THE IMPORTANCE OF FOREST RE-BURNING

Paul Hessburg, USDA-FS, PNWRS, UW, OSU, UBC
Susan Prichard, University of Washington

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The REBURN model: simulating system-level forest succession and wildfire dynamics

Susan J. Prichard[1*], R. Brion Salter[2], Paul F. Hessburg[1,2], Nicholas A. Povak[3] and Robert W. Gray[4]

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System-level feedbacks of active fire regimes in large landscapes

Nicholas A. Povak[1,2*], Paul F. Hessburg[2,3], R. Brion Salter[2], Robert W. Gray[4] and Susan J. Prichard[3]

RECAP:
Nonforest conditions & resilient landscapes

- ✓ Much nonforest historically, 25-75% of area
  - What again is nonforest? It's recently burned bare ground, sparsely treed woodlands, meadows, prairies, shrublands, wetlands
  - Hardwood patches also abundant
- ✓ These features limited future fire size/severity
  - Tug-o-war btw factors growing/burning forests
  - Nonforests & hardwood forest were the emergent property
  - These features influenced whether fires spread and how hot and severe they got when they could spread


Andrew Larson photo

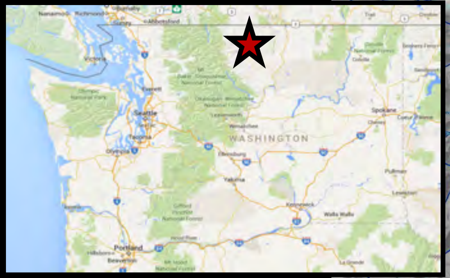
Frequent fires in dry and moist forests continually thinned forest patches, reducing density & fuels, increased the likelihood that the next fire was also low severity

Stand stabilizing feedback

Moderate and high severity fires created patchworks of nonforest, young, middle-aged and older forest, open vs closed canopy conditions, hardwood patches: these patterns regulated future fire size & severity

