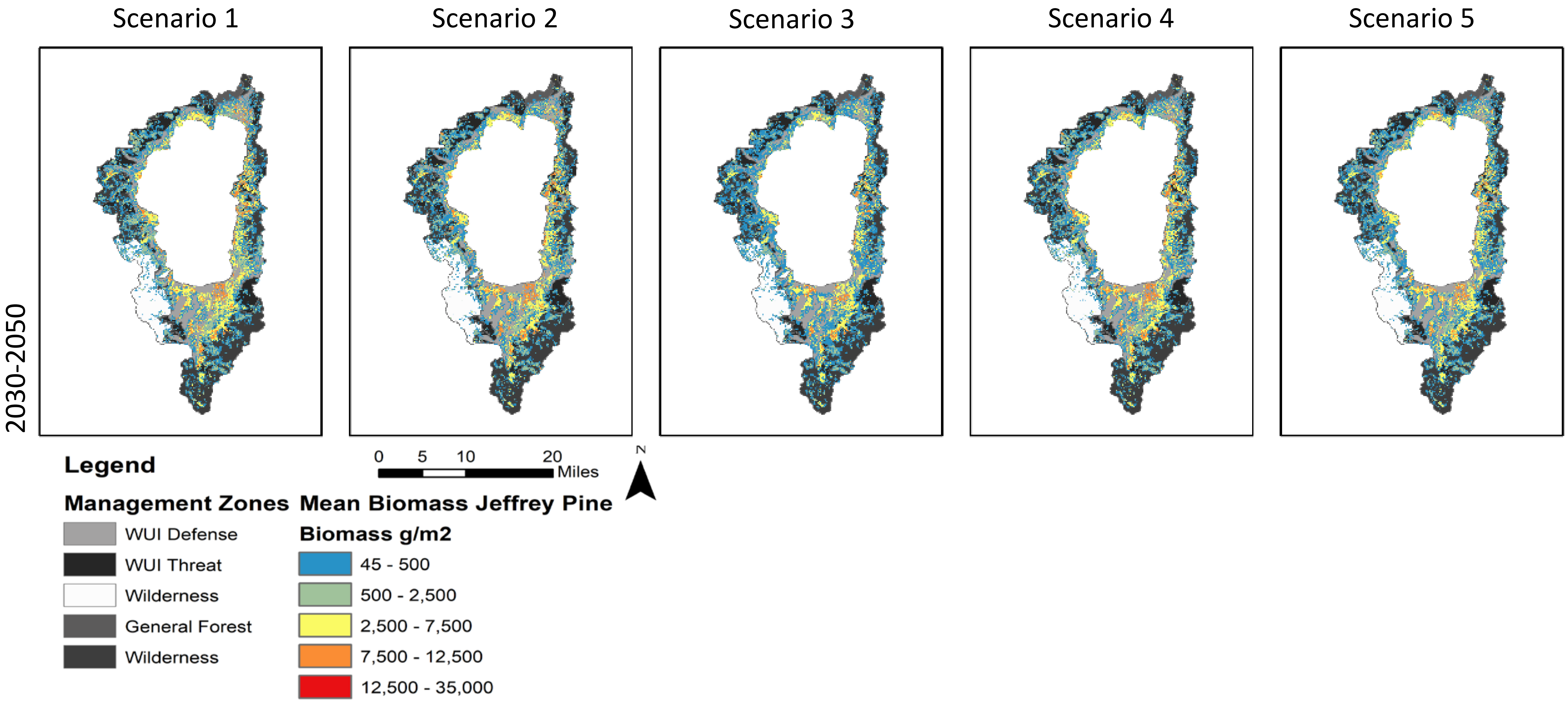
Areas that burned at high severity were also more likely to burn in larger patches

Wildfire mean reburn

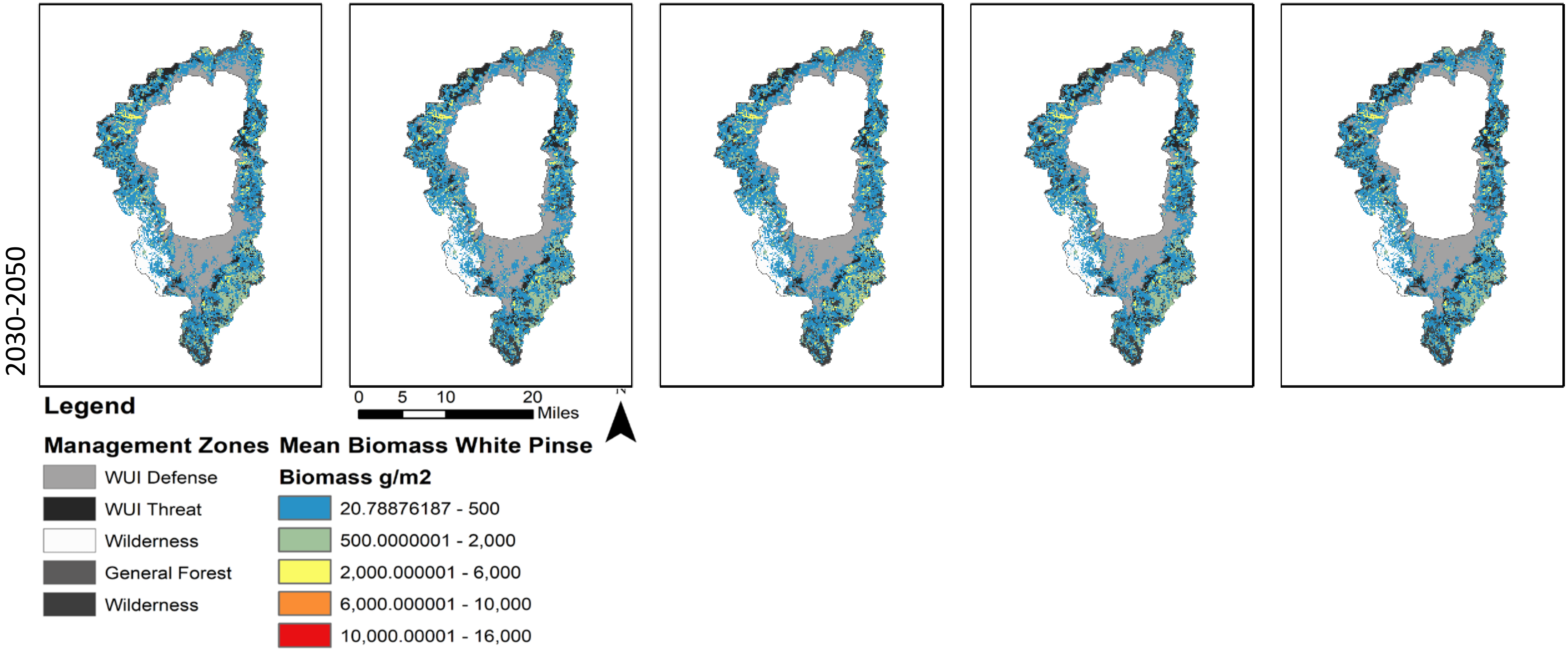


Moderate severity fire was evenly distributed through the landscape, except in wilderness areas