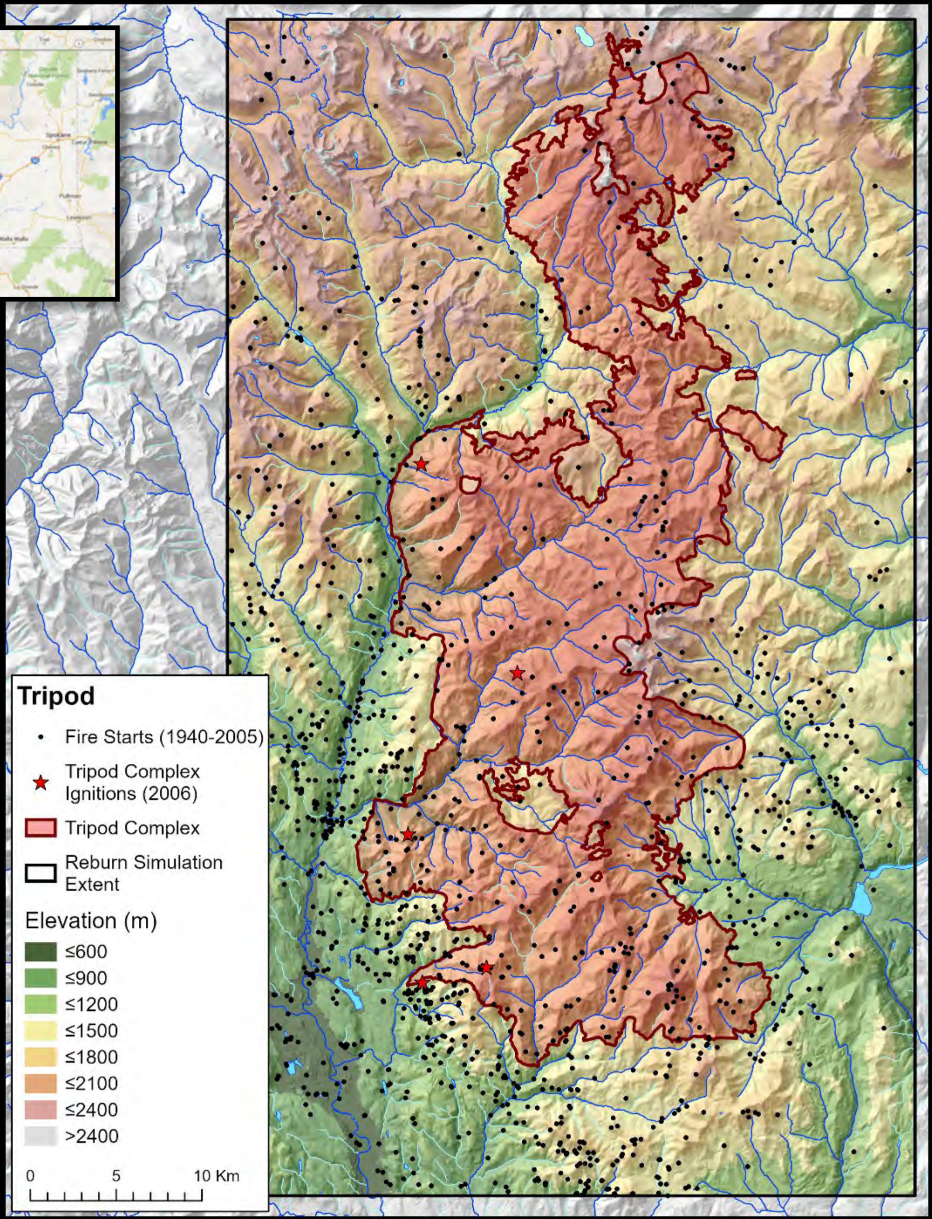
Landscape stabilizing feedback

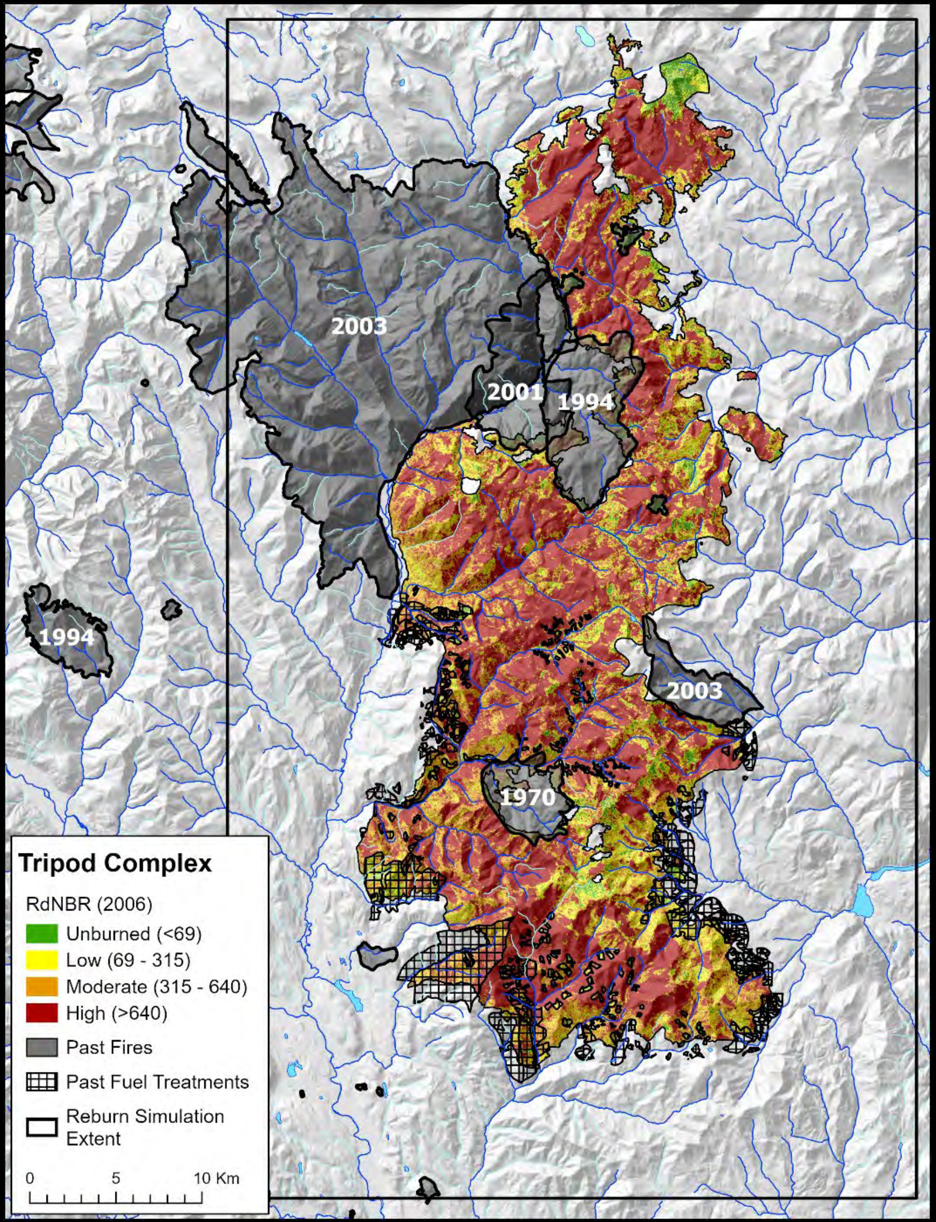
Tripod historically suppressed fire starts



No Cascades Smoke Jumper base nearby

300⁺ starts suppressed!





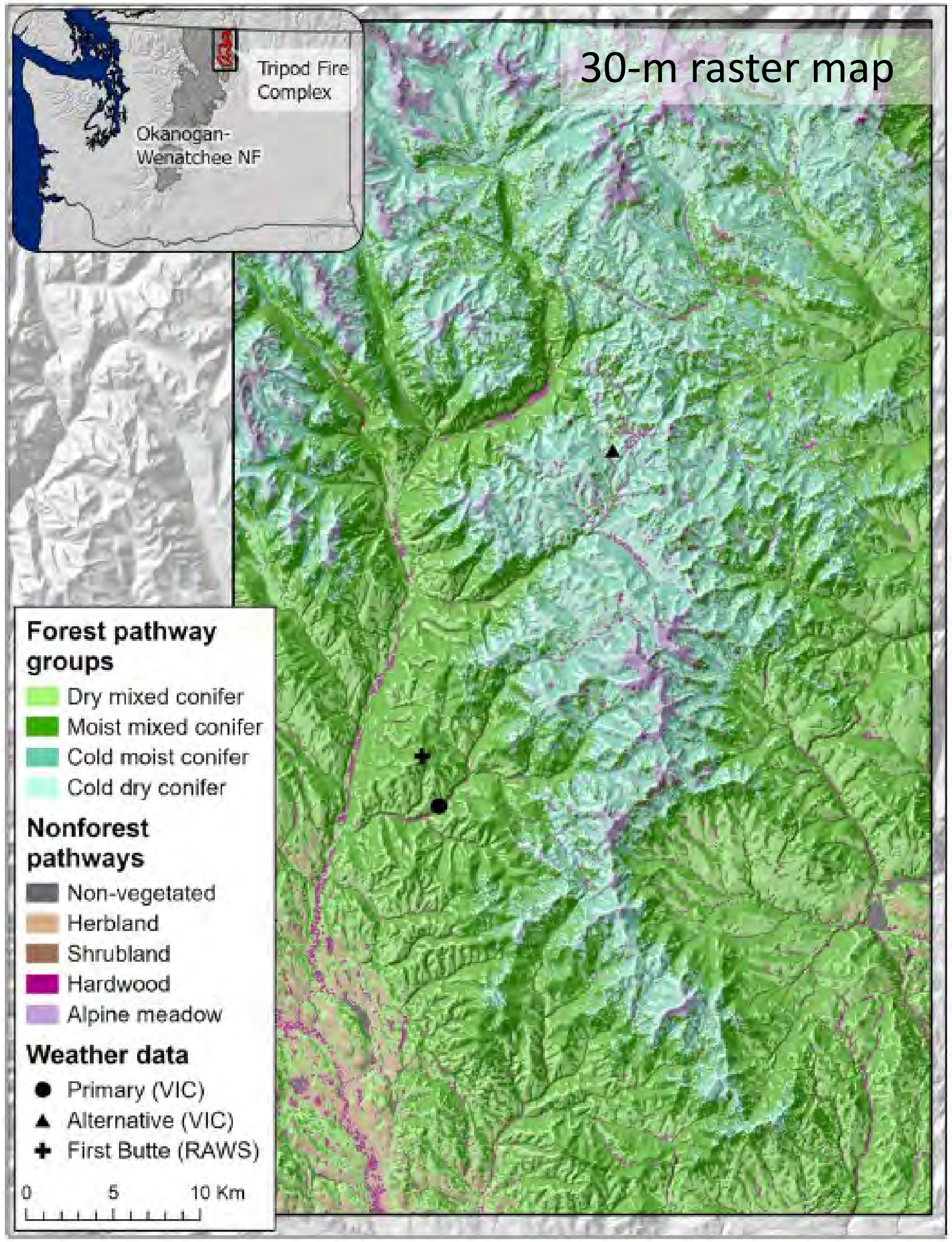


Fig. 2 Vicinity map, study location, and pathway group (PWG) map of the Tripod study area, eastern Washington, USA. Locations of remote area weather stations are indicated by black symbols

Dry & Moist Mixed Conifer Pathway Group State-Transition Model

- Every State (box) has surface & canopy fuels
- DMC and MMC STMs differences are expressed in transition times to the next state, and in their canopy fuels attributes
- Black boxes are no fire, forest growth-only transitions
- Colored boxes vary by the number of reburns, overlapping fires
- Black, green, amber, and red arrows represent no-fire, L, M, & HSF transitions

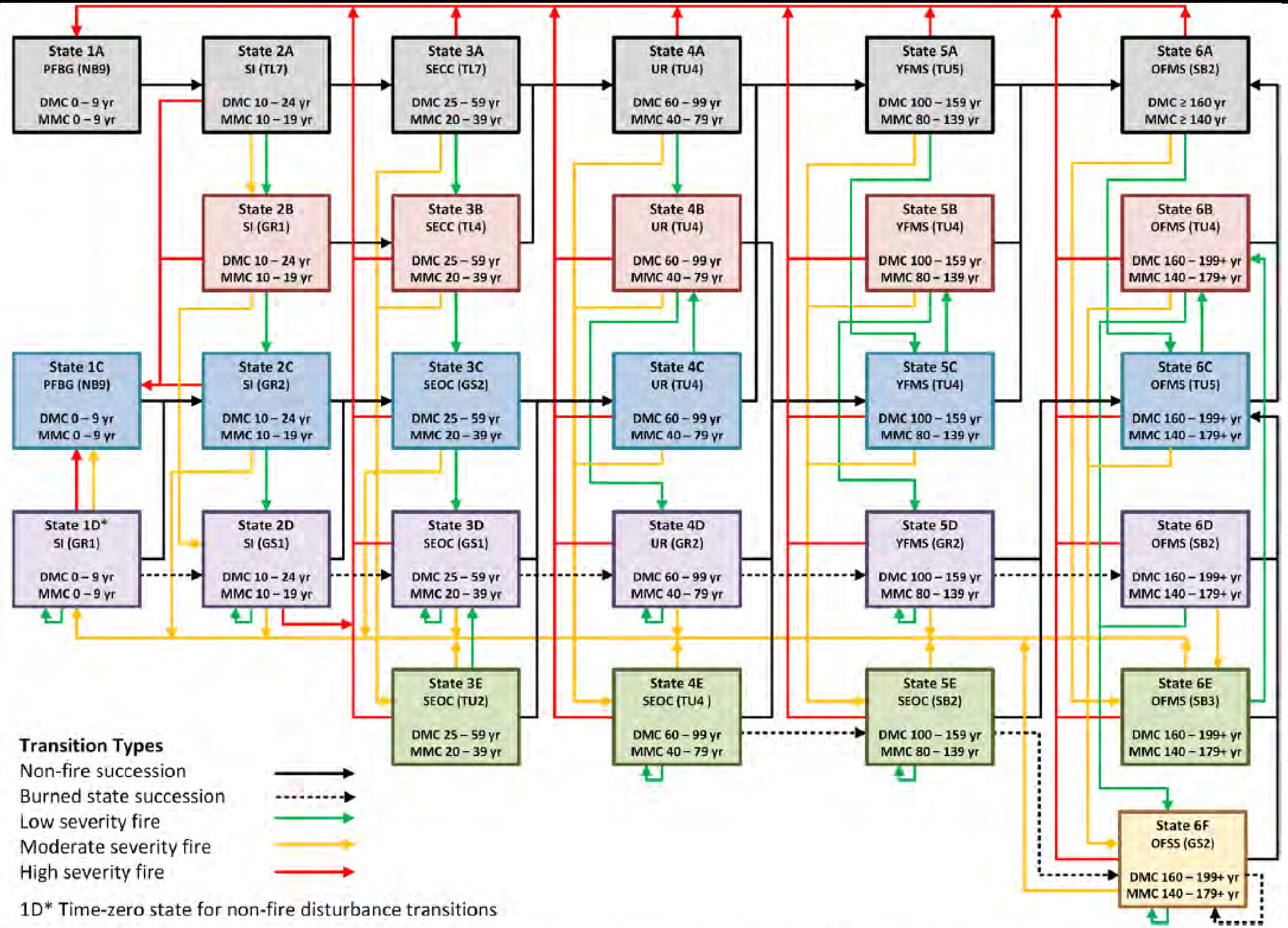


Fig. 3 State-transition model (STM) of dry mixed-conifer (DMC) and moist mixed-conifer (MMC) forests including states with associated structure classes, fire behavior fuel model (FBFM) assignments, and time in state. Transition arrows include non-fire succession (black arrows), succession following low-severity fire within time in state (dotted black line), low-, moderate-, and high-severity fire (green, orange, and red arrows, respectively). Pathways by row: A (fire exclusion), B (low severity), C (high-severity reburn), D (frequent fire), E (moderate severity), and F (savanna)