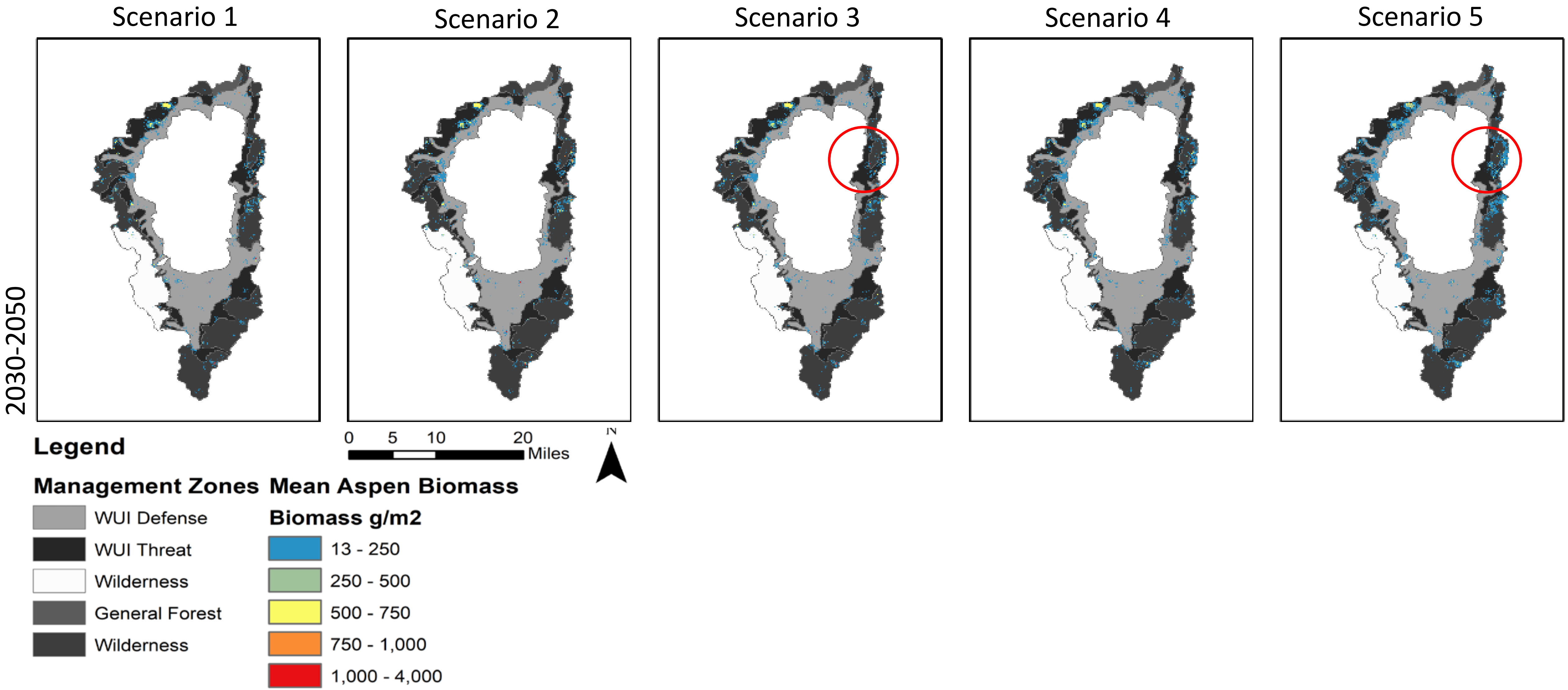
Species dynamics, Jeffrey Pine



Species dynamics, White Pine



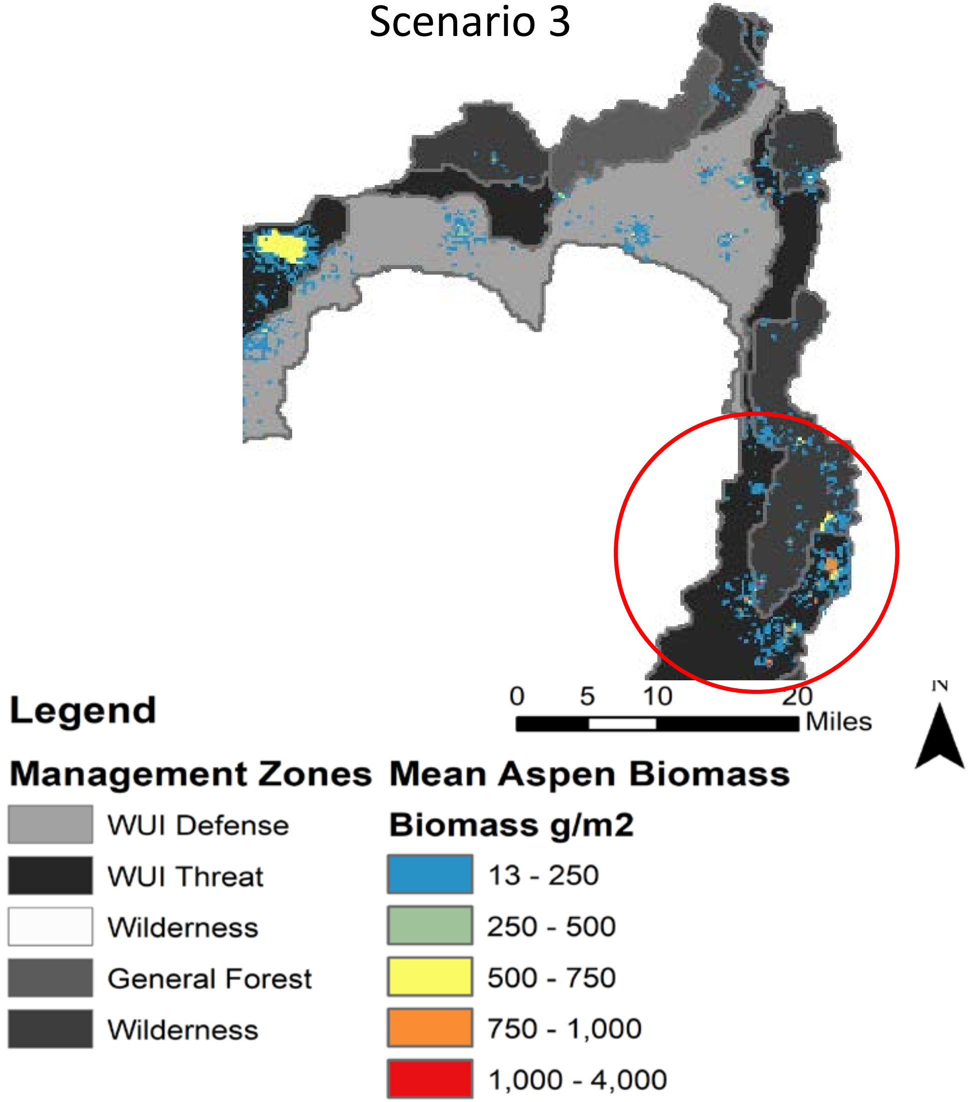
Species dynamics, Aspen



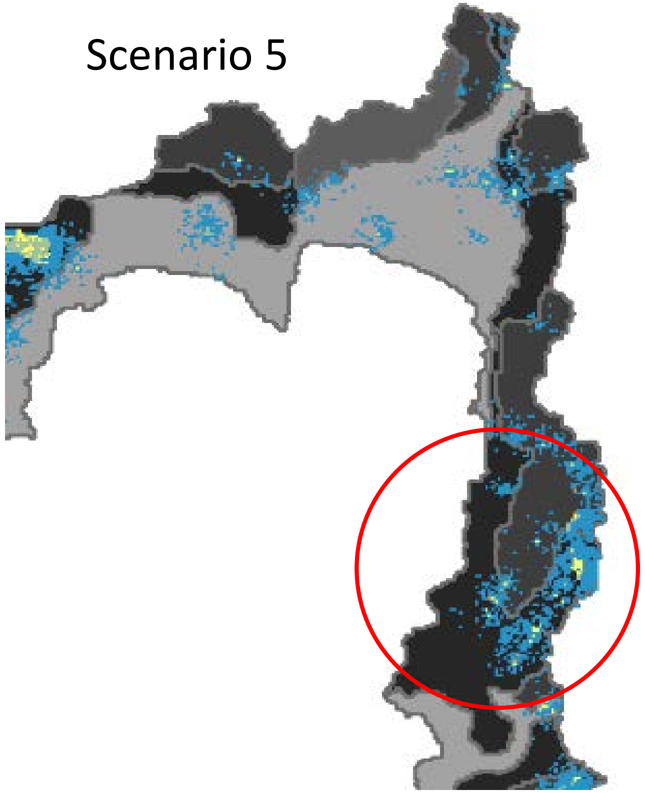
Species dynamics, Aspen

2030-2050

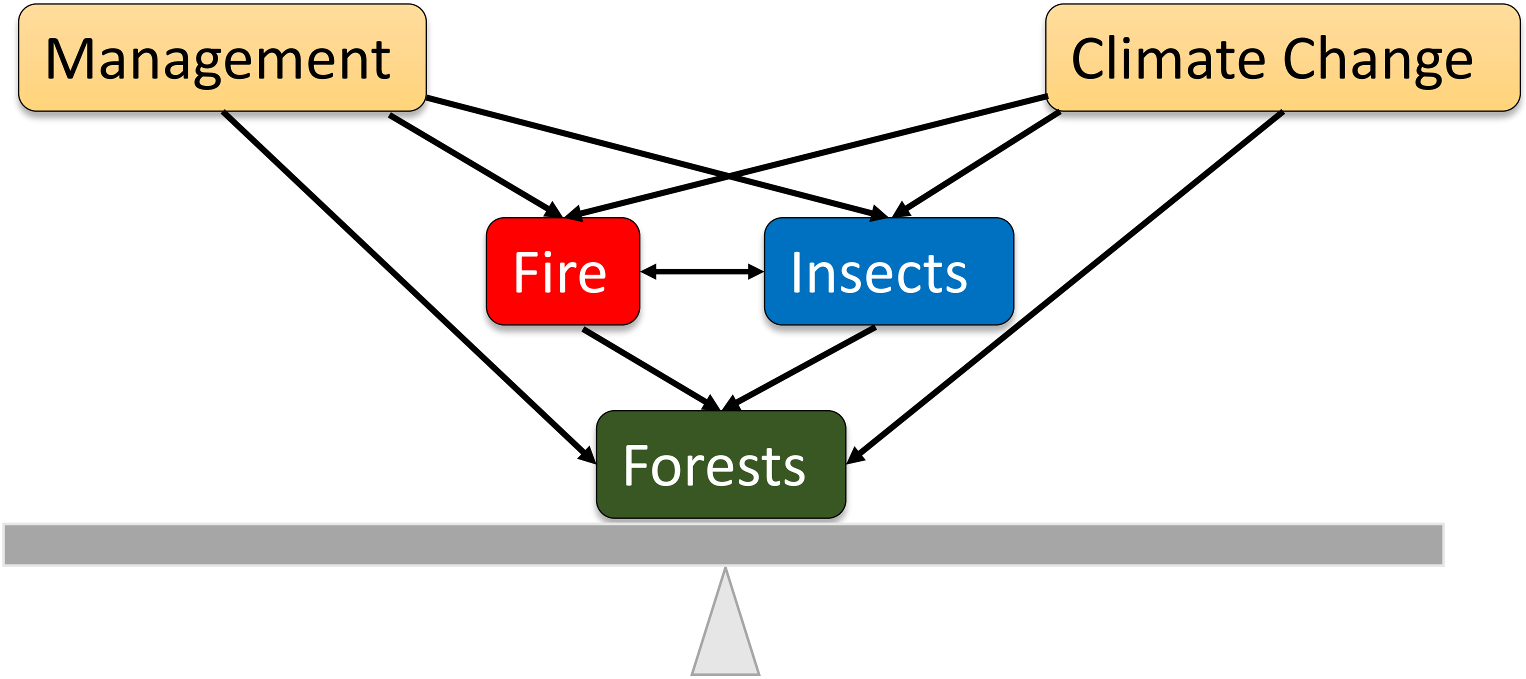
Scenario 3



Scenario 5

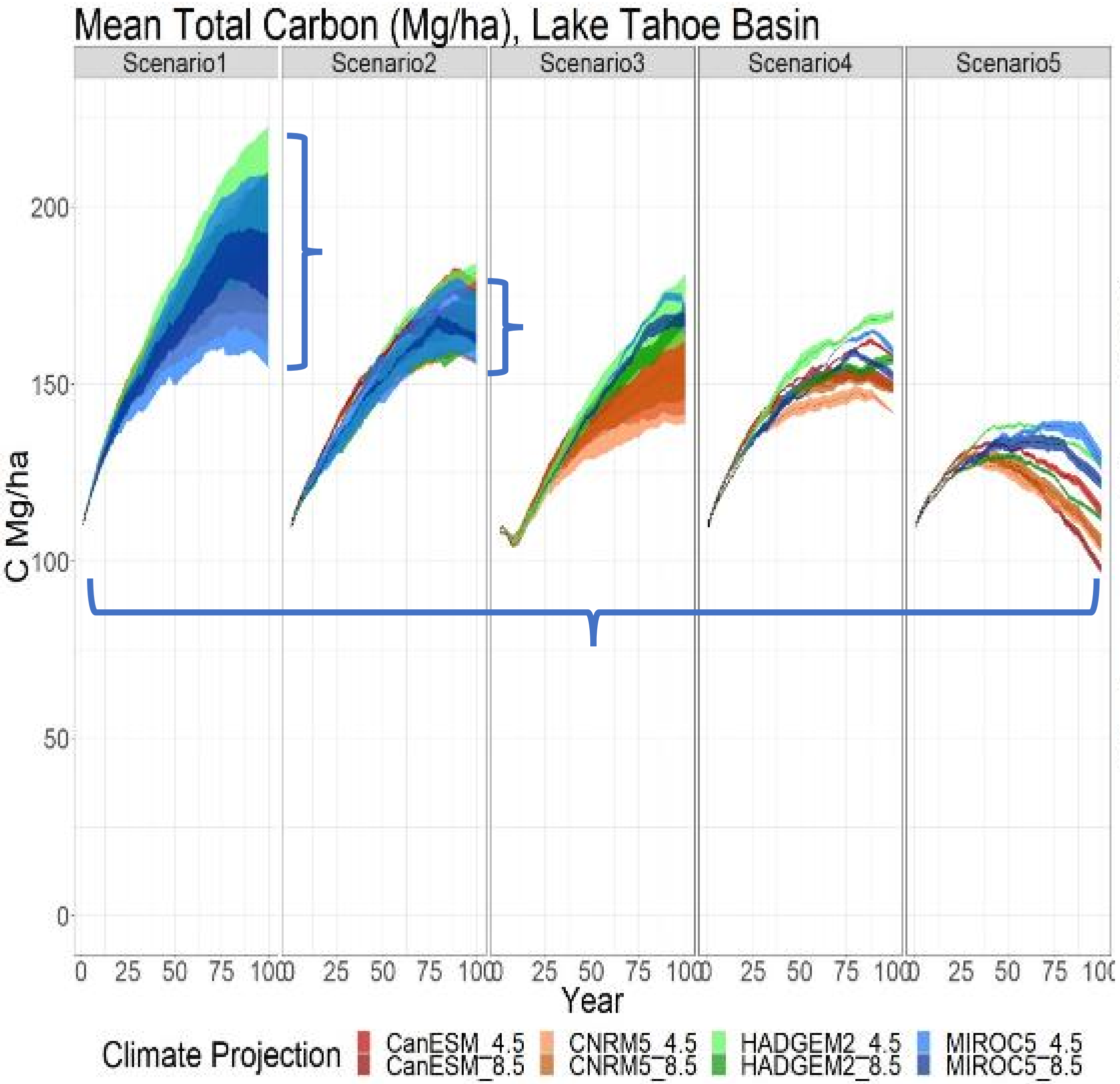


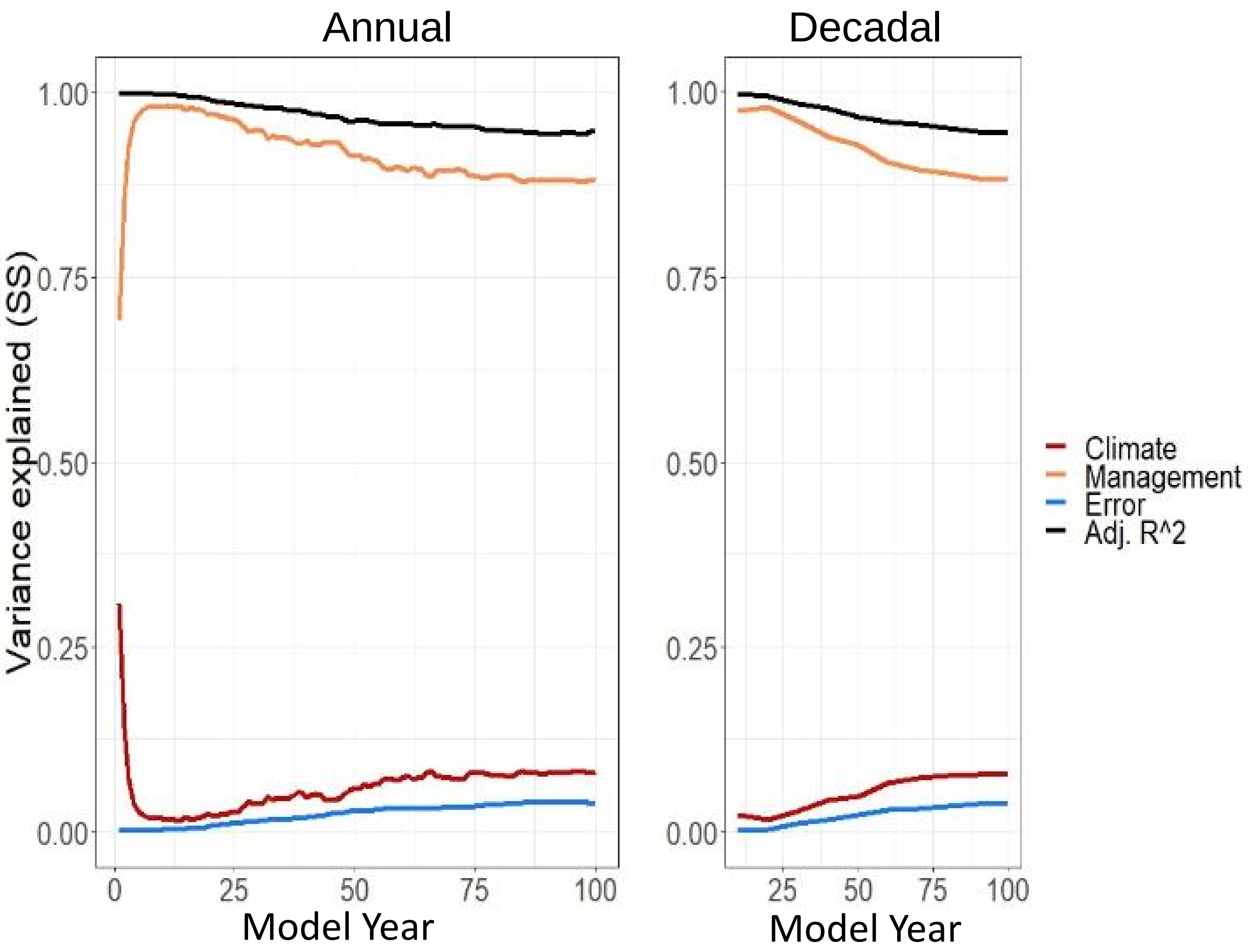
Scientific questions



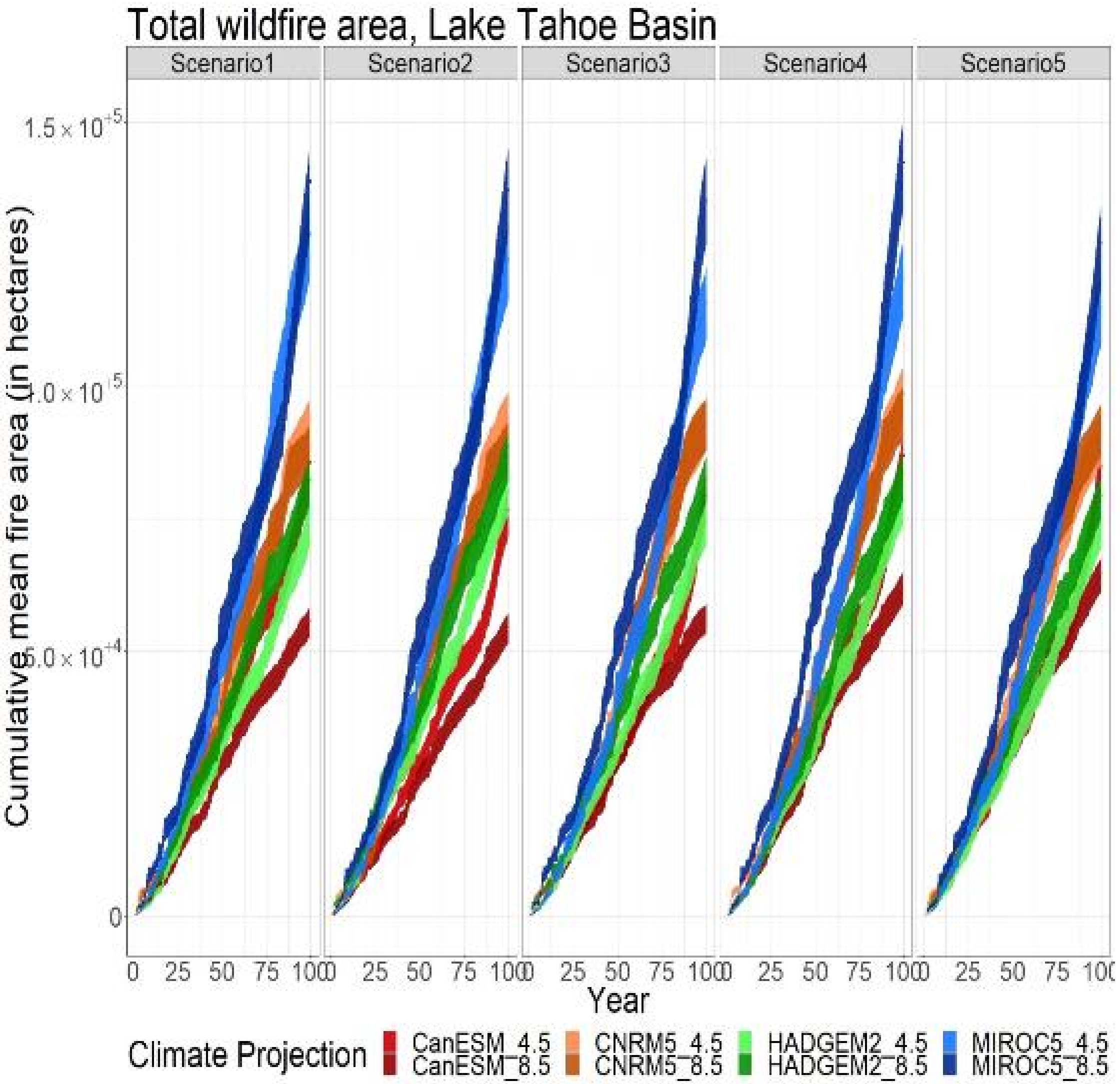
With the factorial experimental design, we can start to answer the question of what matters more: climate change or management?