Surface fuels = the dead & down wood

Canopy fuels = the developing forest

LSF ≤ 20-25% killed
MSF 25-75% killed
HSF > 75% killed

REBURN Model Workflow

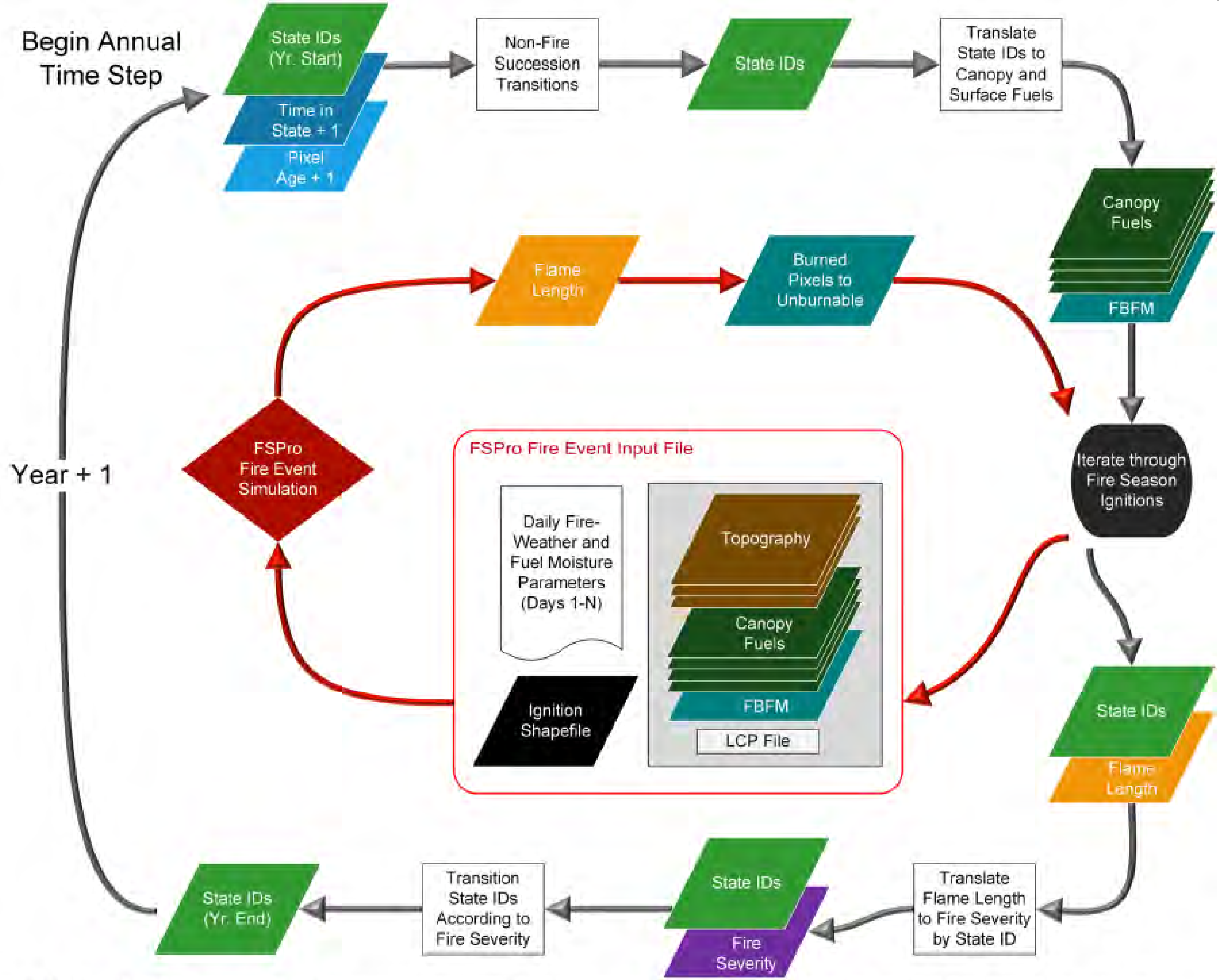
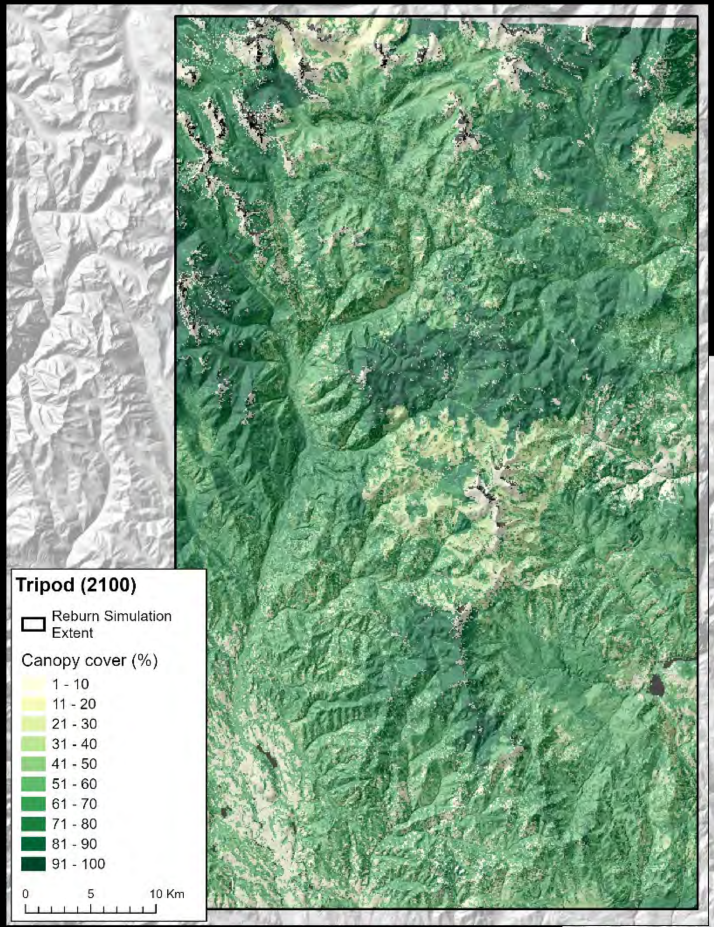
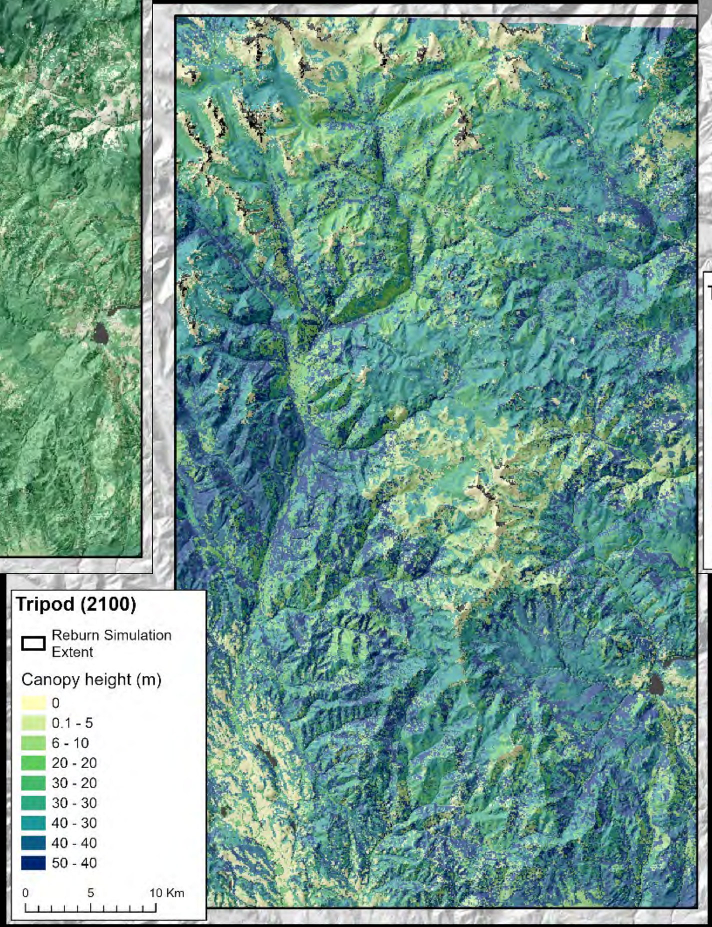
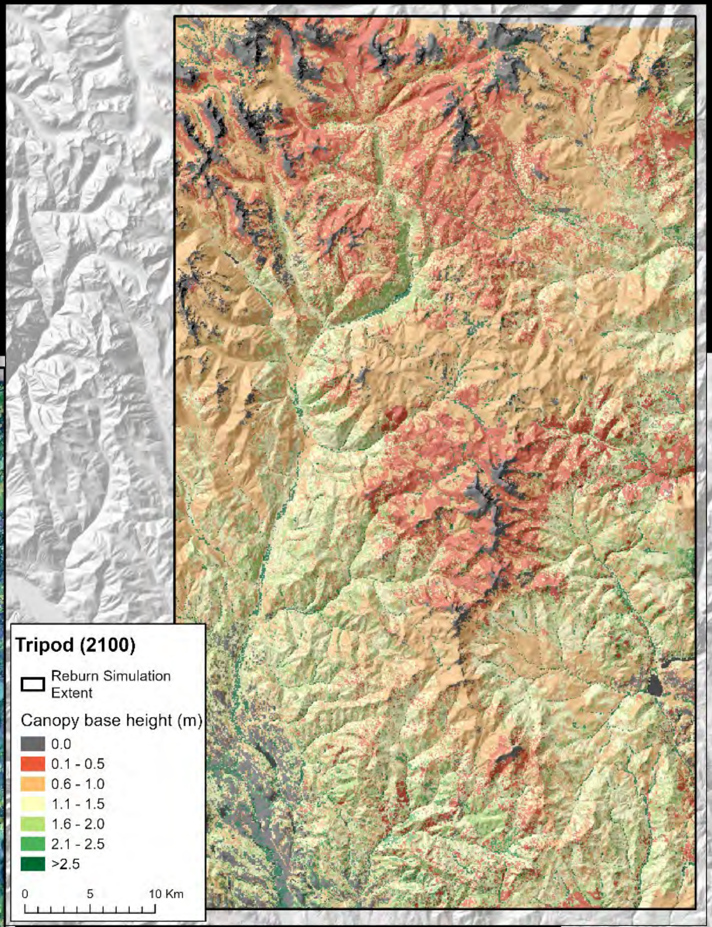