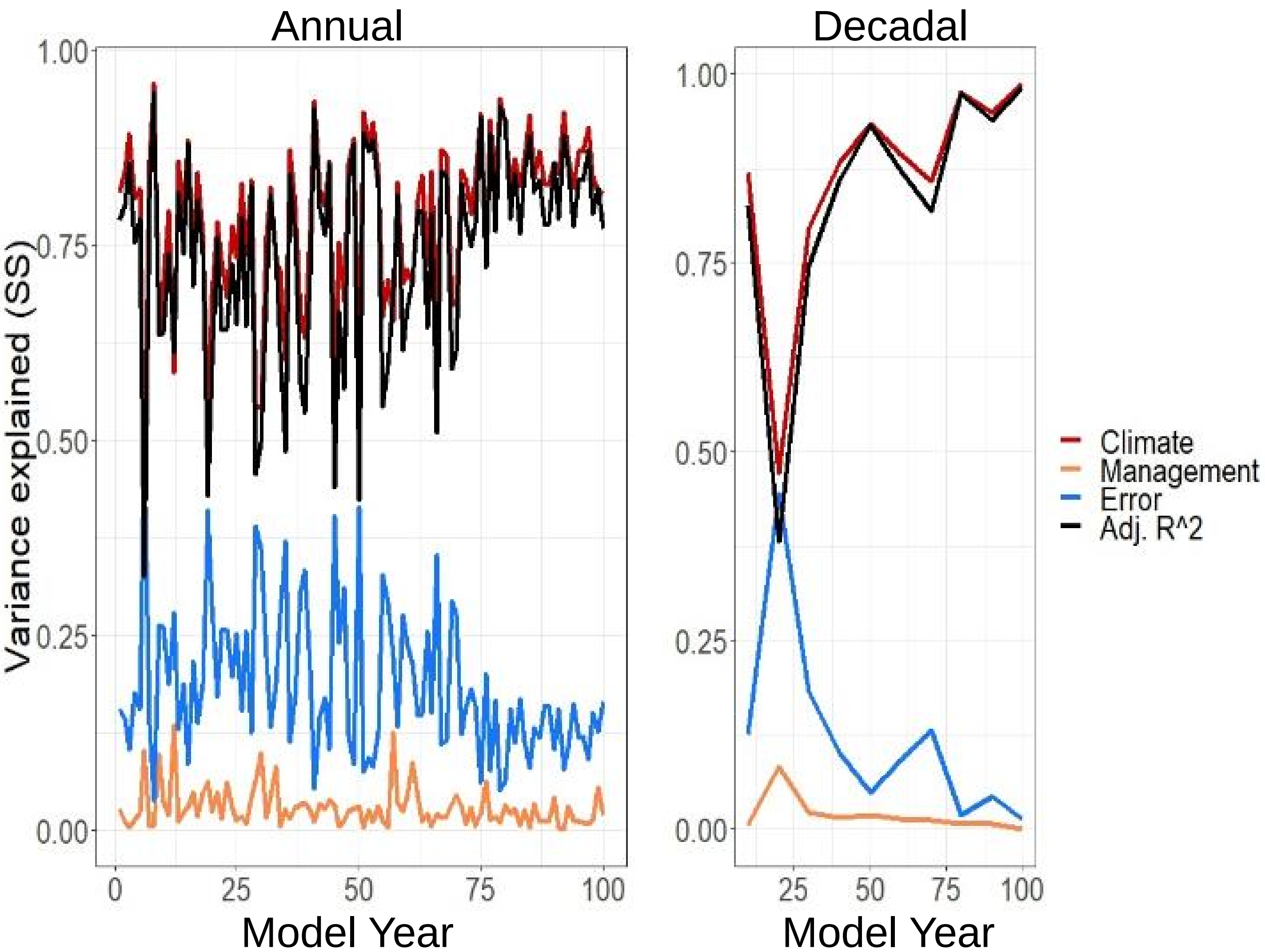
Carbon density



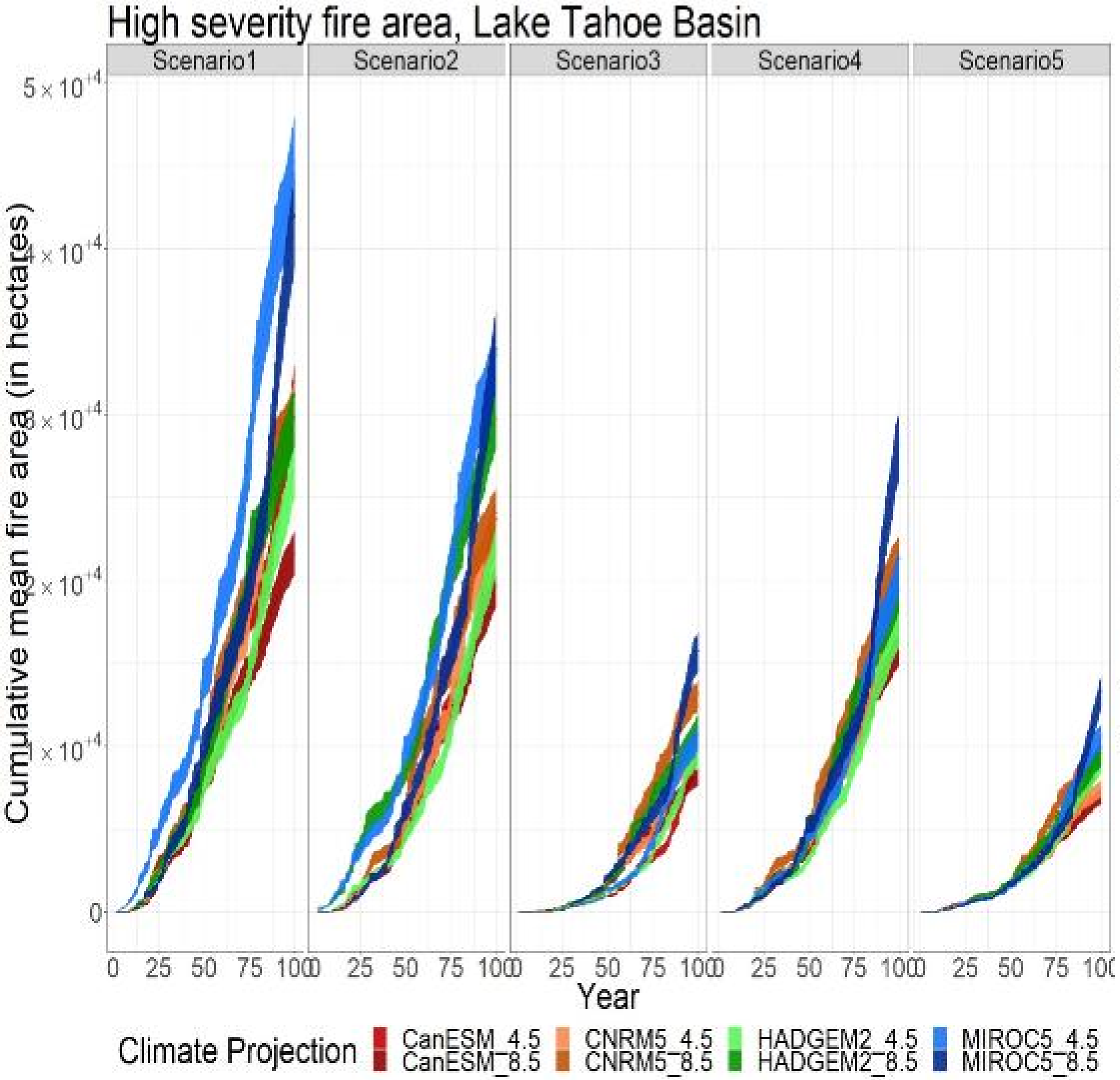


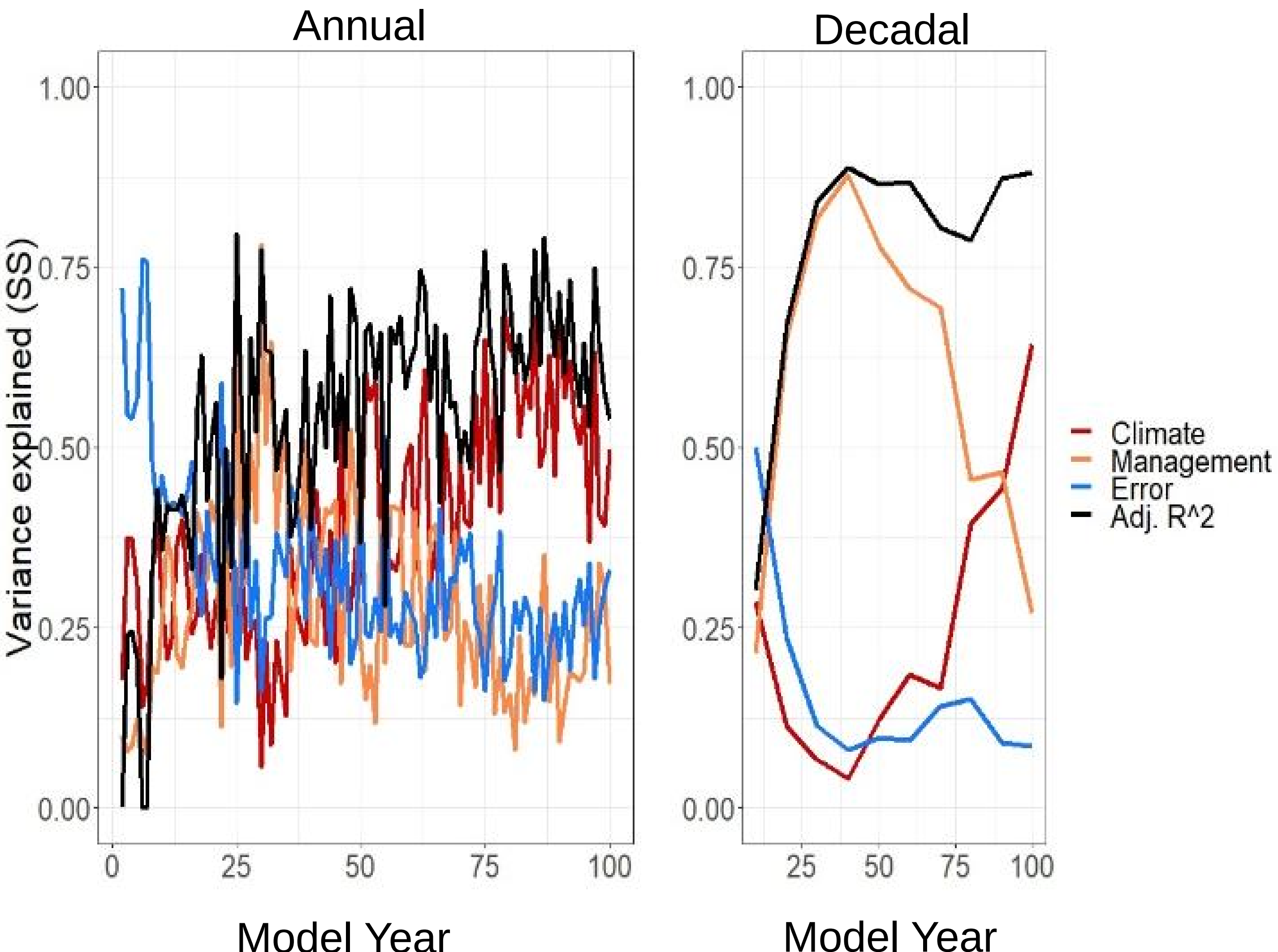
Total wildfire





High severity fire area





Impacts of management

What management can do:

- Reduce the amount of high severity fire
- Influence where and how much carbon is stored across the landscape

What management can't do:

- Reduce the total amount of fire (this is climate driven)
- Adjust species dynamics in the short run (except possibly aspen)

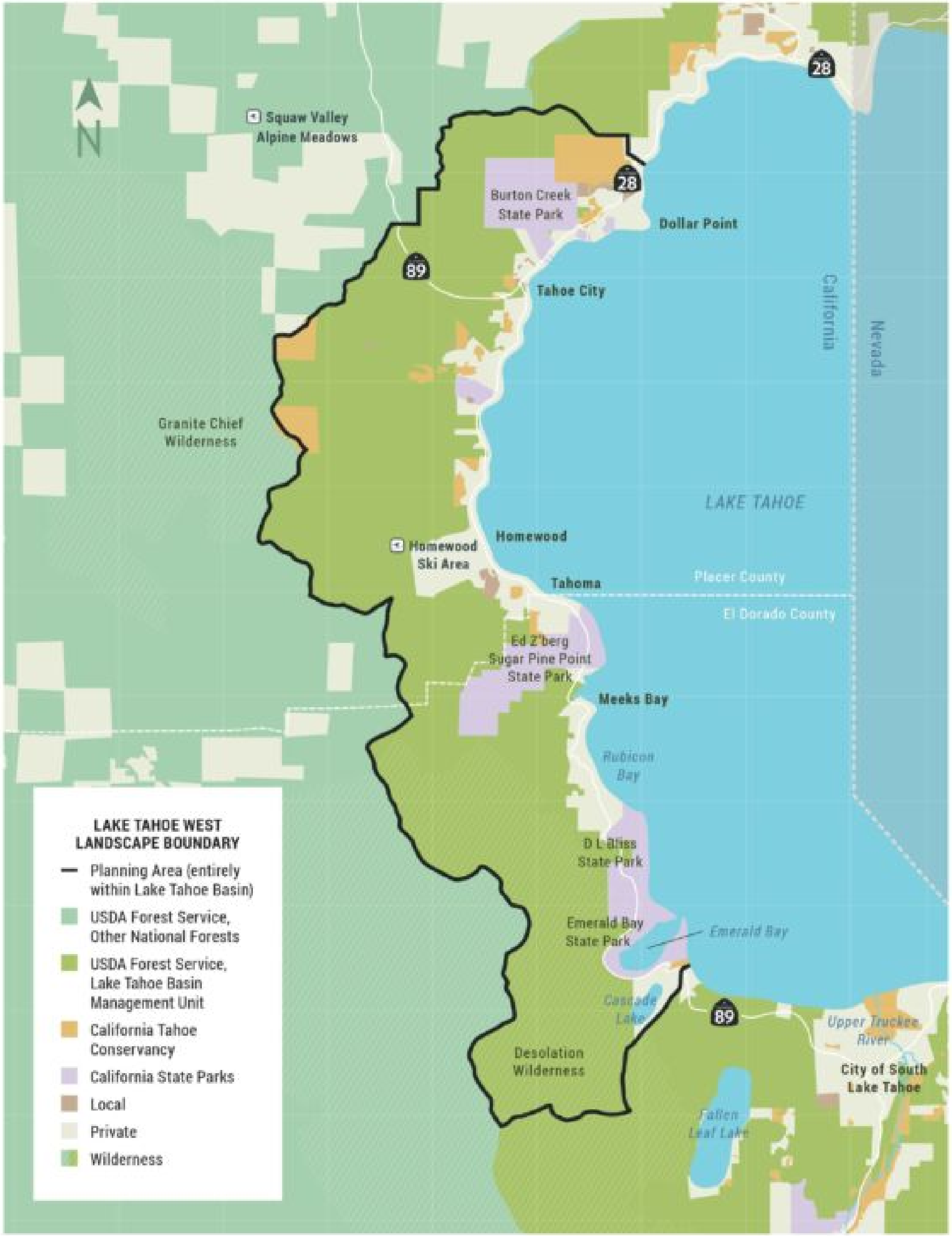
Wildlife Habitat Modeling for the Lake Tahoe West Restoration Partnership

Angela White, Research Wildlife Biologist,

Pacific Southwest Research Station

angela.white2@usda.gov

19 May 2020 Symposium



Evaluation Criteria

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

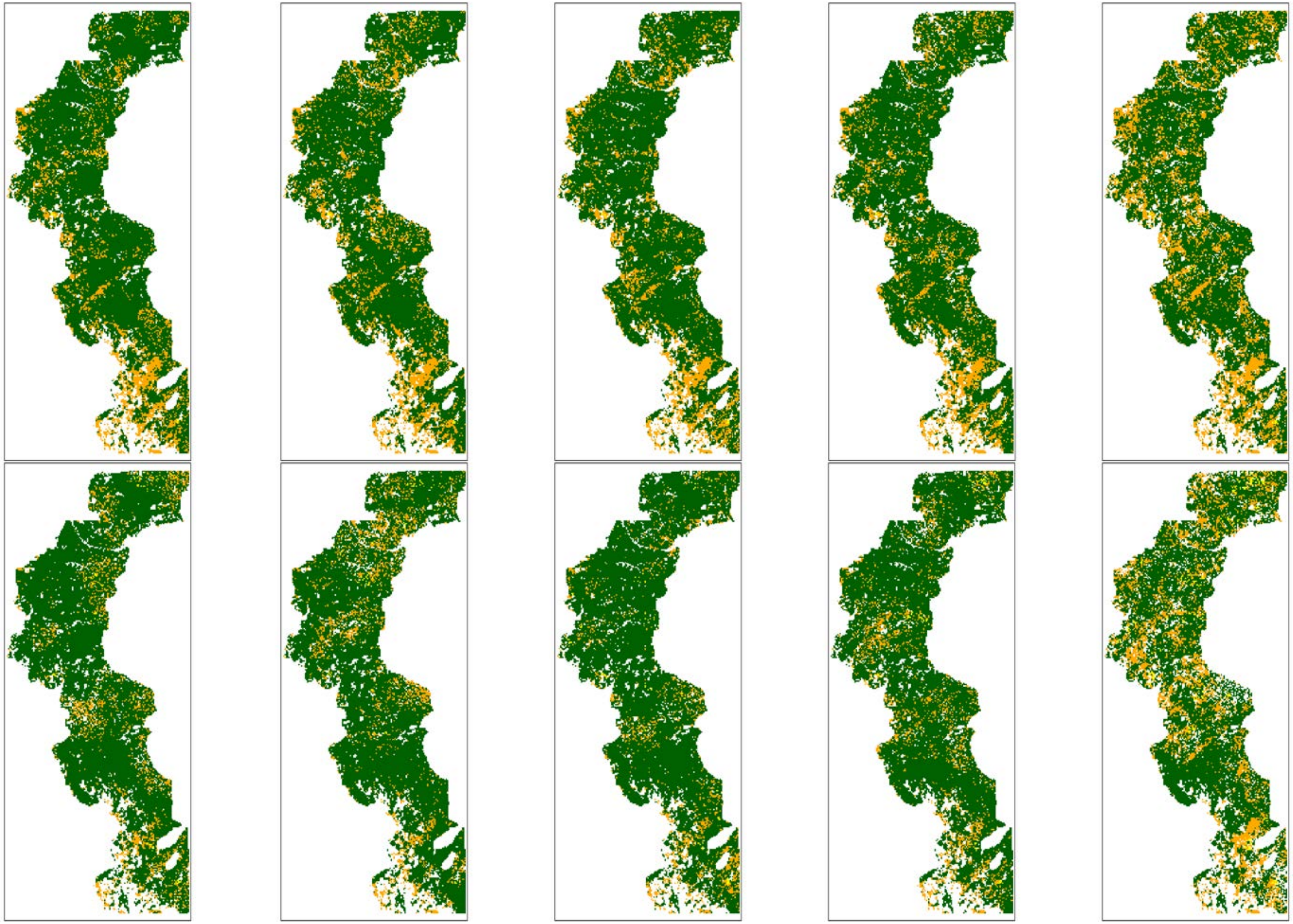
FOREST COVER

	Scenario 1: Fire Suppression	Scenario 2: WUI-focus	Scenario 3: Thinning-focus	Scenario 4: Fire-focus (mod)	Scenario 5: Fire-focus (high)

Decadal outputs
Replicate 1 of 10

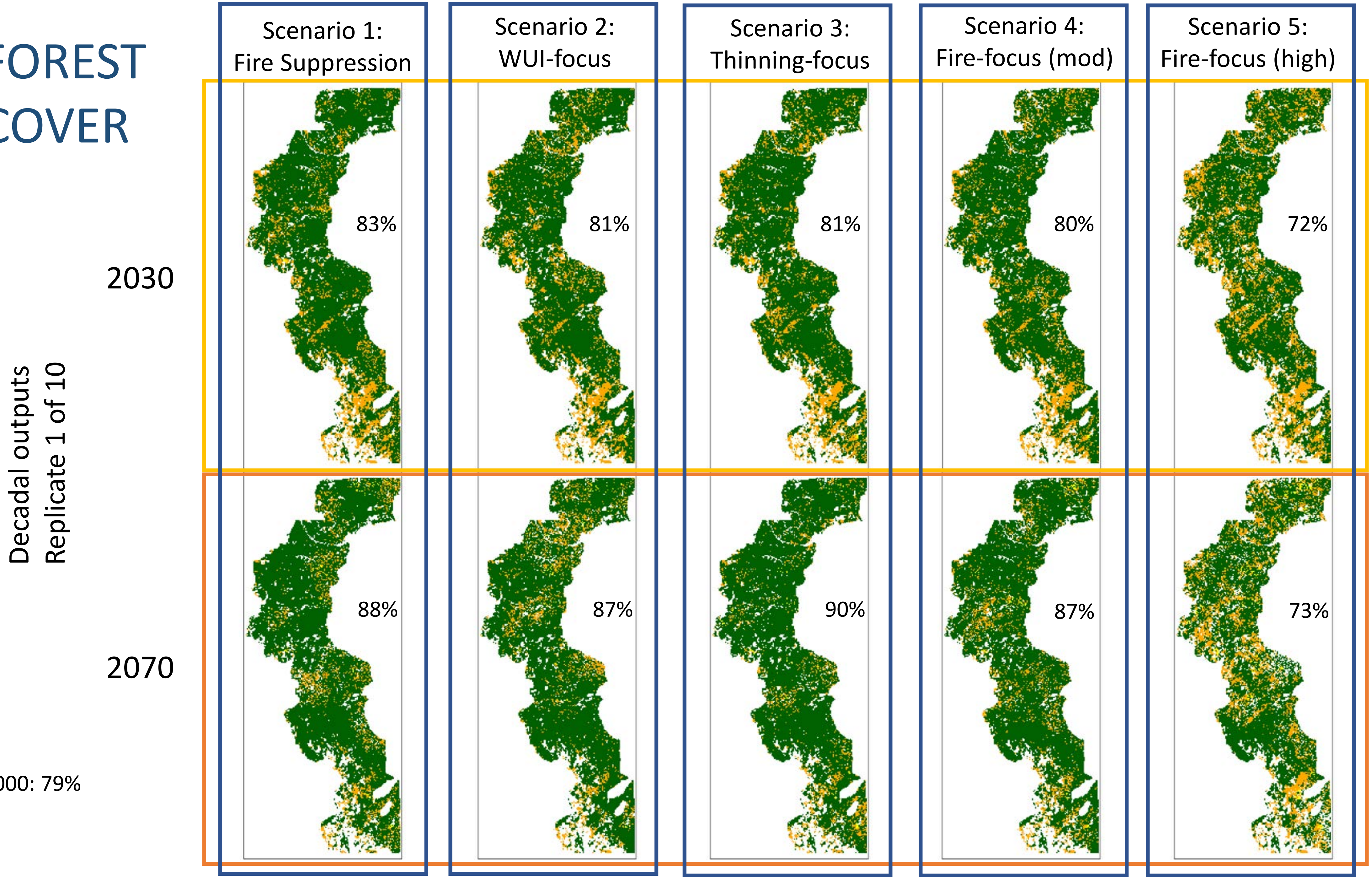
2030

2070



Resolution = 1 ha
$n_{scenario}$=100

FOREST COVER



2000: 79%

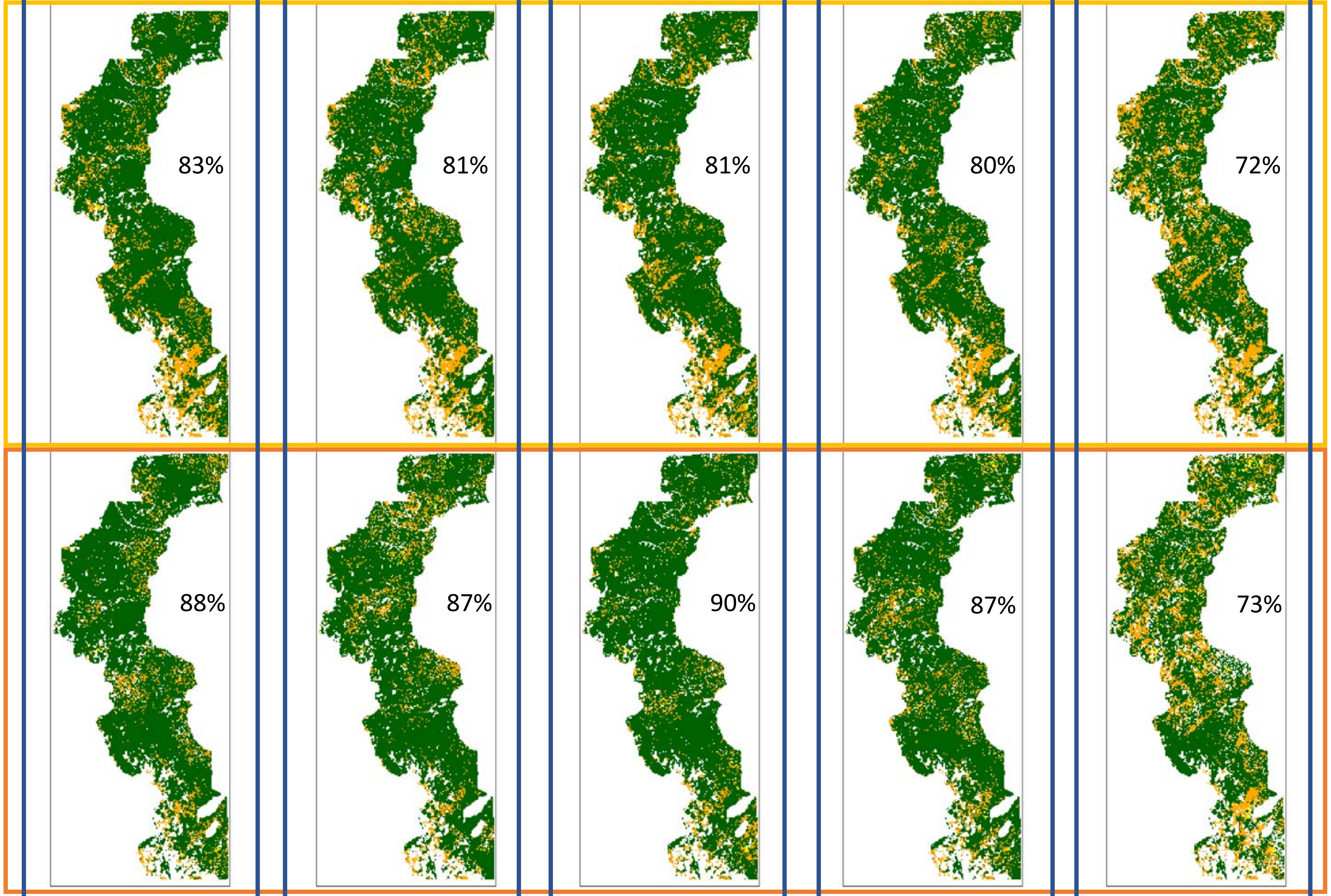
FOREST COVER

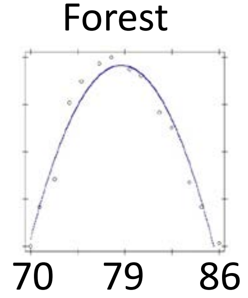
Decadal outputs
Replicate 1 of 10

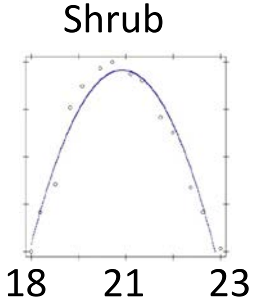
Scenario 1: Fire Suppression	Scenario 2: WUI-focus	Scenario 3: Thinning-focus	Scenario 4: Fire-focus (mod)	Scenario 5: Fire-focus (high)