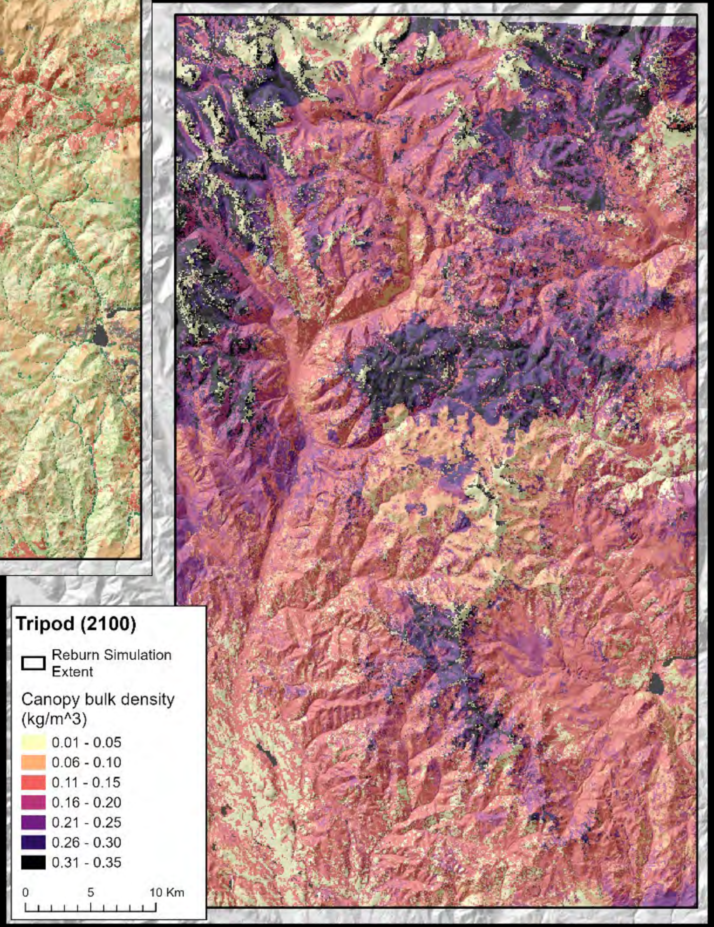
Fig. 1 REBURN workflow diagram. At "*Begin annual time step*," state-transition models (STMs) grow canopy and surface fuels by 1 year (outer workflow). States within STMs are represented by a *State ID*, which is translated to canopy and surface fuel inputs. All ignitions in a given fire year are modeled with FSPro using daily fire weather and a landscape (LCP file) including topography, canopy, and surface fuel inputs (*inner workflow diagram*). Burned pixels are then updated by fire severity (outer workflow) and assigned a new State ID

Canopy Fuels

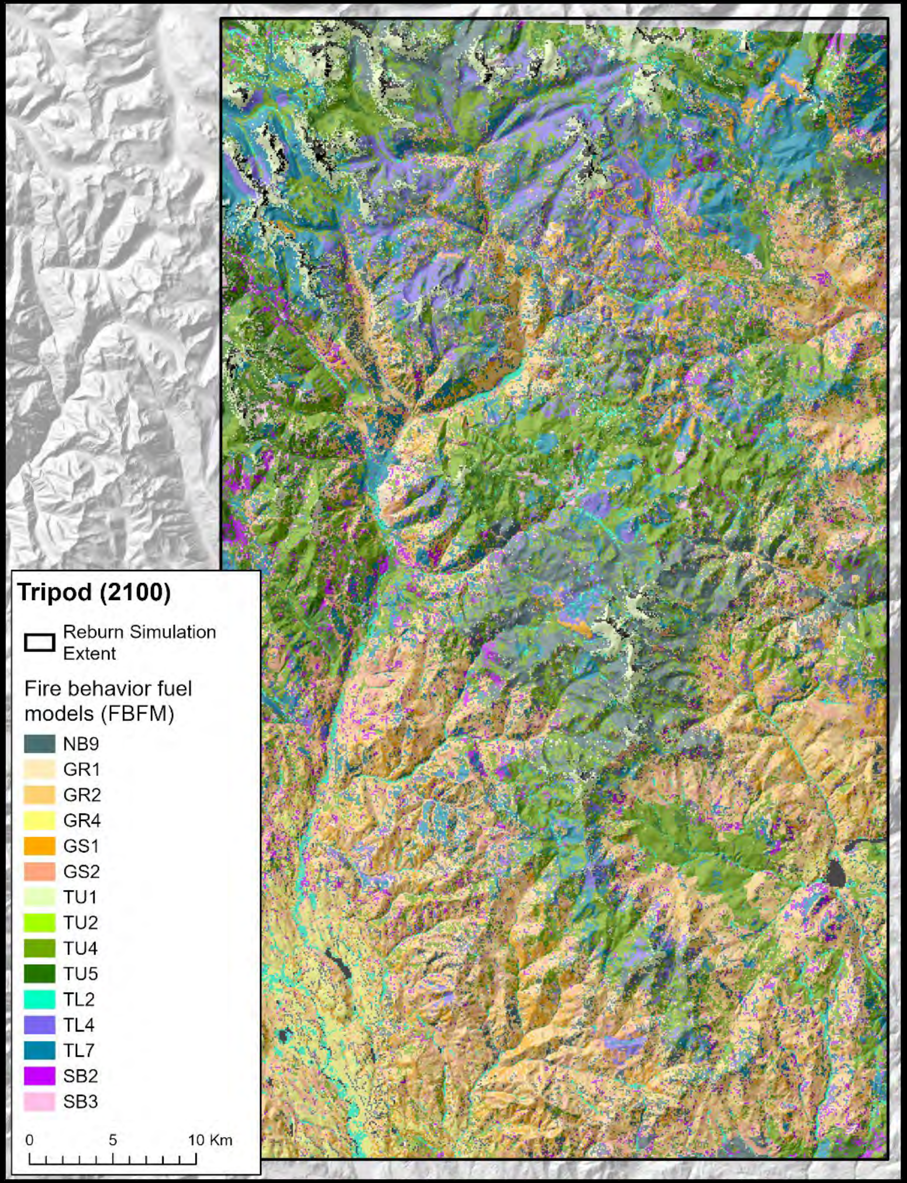






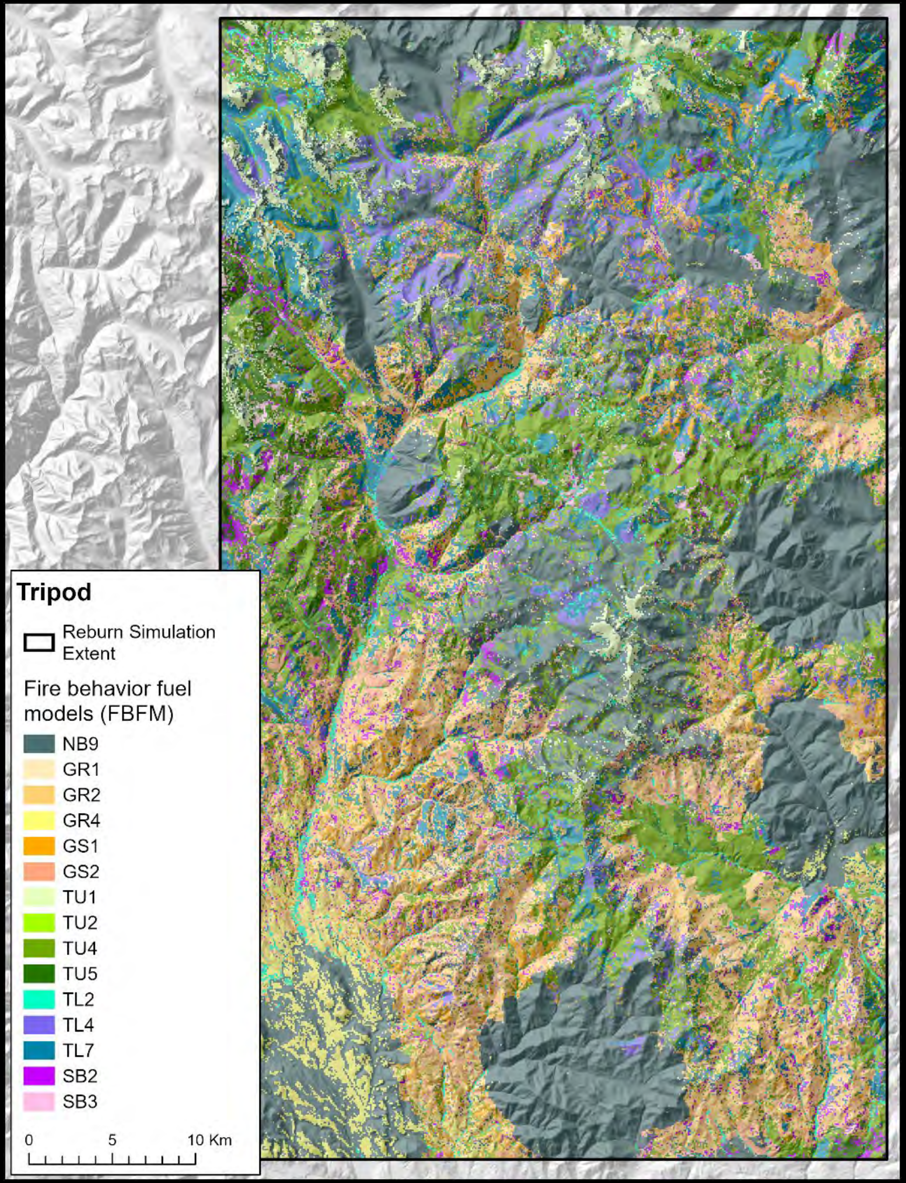


Fire Behavior Fuel Models (FBFM, Scott & Burgan 2005)

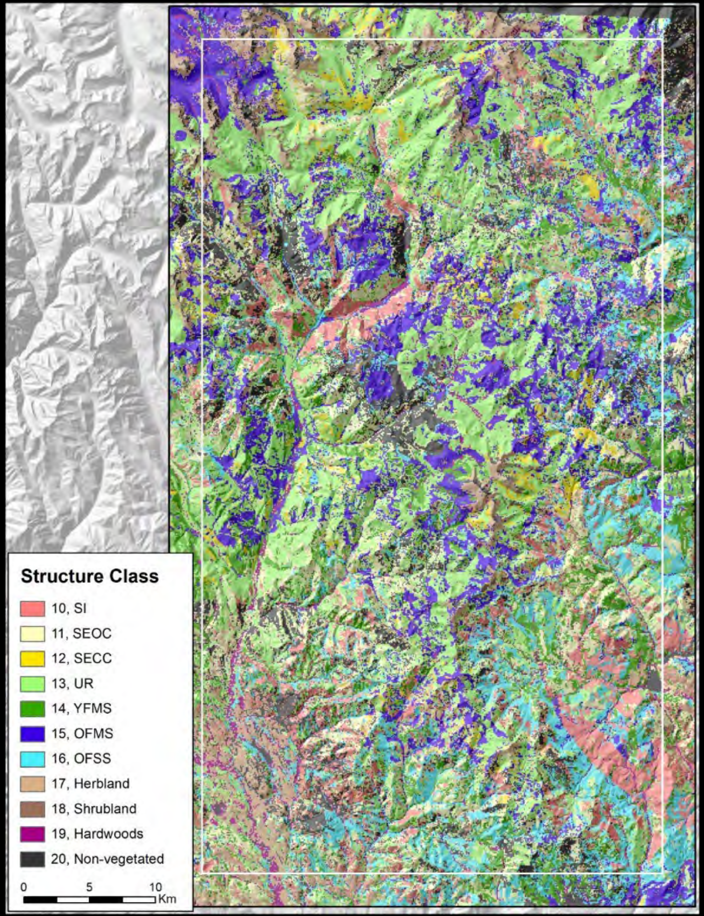


State ID to FBFM conversion

Convert recently burned pixels to non-burnable (NB9)



FBFM input to the fire simulation model

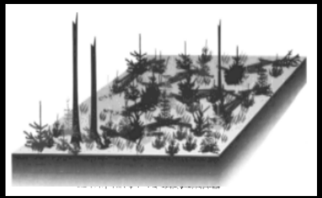


Stand Structural Classes

O’Hara et al. 1996. West J Appl For: 11(3): 97–102; https://doi.org/10.1093/wjaf/11.3.97

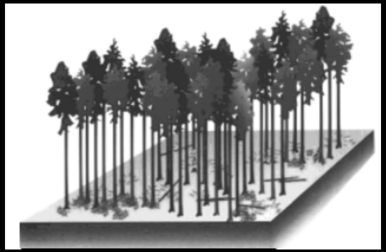
States are translated in Structural classes