2030

2070

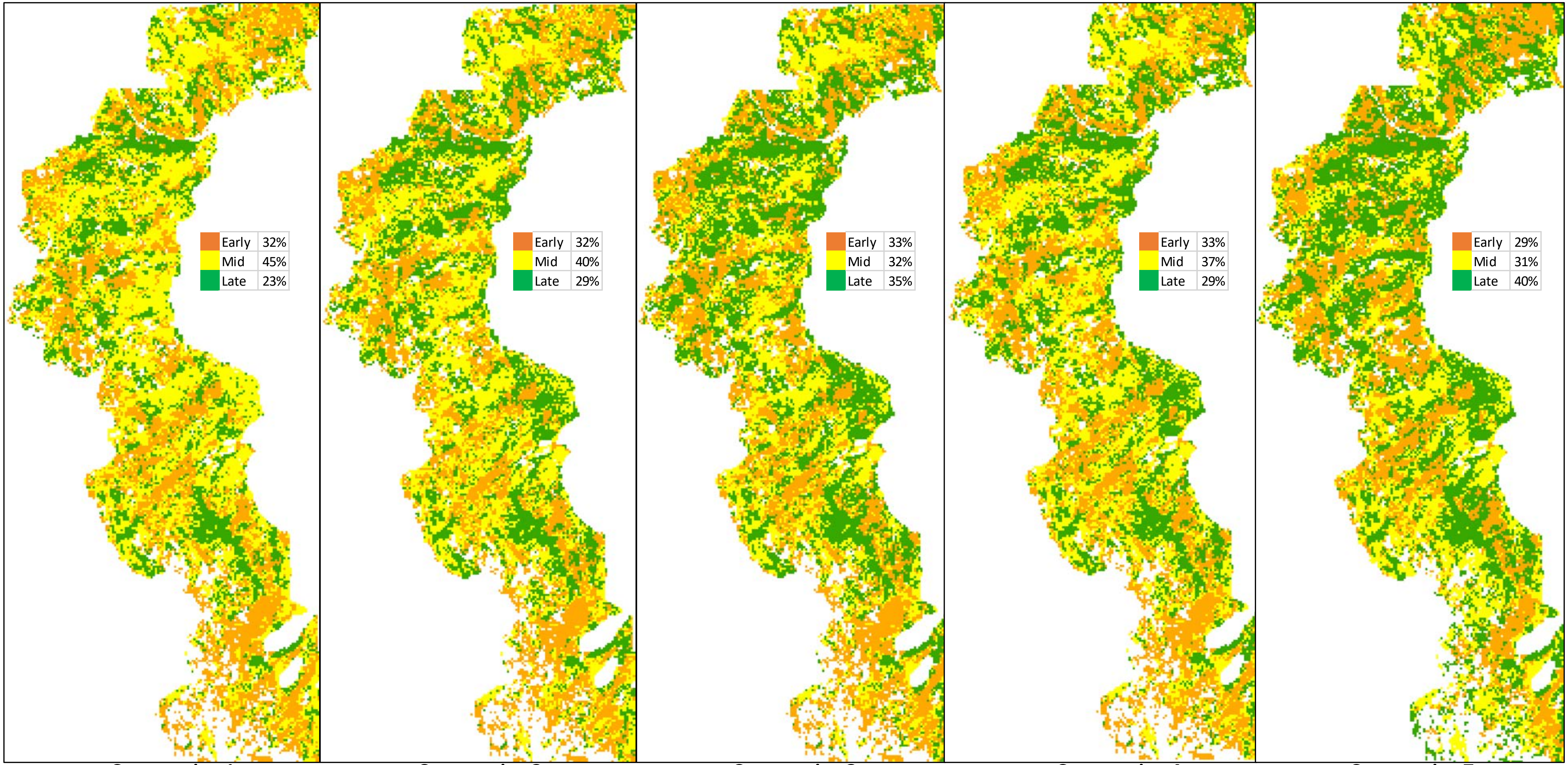






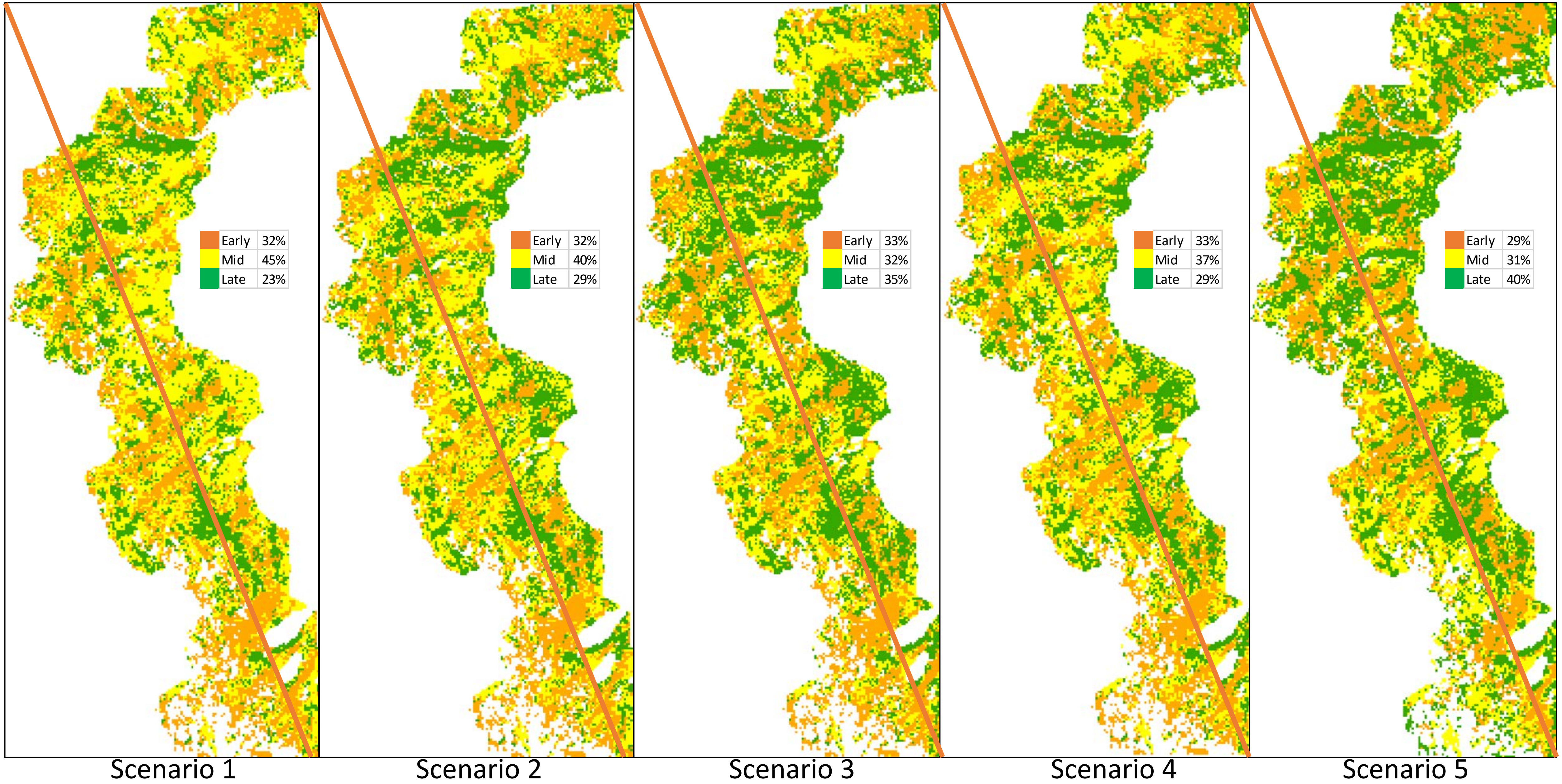
2000: 79%

Landscape Condition: Seral Stage

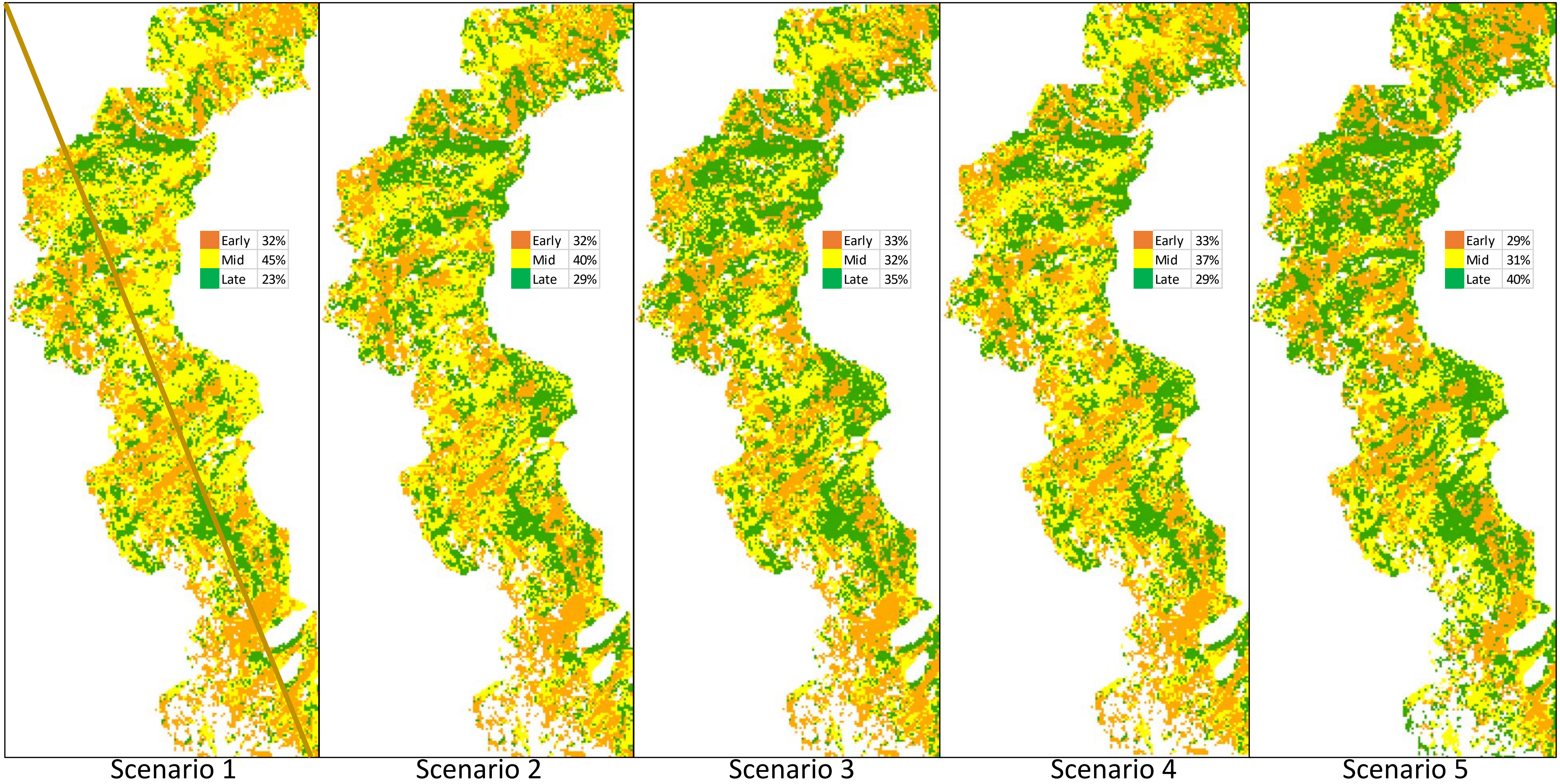


Scenario 1 Scenario 2 Scenario 3 Scenario 4 Scenario 5

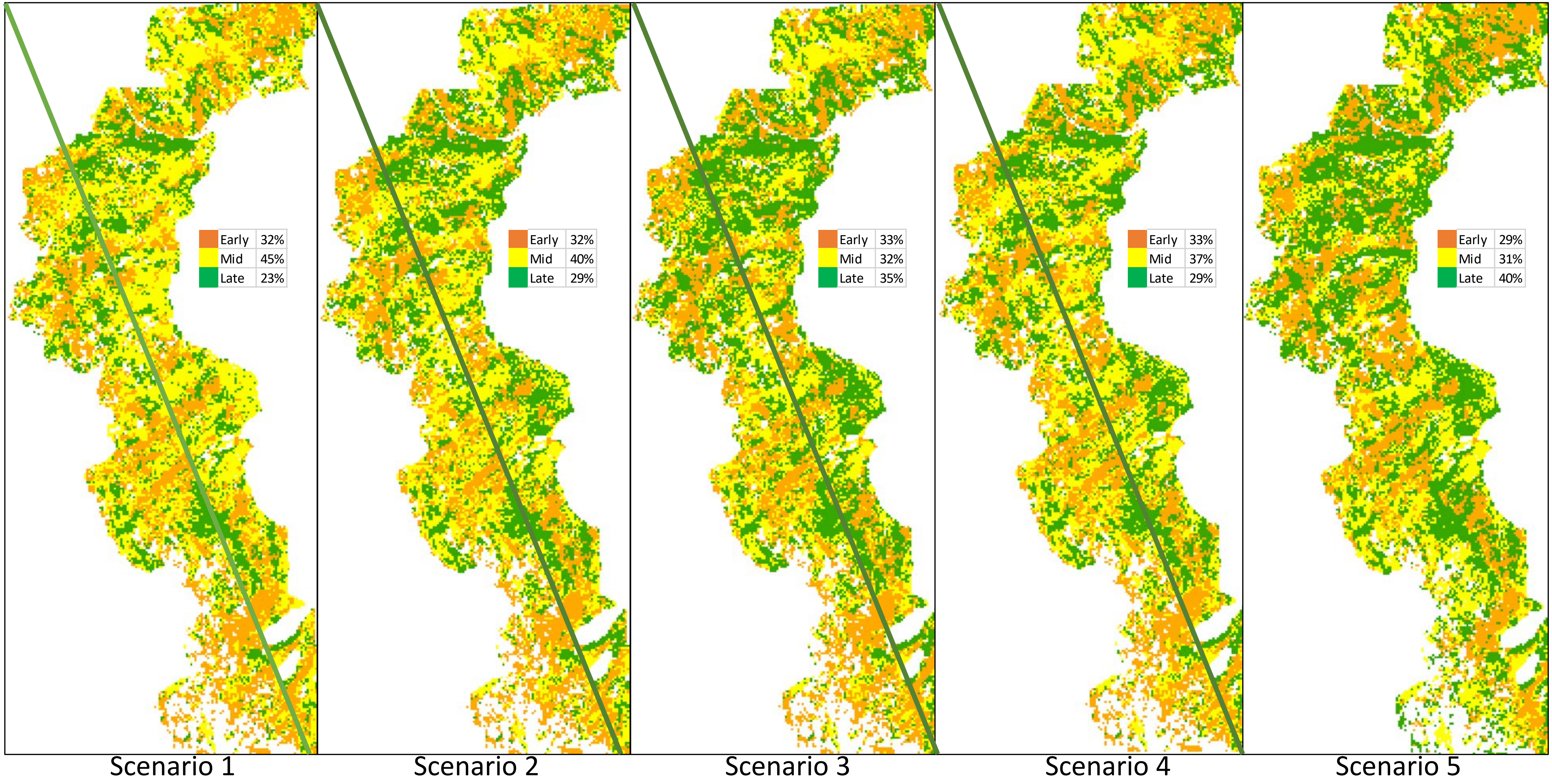
Landscape Condition: Seral Stage



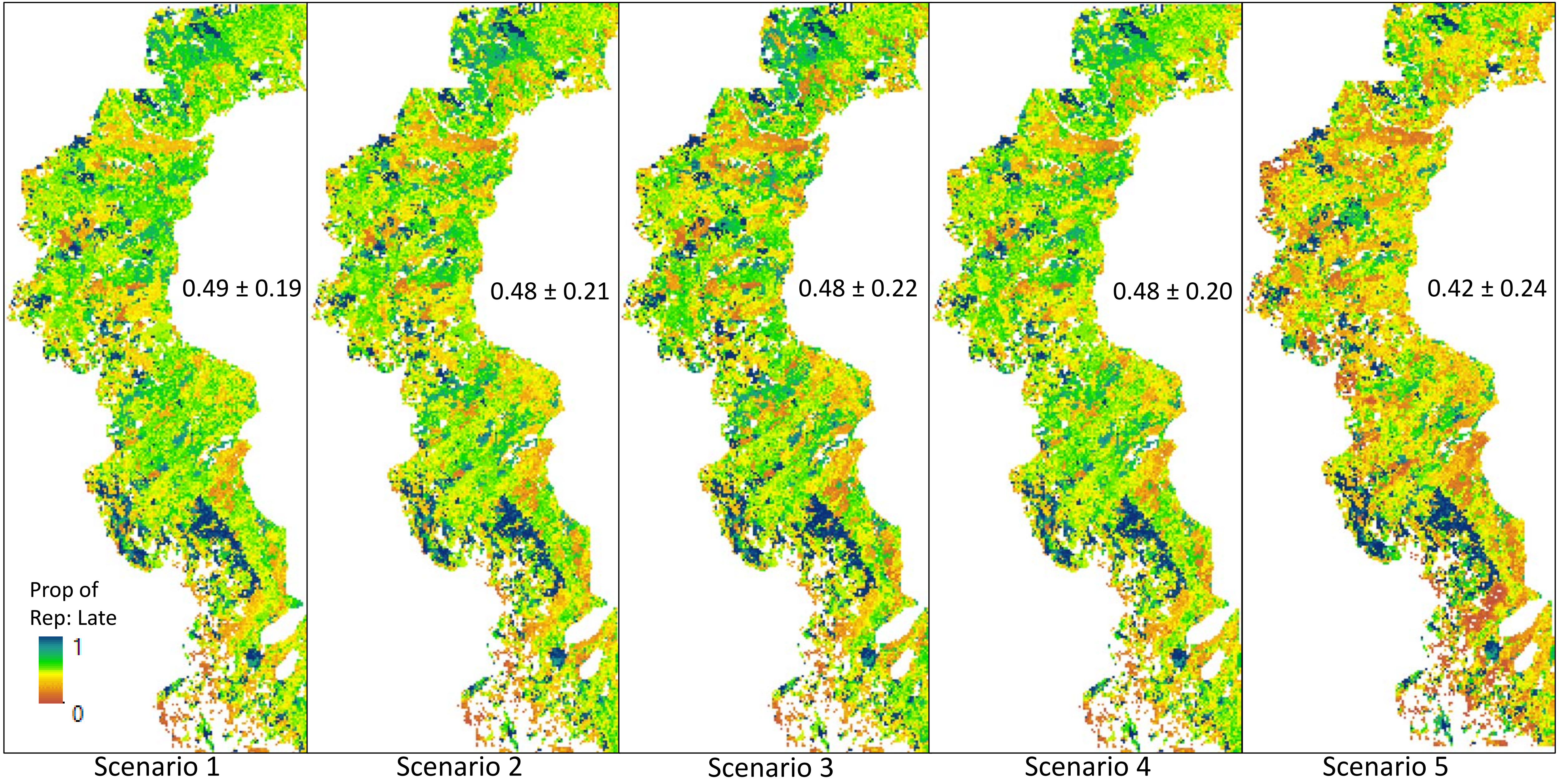
Landscape Condition: Seral Stage



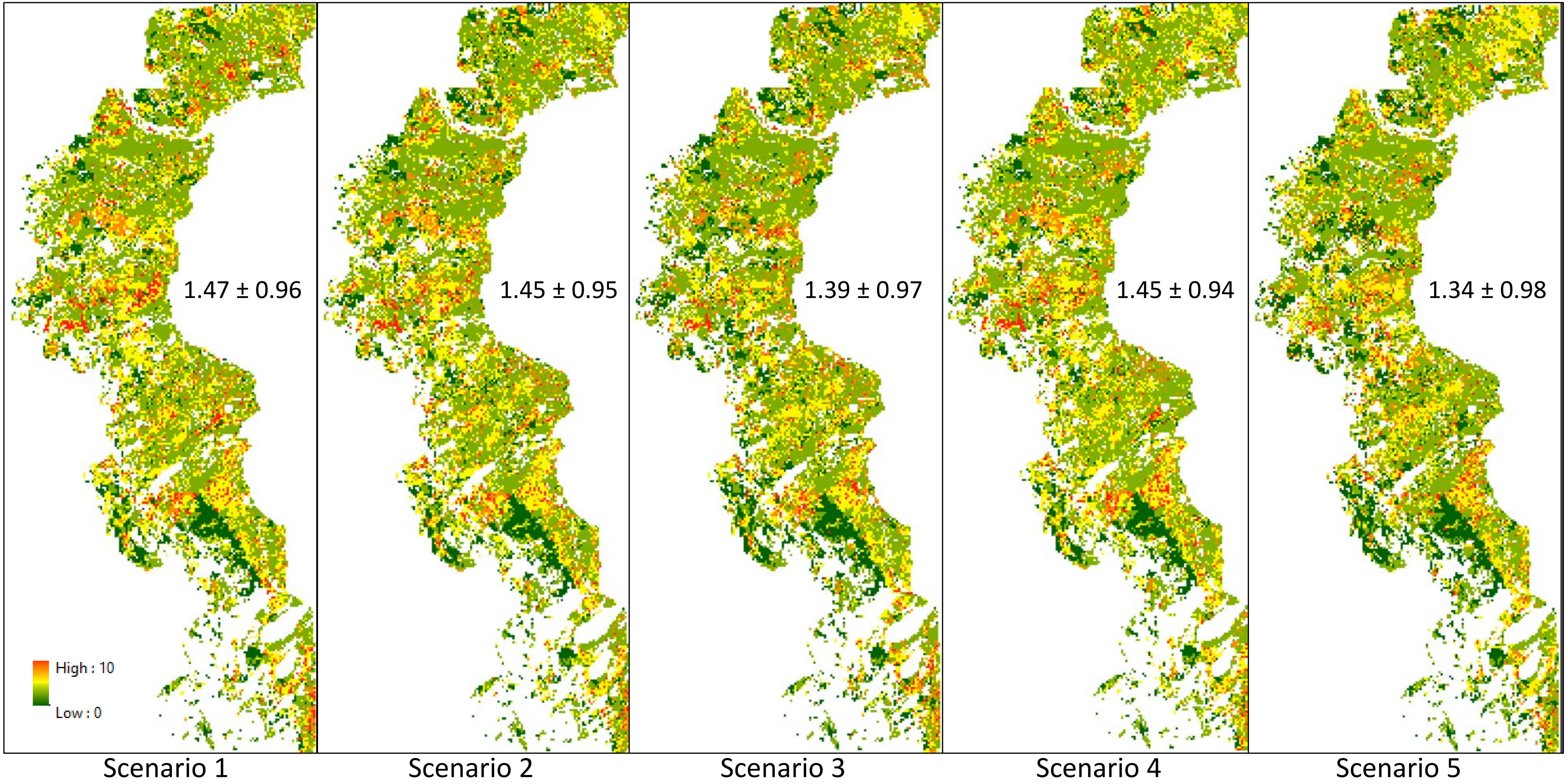
Landscape Condition: Seral Stage



Landscape Heterogeneity: Seral Stage



Landscape Stability: Seral Stage



Wildlife Habitat Modeling – Prediction

Long-term evaluation of pursuing different management *regimes* on wildlife

Modeling Wildlife Habitat

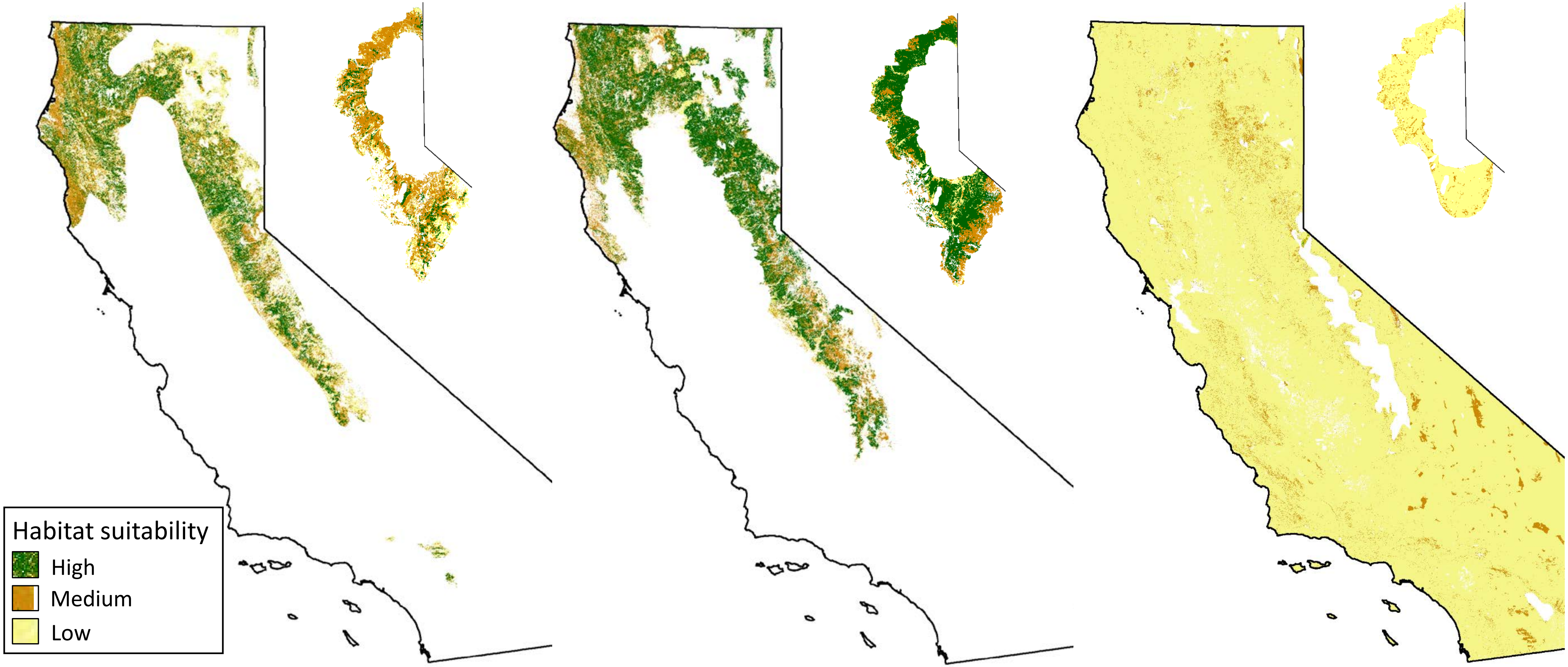
- Expert opinion
  - California Wildlife Habitat Relationships (CWHR)
- Inferences
  - Composition, tree size and cover
  - Habitat value by life stage (low, moderate, high)
  - Species can shift with habitat
  - Data available for many species

Occupancy Modeling

Scientist: Keith Slauson

- Variable selection
  - Maxent modeling
  - Occupied versus random points
- Inferences
  - Habitat suitability (range: 0-1)
  - Variable importance is quantified and assumed “optimal”
  - Requires higher-quality species-specific data

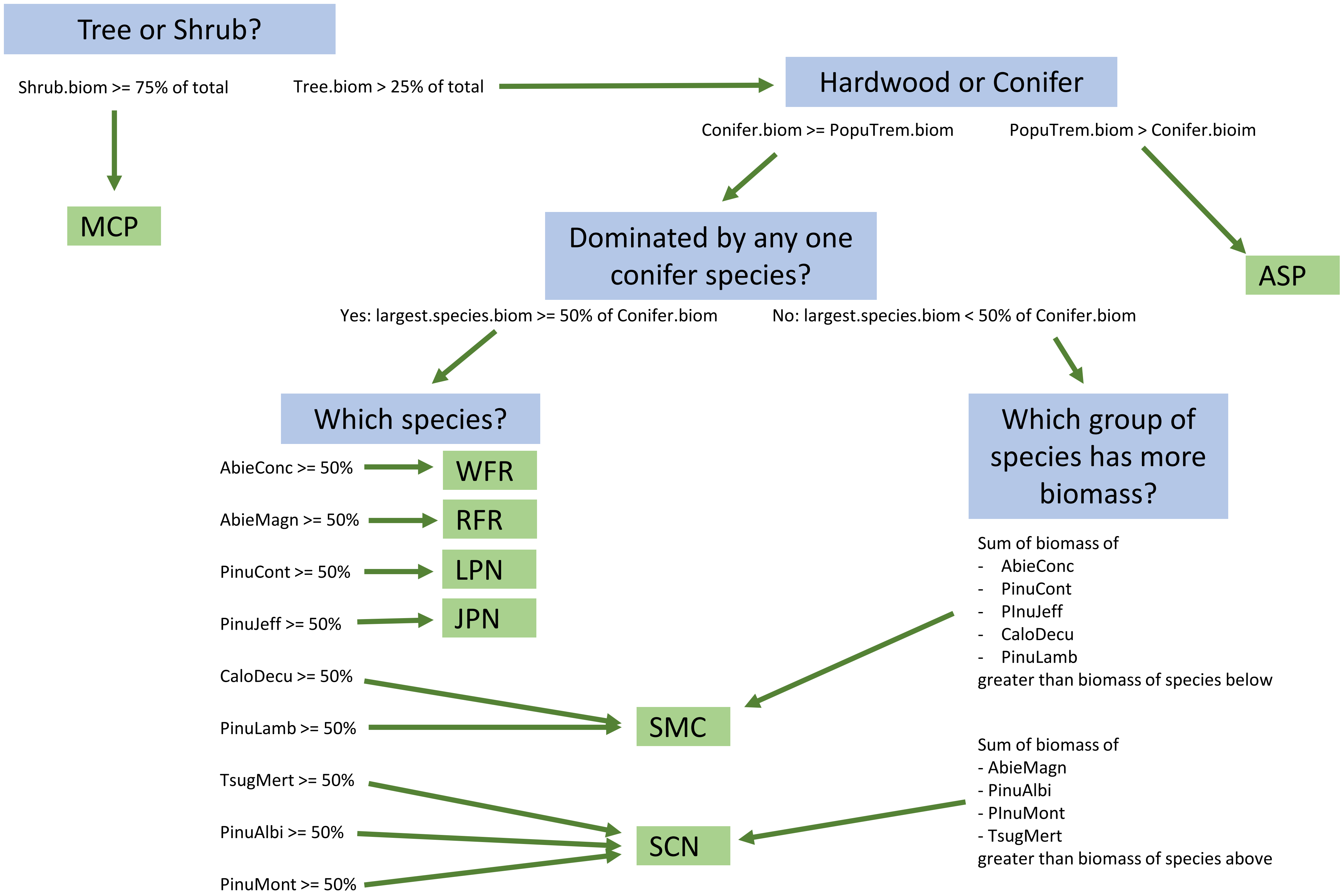
Sooty grouse | Northern flying squirrel | Townsend's big-eared bat



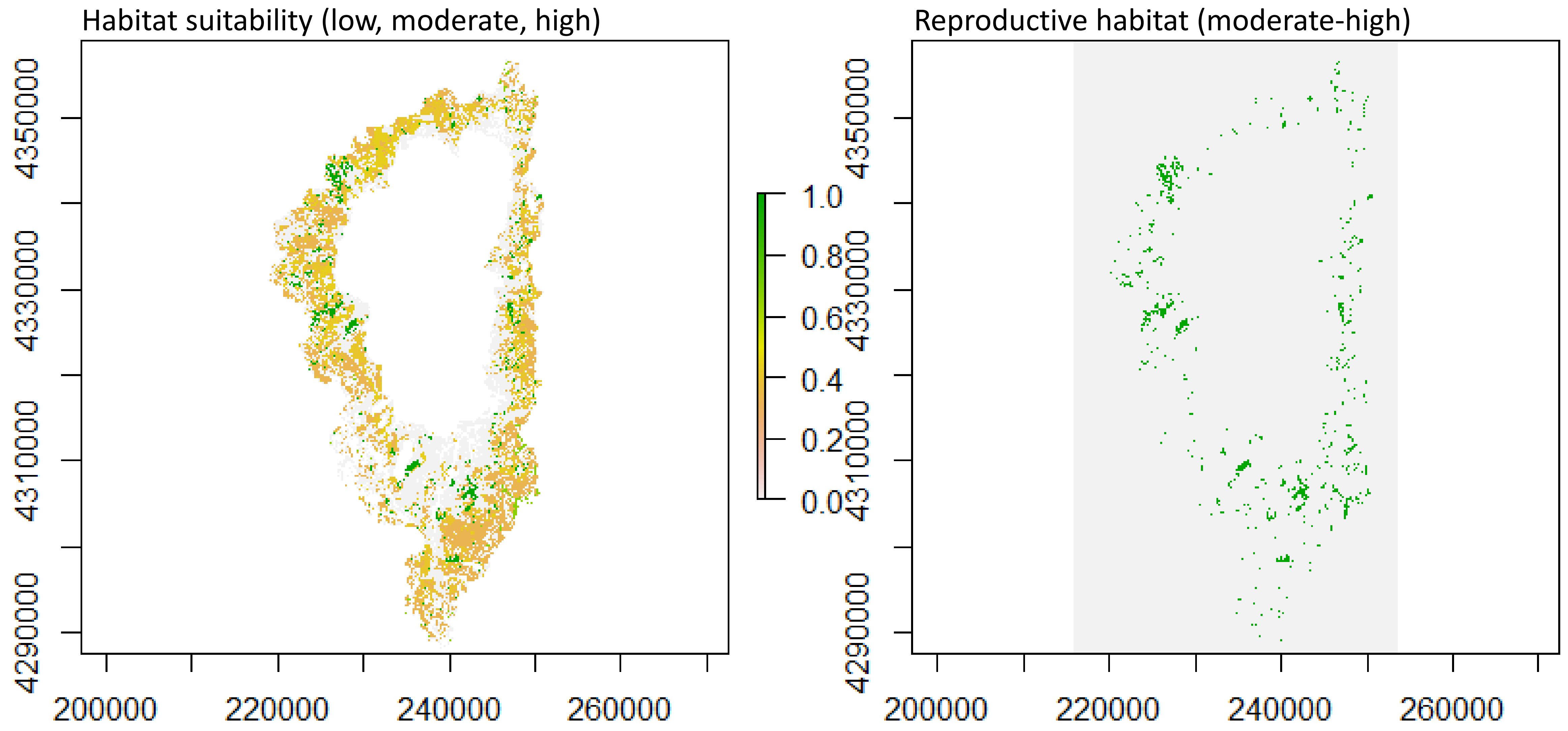
Sooty grouse
Range: restricted
Suitability CA: patchy
Suitability LTBMU: high

Northern flying squirrel
Range: restricted
Suitability CA: high to moderate
Suitability LTBMU: patchy high

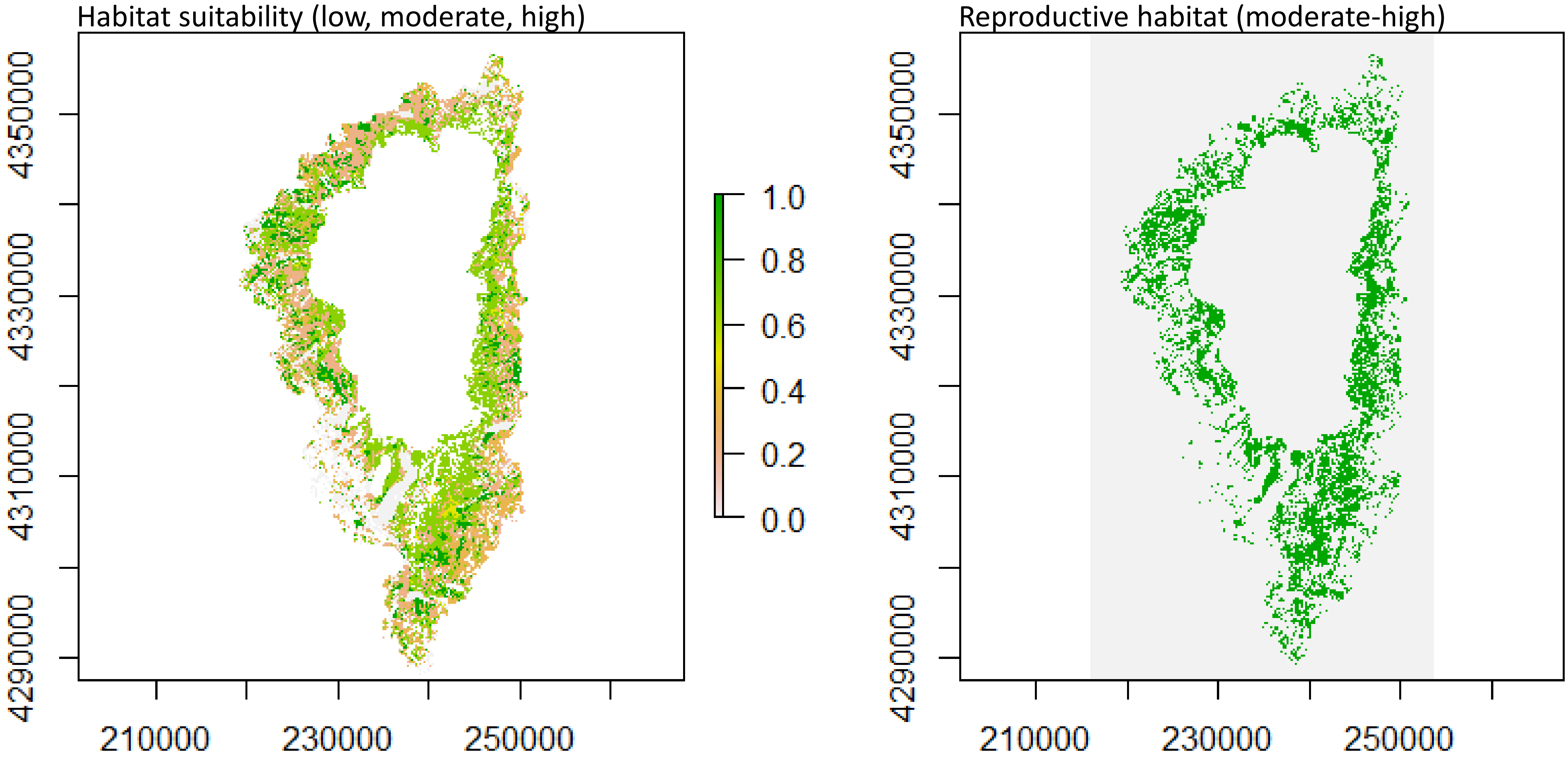
Townsend's big-eared bat
Range: ubiquitous
Suitability CA: low
Suitability LTBMU: patchy moderate