Key mileposts in forest development

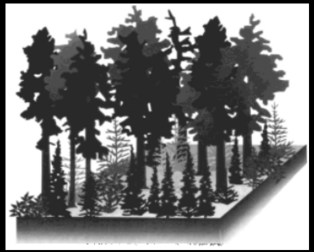


New stand initiation

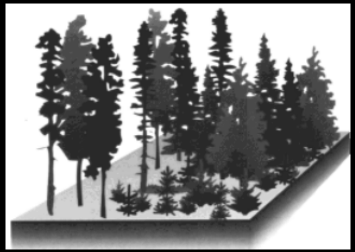
Open canopy stem exclusion



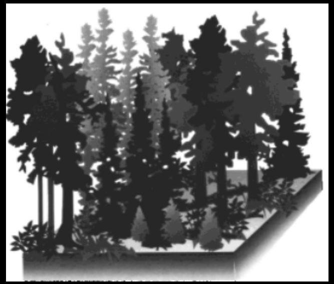
Closed canopy stem exclusion



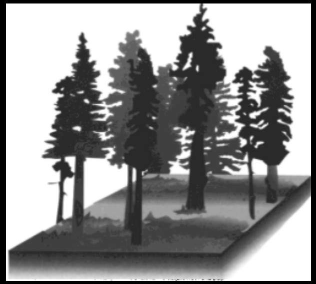
Understory re-initiation



Young multi-story forest



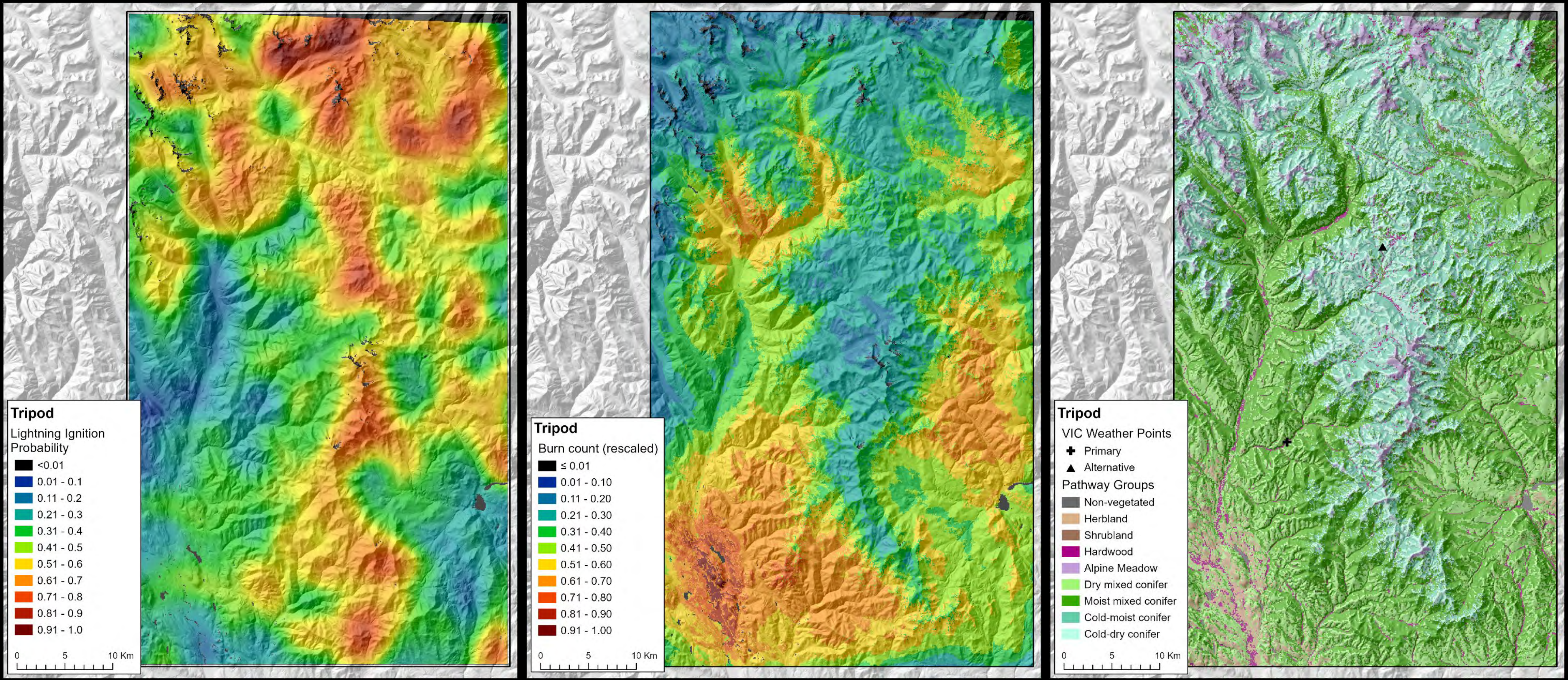
Old multi-story forest