Tree or Shrub?
Shrub.biom >= 75% of total
Tree.biom > 25% of total
MCP
Hardwood or Conifer
Conifer.biom >= PopuTrem.biom
PopuTrem.biom > Conifer.bioim
ASP
Dominated by any one conifer species?
Yes: largest.species.biom >= 50% of Conifer.biom
No: largest.species.biom < 50% of Conifer.biom
Which species?
AbieConc >= 50%
WFR
AbieMagn >= 50%
RFR
PinuCont >= 50%
LPN
PinuJeff >= 50%
JPN
CaloDecu >= 50%
PinuLamb >= 50%
SMC
TsugMert >= 50%
PinuAlbi >= 50%
PinuMont >= 50%
SCN
Which group of species has more biomass?
Sum of biomass of
- AbieConc
- PinuCont
- PInuJeff
- CaloDecu
- PinuLamb
greater than biomass of species below
Sum of biomass of
- AbieMagn
- PinuAlbi
- PInuMont
- TsugMert
greater than biomass of species above

Calliope hummingbird



Northern flying squirrel



131 species

Decadal outputs
Replicate 4 of 10

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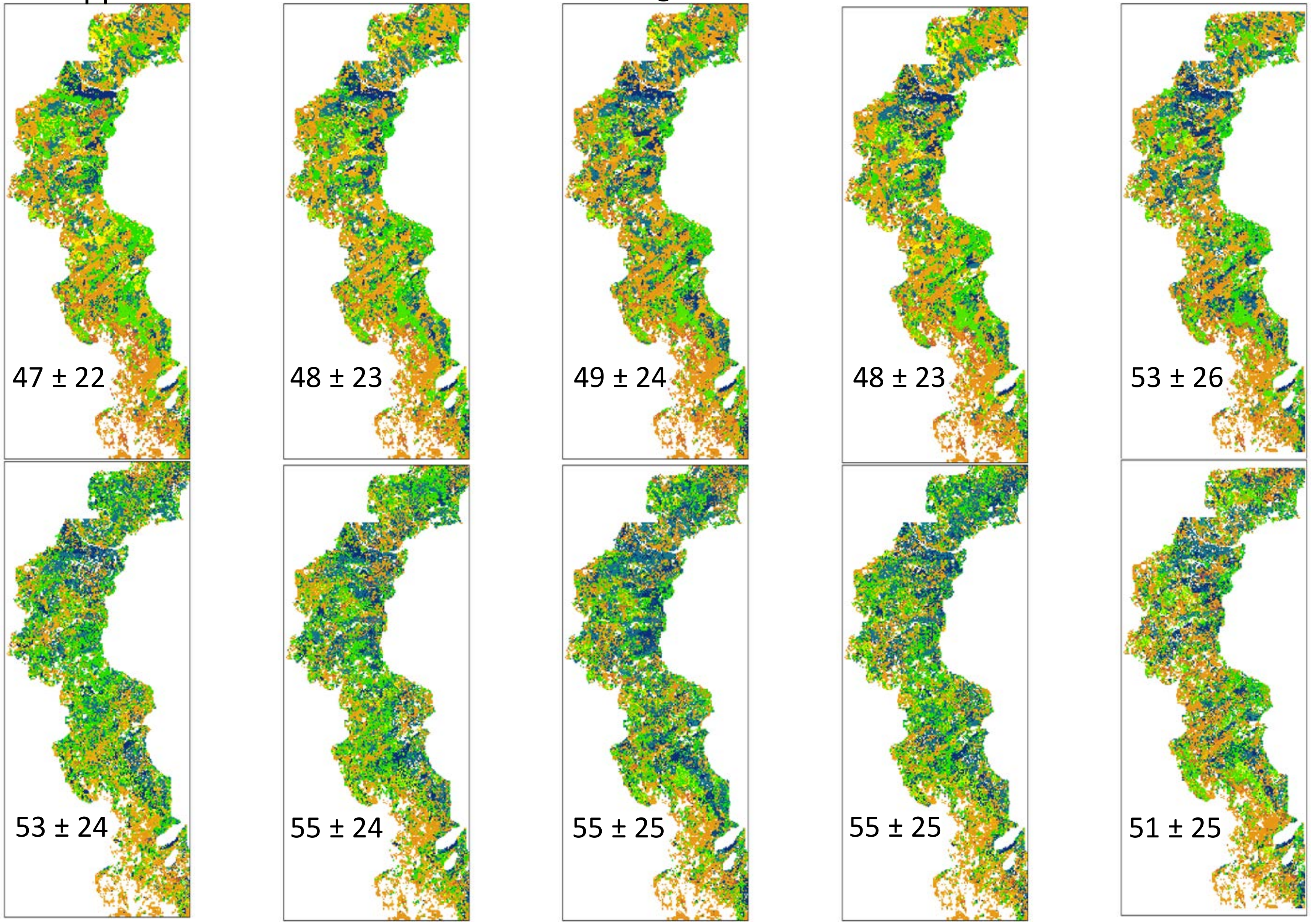
2030	47 ± 22	48 ± 23	49 ± 24	48 ± 23	53 ± 26
2070	53 ± 24	55 ± 24	55 ± 25	55 ± 25	51 ± 25



2000: 45 ± 18

Wildlife Indicator

Goal: Provide one indicator that combines most commonly used wildlife indicators to assess ecosystem health

Species richness

Goal: Maintain species persistence on the landscape maintaining ≥70% of each species current available habitat

Implication: All species are treated equally at the level of the landscape

Ecological function

Goal: Ecosystem functioning is best maintained by ensuring redundancy in important functional groups

Implication: Ecological functions are equally important and should be maintained across the landscape

Species diversity

Goal: Maximize species diversity (beta diversity) across the landscape

Implication: Rarer species are given disproportionately more weight and are often dependent on particular habitats

Maintain top predators in system

Goal: Maintain top-down control of ecosystem by ensuring persistence of apex predators

Implication: Apex predators are disproportionately important to ecosystem health

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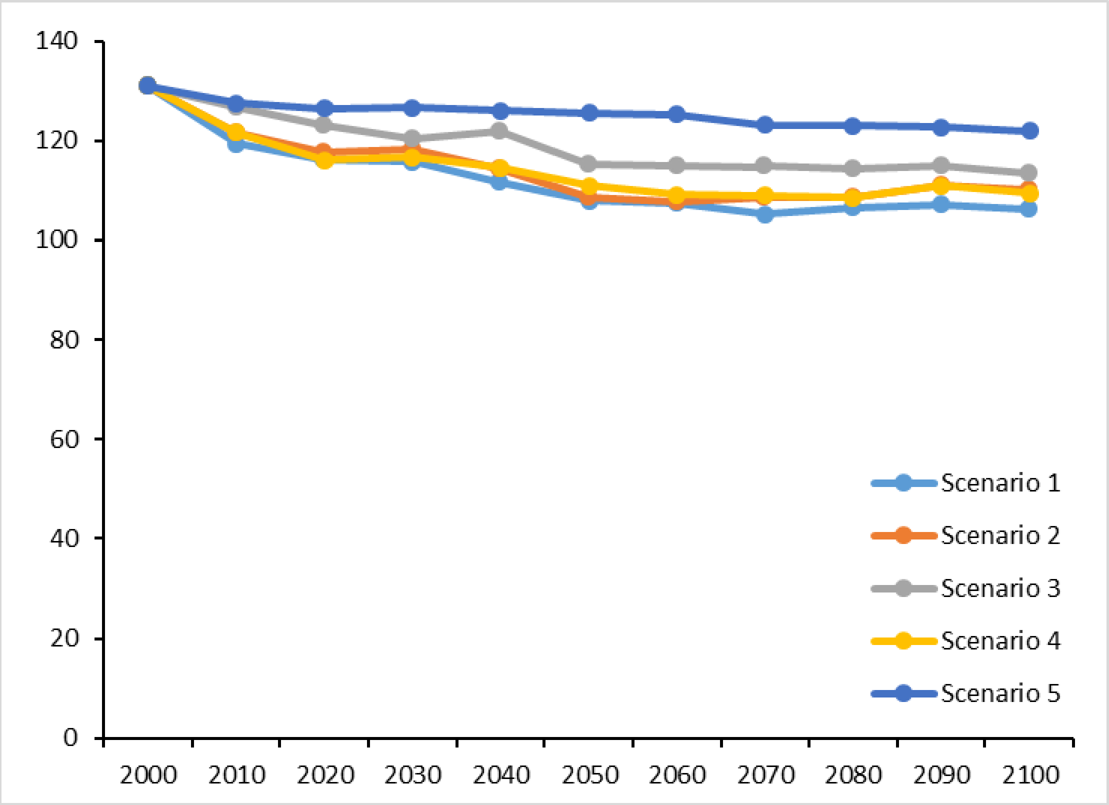
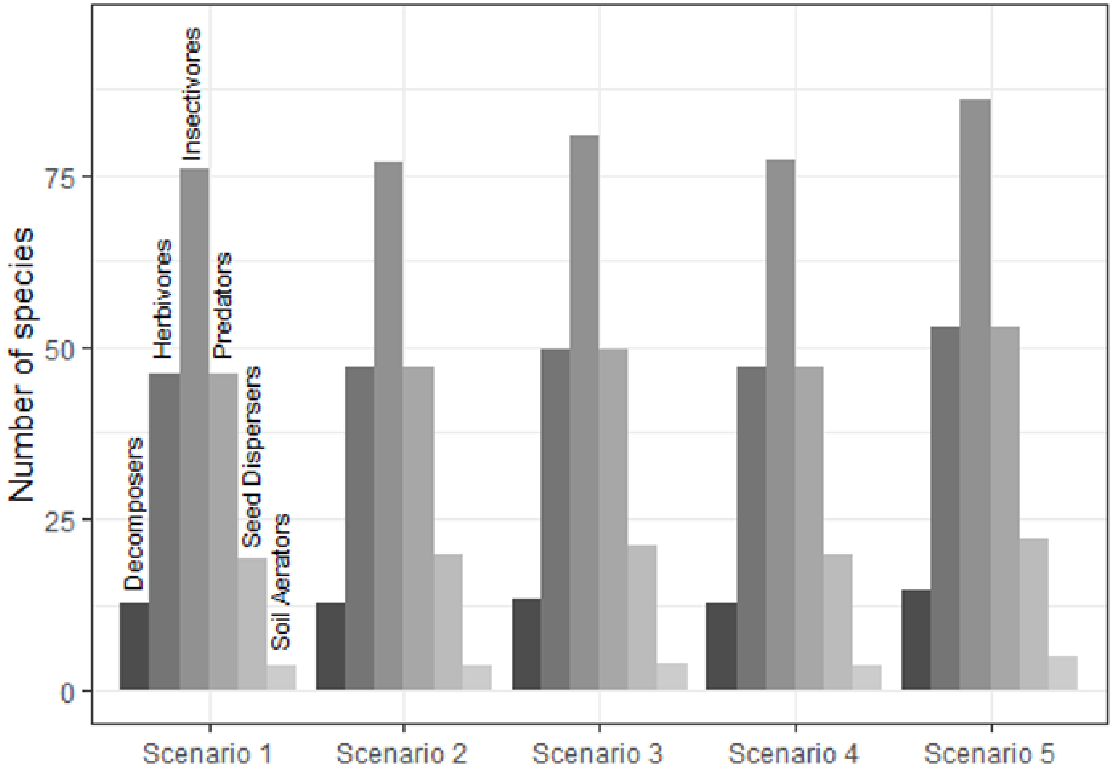
Minimize Risk

Optimize Resource

Metric	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
No. species in which ≥70% HQR habitat was maintained	98	98	105	97	115
No. species in which the amount of HQR habitat increased	51	54	62	57	51
No. species in which size of HQR habitat patches increased	79	81	85	81	40
No. species in which the distance between patches of HQR habitat decreased	101	102	107	100	94

Species Richness





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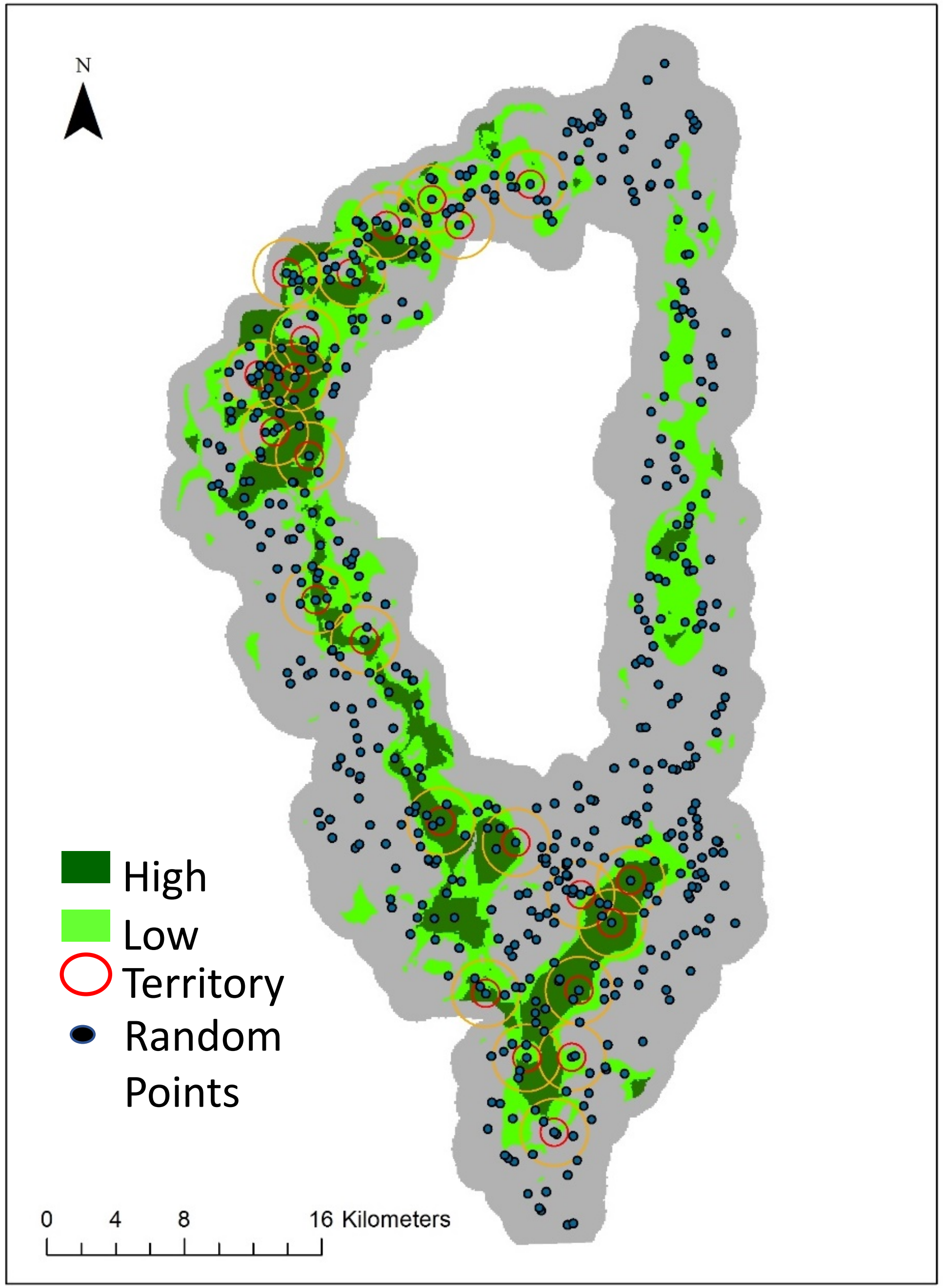
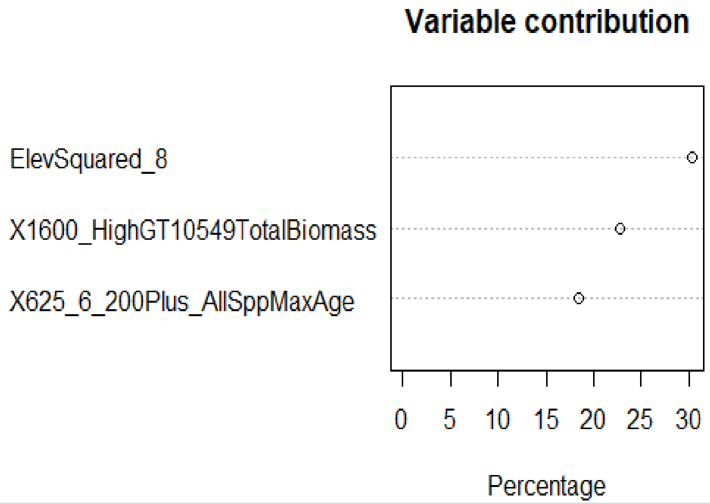
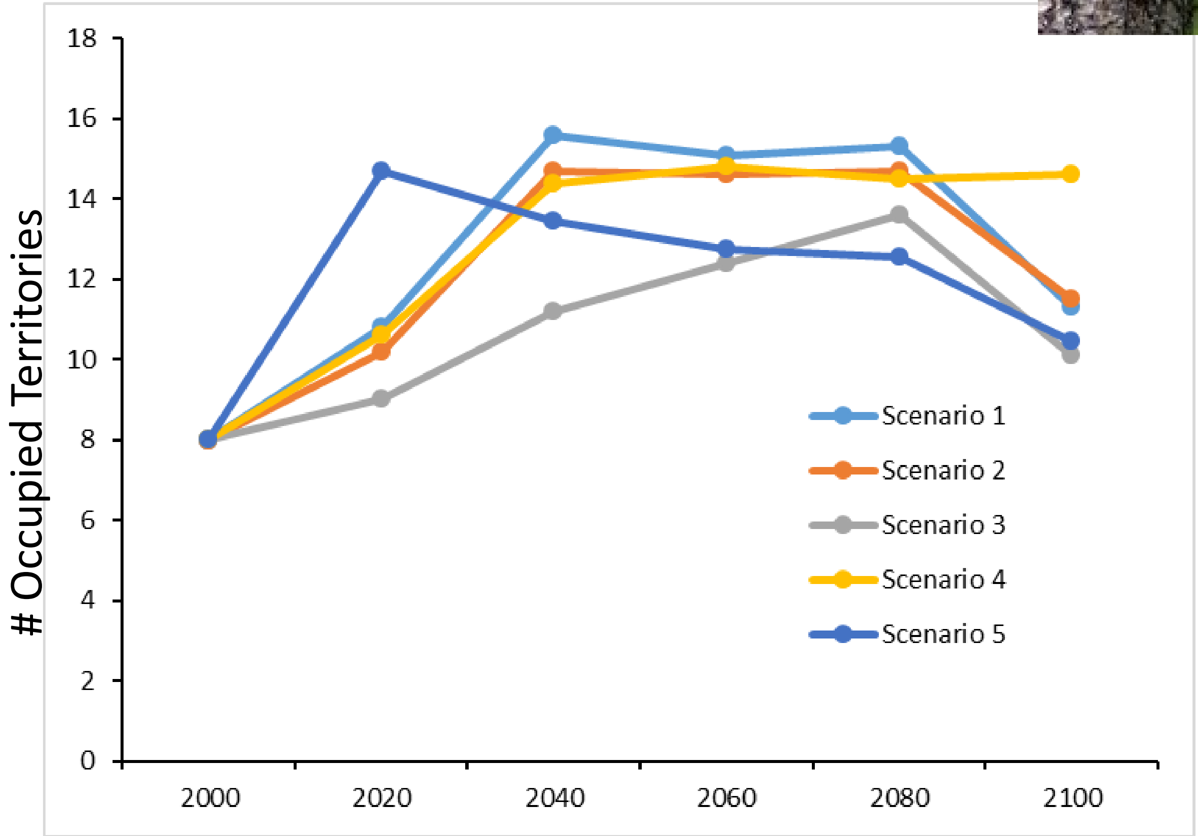
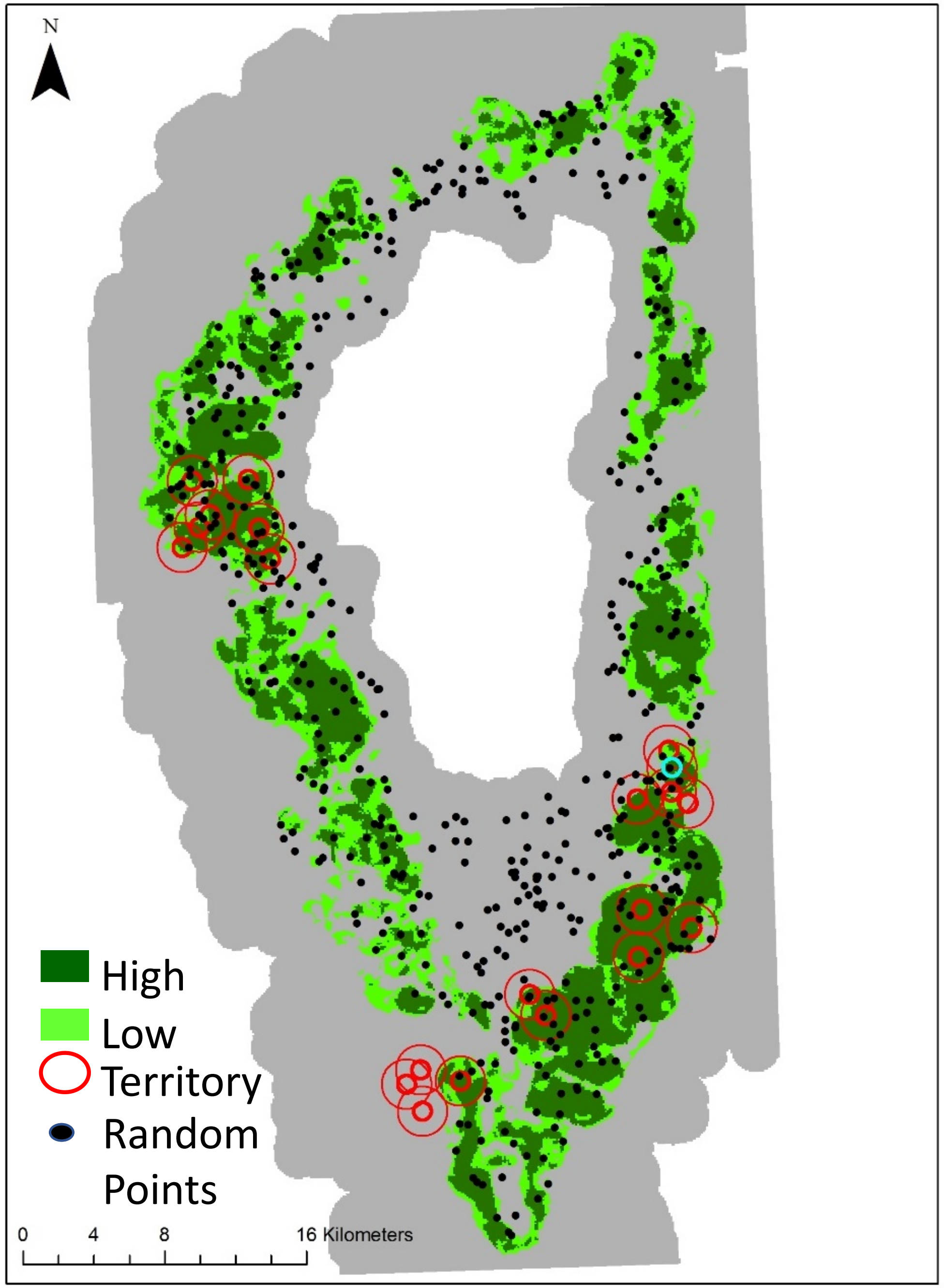
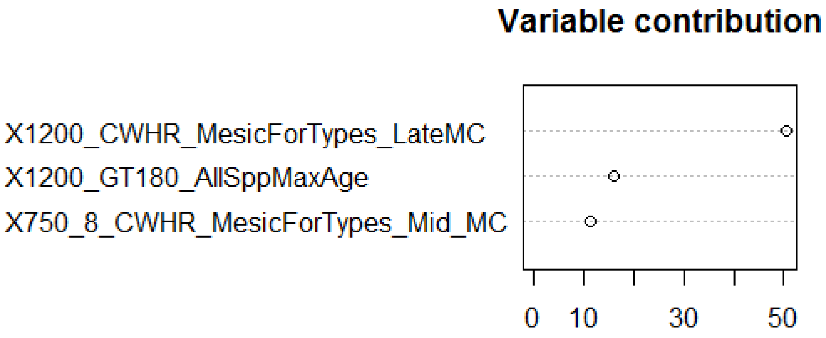
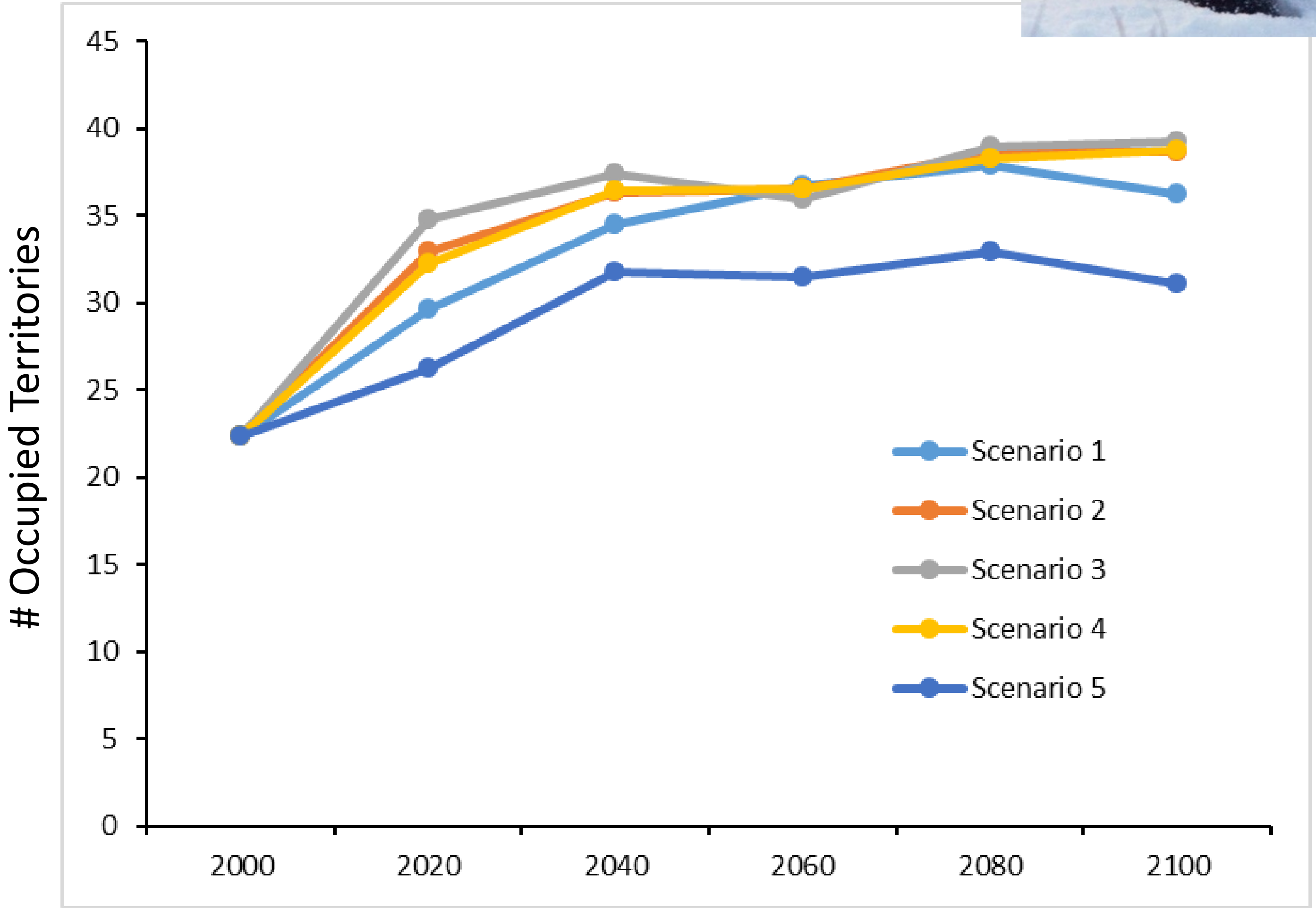

N
High
Low
Territory
Random Points
0
4
8
16 Kilometers


Variable contribution
ElevSquared_8
X1600_HighGT10549TotalBiomass
X625_6_200Plus_AllSppMaxAge
0
5
10
15
20
25
30
Percentage


Occupied Territories
18
16
14
12
10
8
6
4
2
0
2000
2020
2040
2060
2080
2100
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5


N
High
Low
Territory
Random
Points
0
4
8
16 Kilometers


Variable contribution
X1200_CWHR_MesicForTypes_LateMC
X1200_GT180_AllSppMaxAge
X750_8_CWHR_MesicForTypes_Mid_MC
0
10
30
50


Occupied Territories
45
40
35
30
25
20
15
10
5
0
2000
2020
2040
2060
2080
2100
Scenario 1
Scenario 2
Scenario 3
Scenario 4
Scenario 5

Wildlife Indicator

Goal: Provide one indicator that combines most commonly used wildlife indicators to assess ecosystem health

Species richness

Goal: Maintain species persistence on the landscape maintaining ≥70% of each species current available habitat

Implication: All species are treated equally at the level of the landscape

Ecological function

Goal: Ecosystem functioning is best maintained by ensuring redundancy in important functional groups

Implication: Ecological functions are equally important and should be maintained across the landscape

Species diversity

Goal: Maximize species diversity (beta diversity) across the landscape

Implication: Rarer species are given disproportionately more weight and are often dependent on particular habitats

Maintain top predators in system

Goal: Maintain top-down control of ecosystem by ensuring persistence of apex predators

Implication: Apex predators are disproportionately important to ecosystem health

Minimize Risk

Optimize Resource

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

Lake Tahoe West Restoration Partnership: Economics Team

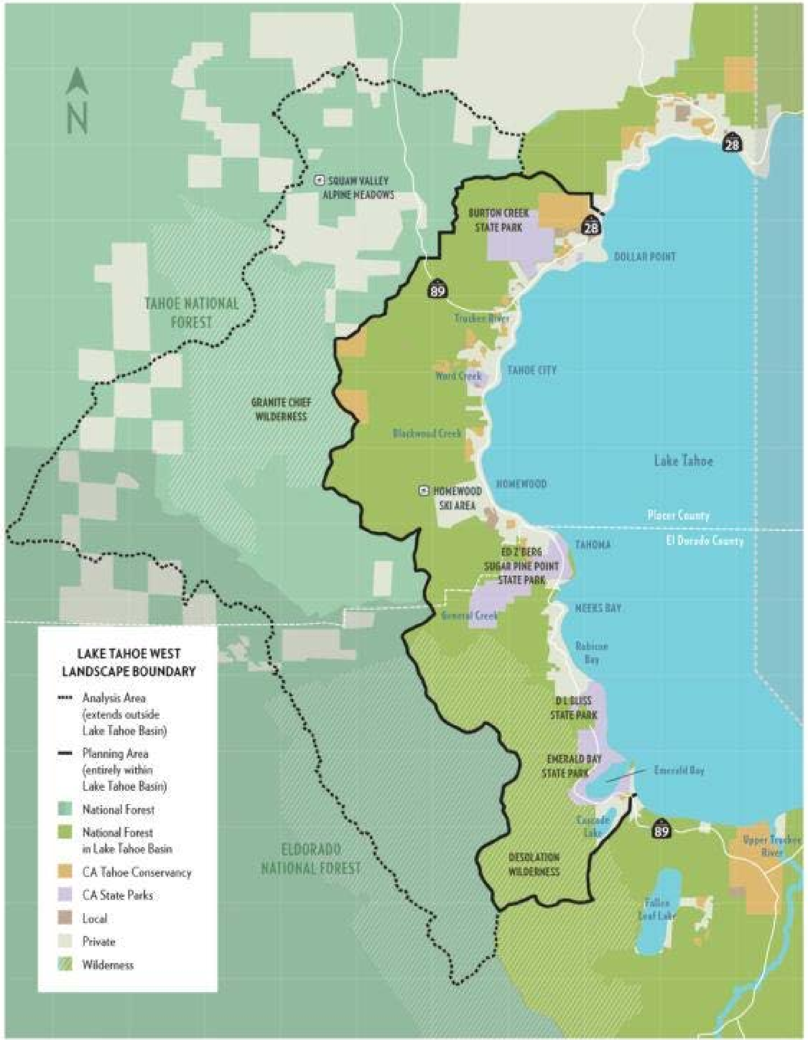
Tim Holland, Sam Evans, Matthew D. Potts

Department of Environmental Science, Policy and Management

UC, Berkeley

May 19th, 2020

Science Workshop



Outline

- Management and Fire Suppression Costs
- Carbon Accounting
- Property Risk from Wildfire

LTW Scenarios

Ultimate goal: move LTW forests to long-term resilience while maximizing the benefit / minimizing the harm to local communities.

- **S1: Suppression only –** No treatment other than continued fire suppression.
- **S2: WUI focus –** A WUI-focused strategy similar to recent management. This scenario includes hand and mechanical treatments in the WUI, with a particular emphasis on the defense zone and hand thinning.
- **S3: Increased thinning –** A strategy of increasing pace and scale of vegetation thinning treatments, including hand and mechanical treatments in the WUI and the general forest, with some hand treatments occurring in the wilderness as well.
- **S4: Fire treatment focus** – A fire-focused strategy that focuses on using fire by combining model WUI thinning with prescribed burning and some managed natural ignitions for resource objectives.
- **S5: Fire-focused, expanded**: A fire-focused strategy combining modest WUI thinning with *much* greater use of prescribed burning and some managed natural ignitions for resource objectives.

Management Cost Assessment

Forest Management Net Costs

$$Net\ Cost_s = \sum_{i=1}^{N}\sum_{t=1}^{T}\frac{1}{(1+r)^t}\left[Revenue_{s,i,t} - Management_{s,i,t} - Transport_{s,i,t} - Suppression_{s,i,t}\right]$$

Scenario

Spatial unit

Year

Discount rate

Revenue from timber and biomass

Thinning and prescribed burn costs

Timber/biomass transportation costs

Wildfire suppression costs

<u>Note</u>:

- Net management costs are calculated for all five scenarios (*s*)
- Spatial units are matched to Landis model
- Physical units (timber, biomass, thinning volume, etc. are adapted directly from Landis
- Final results will illustrate net present value of management costs across the 5 scenarios

Data overview

Harvest costs: Landis-derived estimates of stand characteristics

- Trees per acre, biomass removed, size classes removed

Contract costs for hand thin, Ground-based whole tree, Ground-based cut-to-length contracts provided by LTBMU

Timber revenues: Biomass removed by size class from Landis; timber prices from CEC report

Transport costs and yarding distance: derived from GIS & road network data

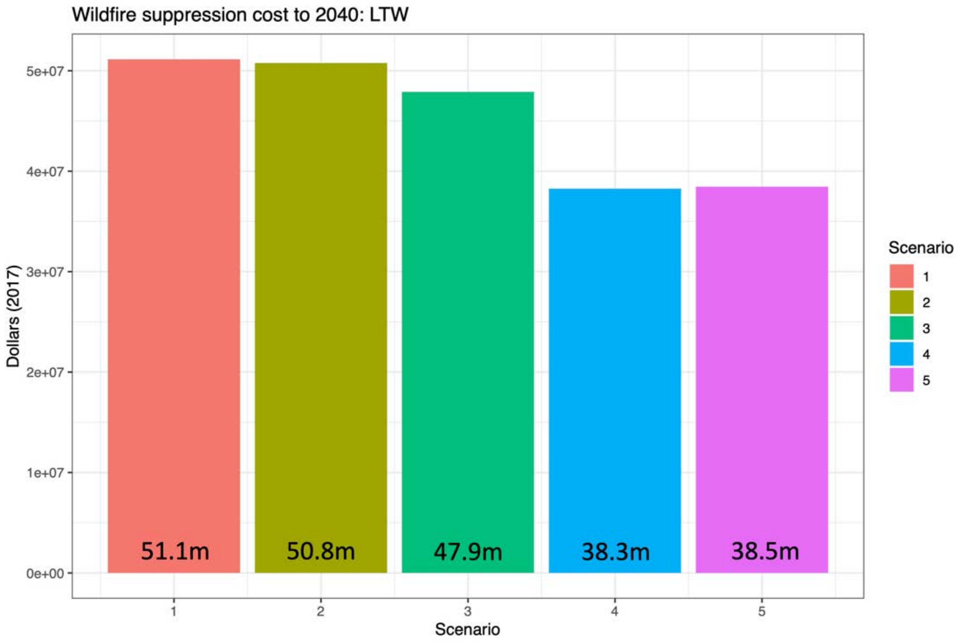
Managed fire cost: based on 2011 Long Fire

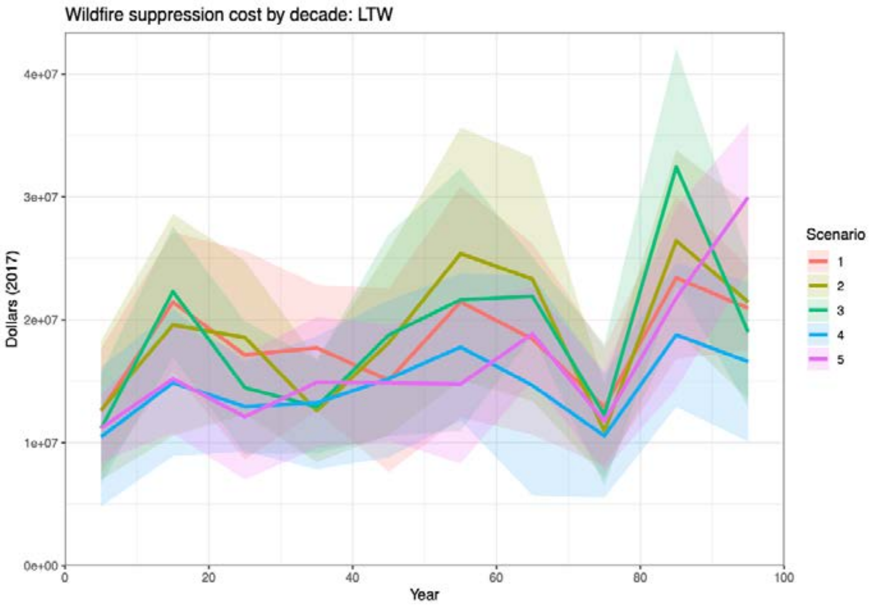
Rx fire cost: in-basin estimate supplied by CA State Parks

Wildfire suppression costs: Analysis of historical data from USFS (1987 -2018)

- Average per acre values determined for different size classes

Wildfire Suppression Costs





Components of harvest & thinning cost

Estimating stand and harvest characteristics

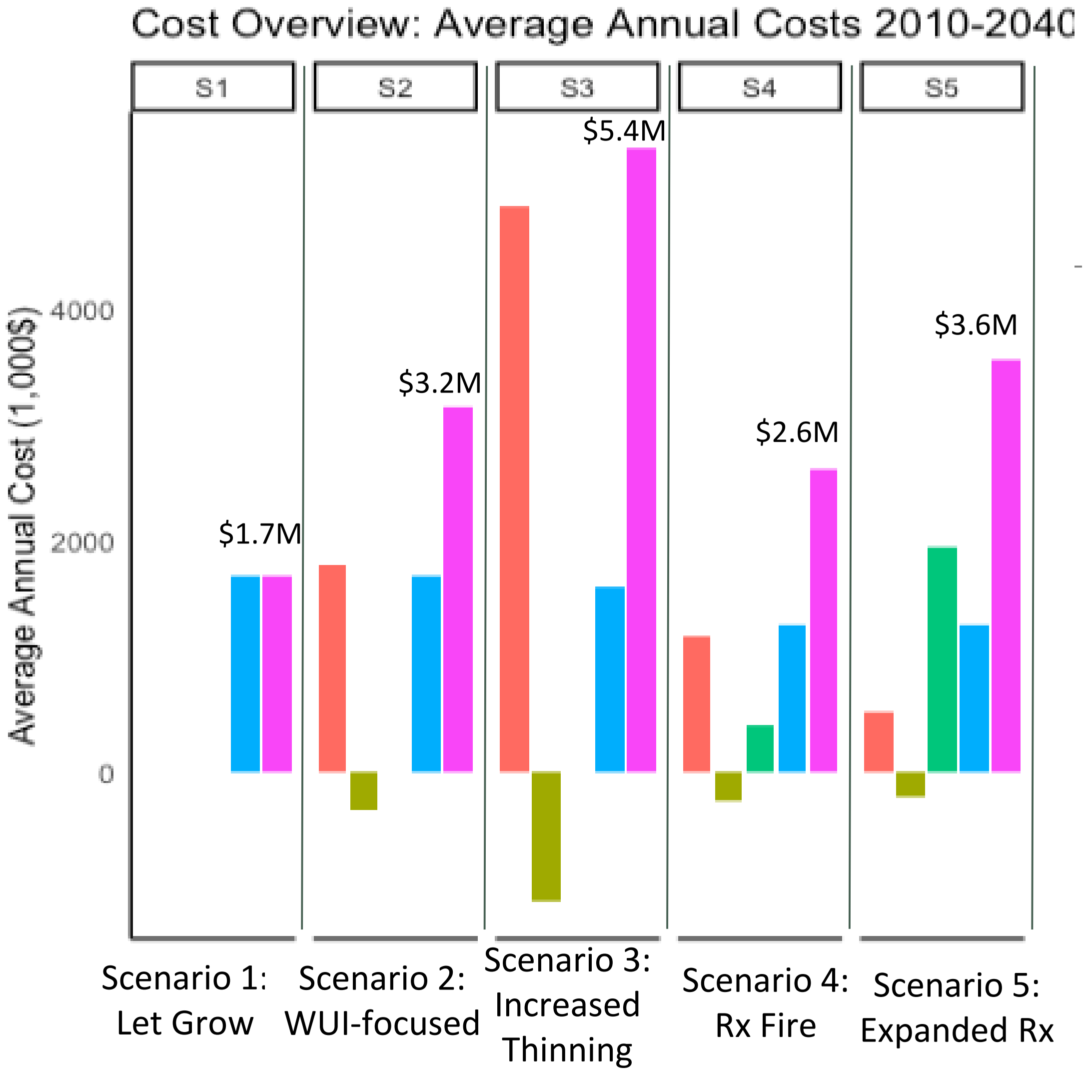
- Stand: TPA in different size classes; biomass distribution; species composition
- Harvest information: Biomass removed; technology used
- Removal effort: GIS-derived information on yarding distance and slope from each stand

Two stage:

1. Calculate estimates from FIA BioSum OpCost equations – based on stand characteristics, harvest volumes, and yarding distance
2. Use actual LTBMU contracts to adjust estimates to basin-specific costs

Costs by Harvest/Thinning System

Harvest System	Assumed average cost per acre	
Ground-based CTL	$2,559	Calculated directly from LTBMU contracts
Ground-based WT	$2,013	
Hand Thinning	$779	
Cable WT	$3,711	Extrapolated from 3 systems above
Helicopter	$7,422	



Key Points:

- Scenario 5 is lower cost than 3 but performs better on high intensity fire metrics.
- Scenario 4 and 5 have similar total costs but large difference in wildfire performance.
- BAU scenario is similar in cost to Rx scenarios but without the improvement in wildfire performance.

Carbon Accounting

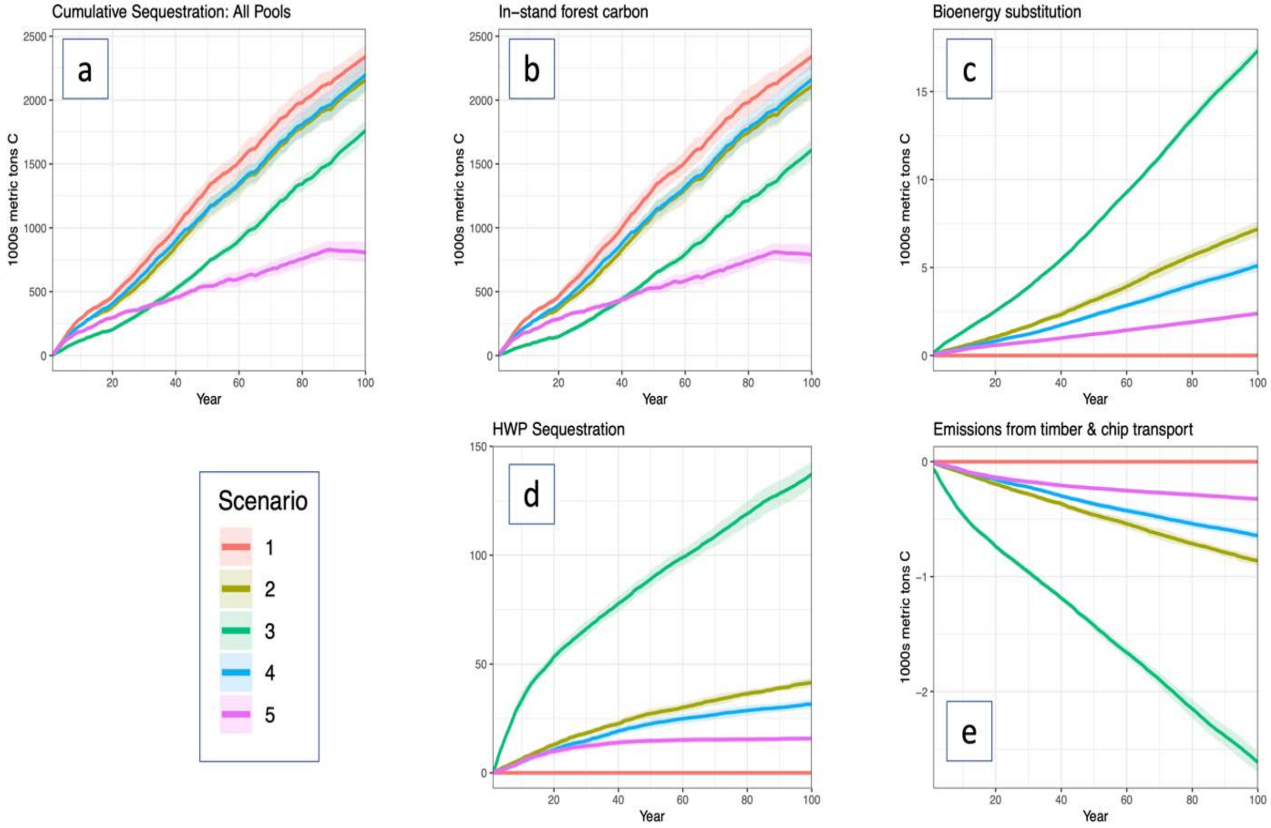
Carbon accounting methodology

Using a stock-difference approach to accounting

- Carbon pools are monitored through time
- Emissions / sequestration are estimated as net change in and out of pools

Monitoring four carbon pools:

- In forest (including aboveground, belowground, and soil)
- Carbon in harvested wood products (HWP) and post-consumer waste
- Fossil C that stays underground b/c of energy generated from biomass
- Emissions from transport of HWP and other biomass from stand to facilities



In all scenarios, large in-forest sequestration

- 2.48 million metric tons of in-forest biomass carbon in LTW in 2010
- Increases by 12% (S3) to 30% (S1) by 2040.

Scenario 1 shows highest in-forest sequestration; Scenario 5 (increased thinning) is lowest; 2, 3 and 4 are intermediate.

Scale of in-forest sequestration dwarfs other carbon pools.

Social Cost of Carbon

Monetized Difference (from S2) in CO_2 Sequestered by Discount Rate, RCP 4.5 (thousand 2017$/year)			
Scenario	**2.5%**	**3%**	**5%**
1	$216	$154	$54
3	-$33	-$17	-$1
4	-$374	-$280	-$109
5	-$716	-$529	-$201

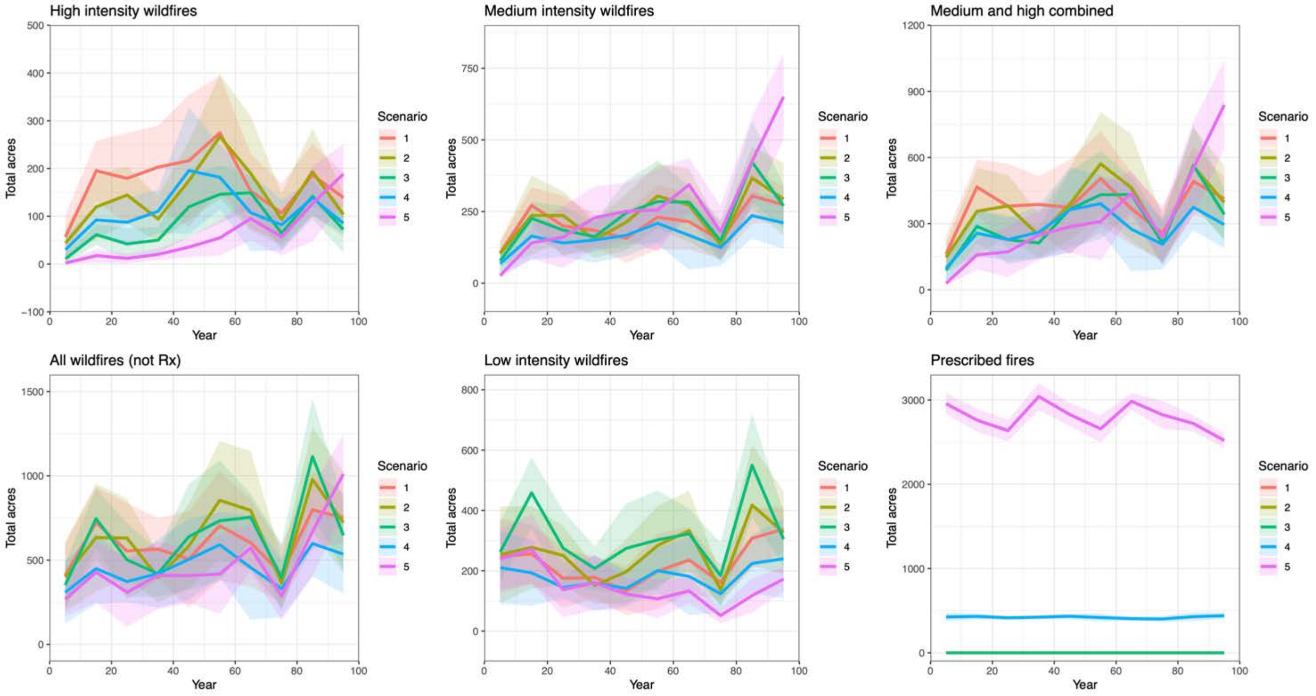
Property Risk

Methodology

- Intersect spatial layers of wildfire risk (from Landis) with data on residential and commercial property locations in the Lake Tahoe Basin.

- Wildfire risk is measured as the probability that a pixel will burn between 2010 and 2040, broken down by fire severity.
  - “At-Risk” is defined as intersecting with a medium or high intensity fire in at least half of the replicates.

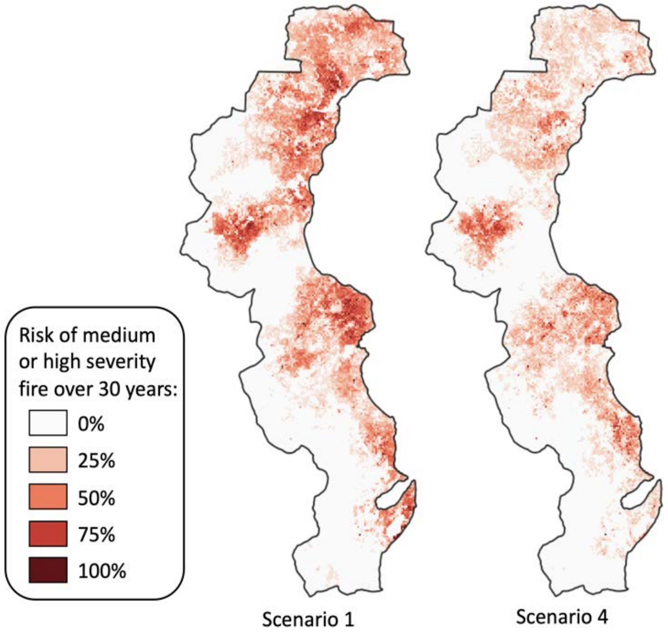
Fire Incidence and Intensity



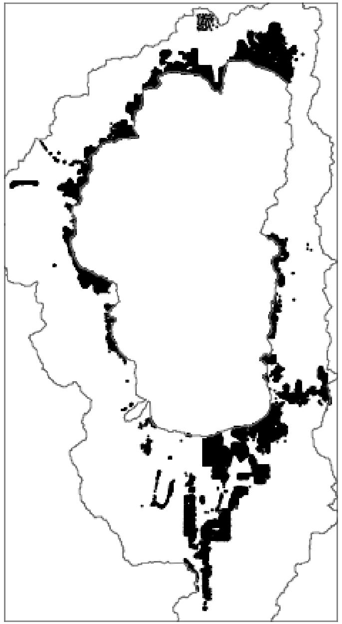
Key Points:
- Total area burned similar across Scenario 1-3, but lower for Rx scenario (for 1st 40 years).
- Large differences in high intensity fires across scenarios.
- Scenarios 3 and 5 perform best for high intensity fire.

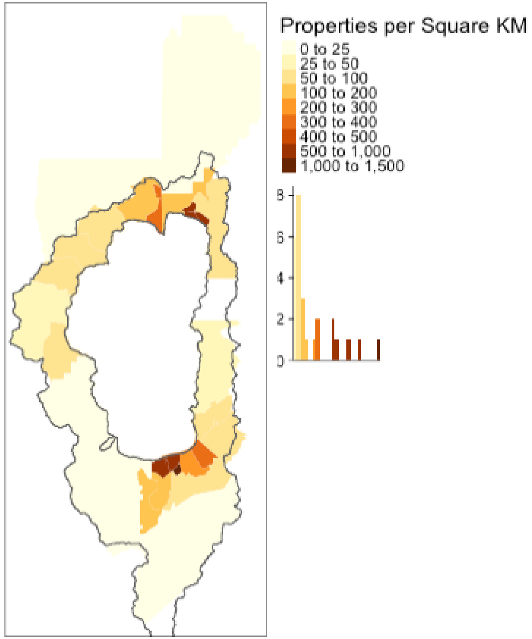
Properties in the Lake Tahoe Basin

Wildfire Risk

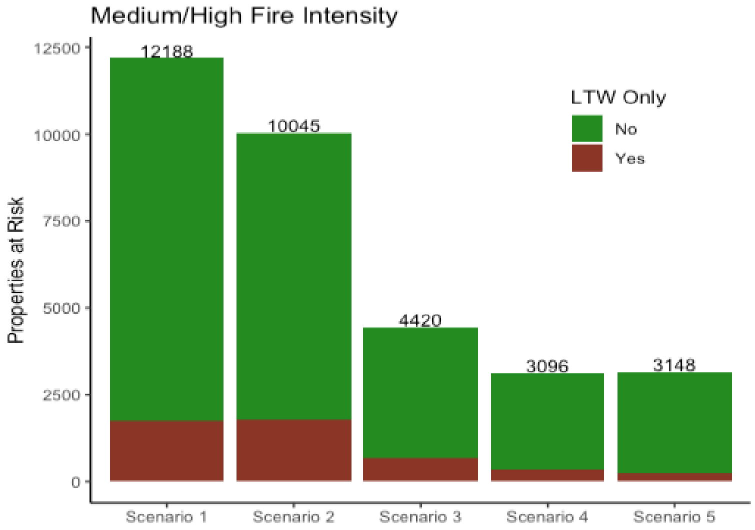


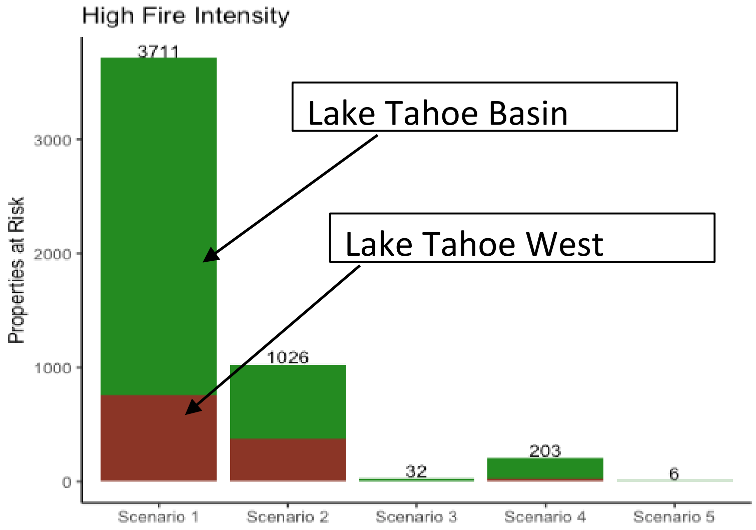
Property Location and Density





Property at Risk: LTW and Basin-Wide





- Figures show the number of properties in the Basin and Lake Tahoe West that are at risk of medium and high intensity wildfires. At risk is defined here as being in a LANDIS pixel that has a 50% chance or greater of burning between 2010 and 2040.
- More intensive management scenarios (S3-S5) greatly reduce the number of homes at risk, although not much difference across these scenarios.

Key Takeaways

- Increased forest management, particularly use of prescribed fire, can reduce fire suppression costs relative to business-as-usual by more than $400,000 per year.
- A scenario that increases the use of prescribed fire is one of the most cost-effective interventions available–about two thirds the annual cost of a scenario focused on increased thinning–and is also highly effective at reducing high intensity fire risk relative to the baseline.
- Climate change mitigation via storage in wood products and in fossil fuel displacement is highest under more intensive management, but total carbon sequestration is highest overall under a suppression-only management scenario.
- Due to an emphasis on removing mostly small trees, revenue from timber and biomass sales is a relatively small component of overall management costs
- Increased intensity of forest management (via thinning and/or Rx fires) substantially reduces by more than half the number of properties at risk from medium and high intensity wildfires.

Questions

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