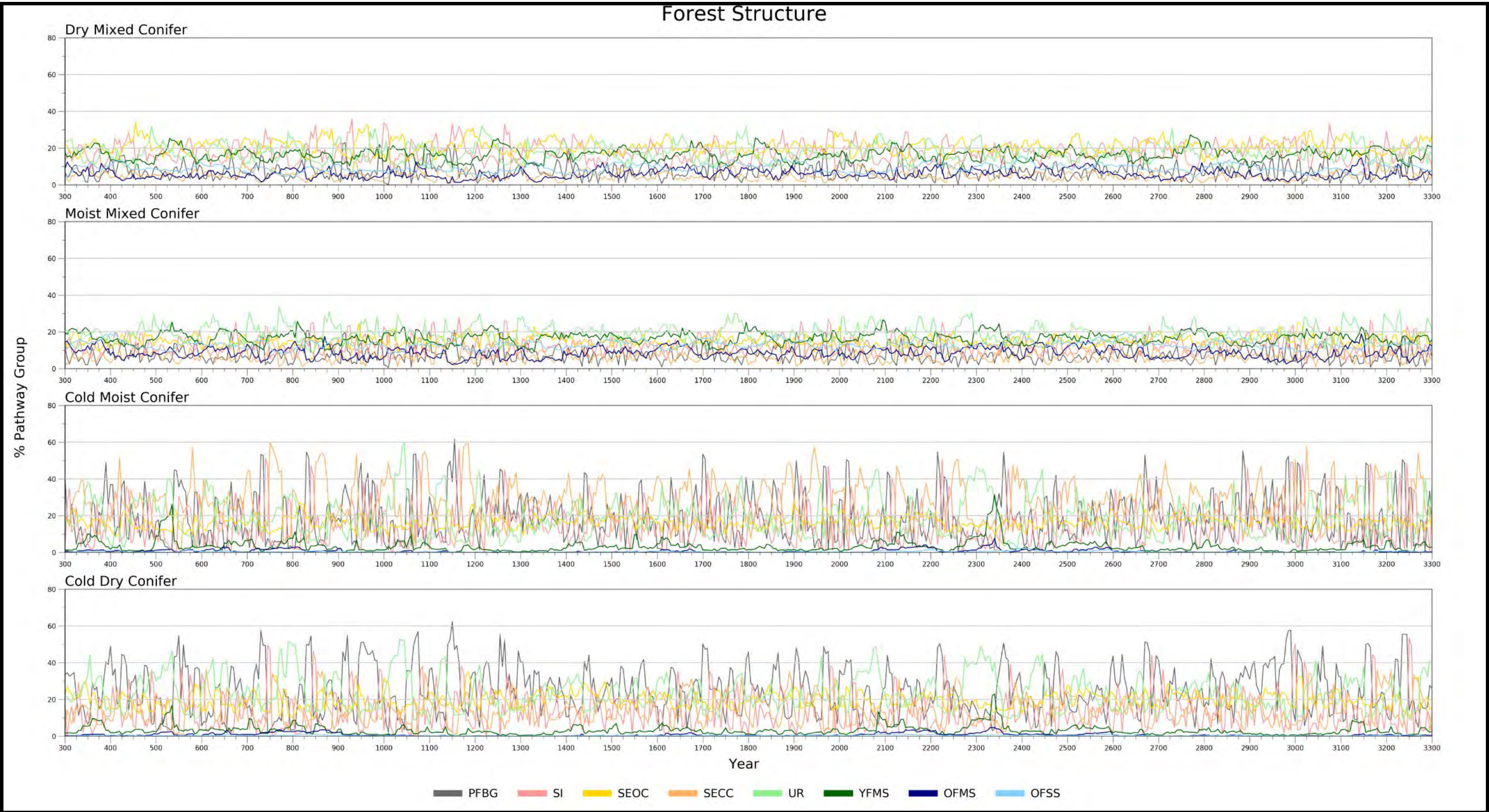
Old single story forest

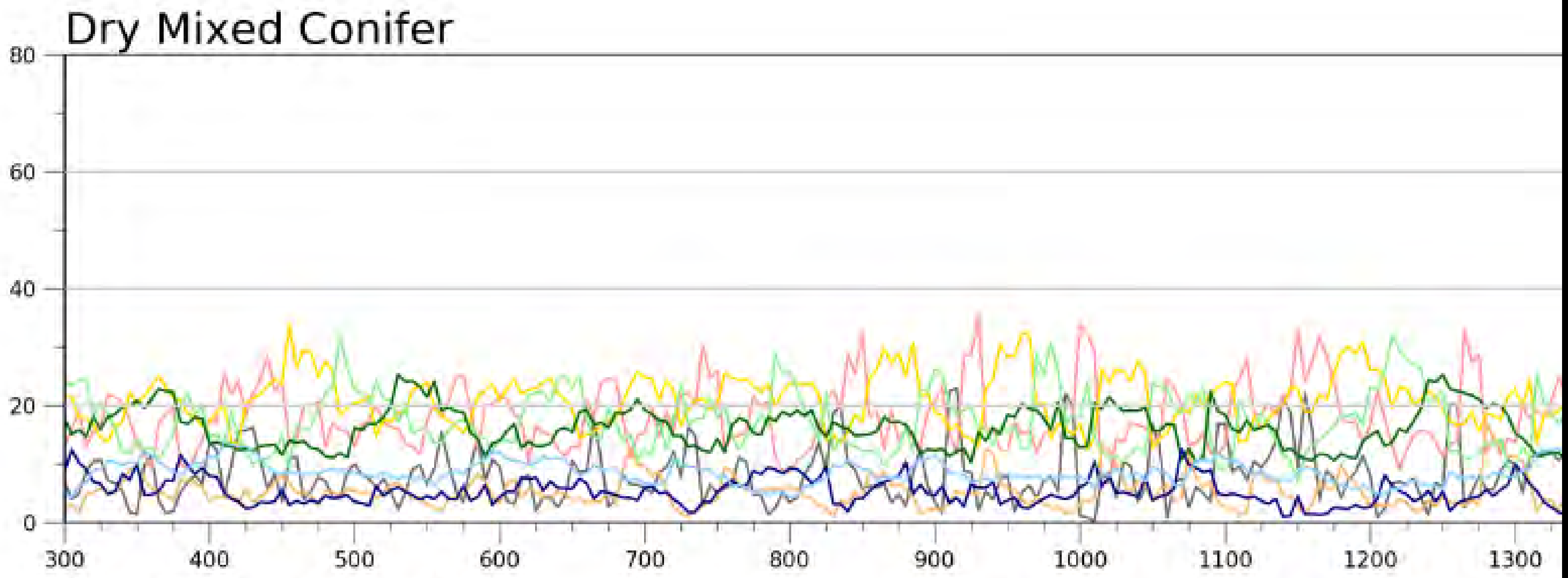
16,000+ fires over 3,000-yr simulation time

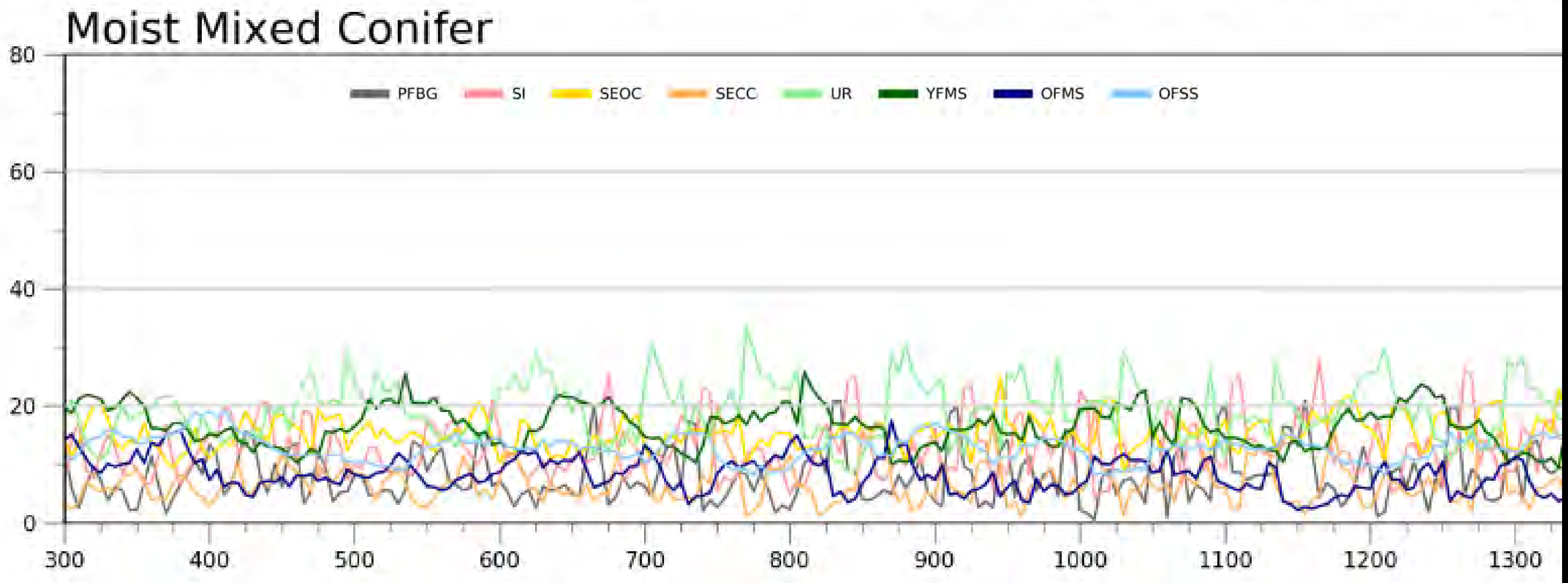
- ✓ 3,000-yr to include rare events, all unique combinations of ignition, slope, weather, fuels, and contagion
- ✓ High elevation north w/ much lightning, few days with fire, even though lightning hotspot
- ✓ Low elevations w/ highest burn count



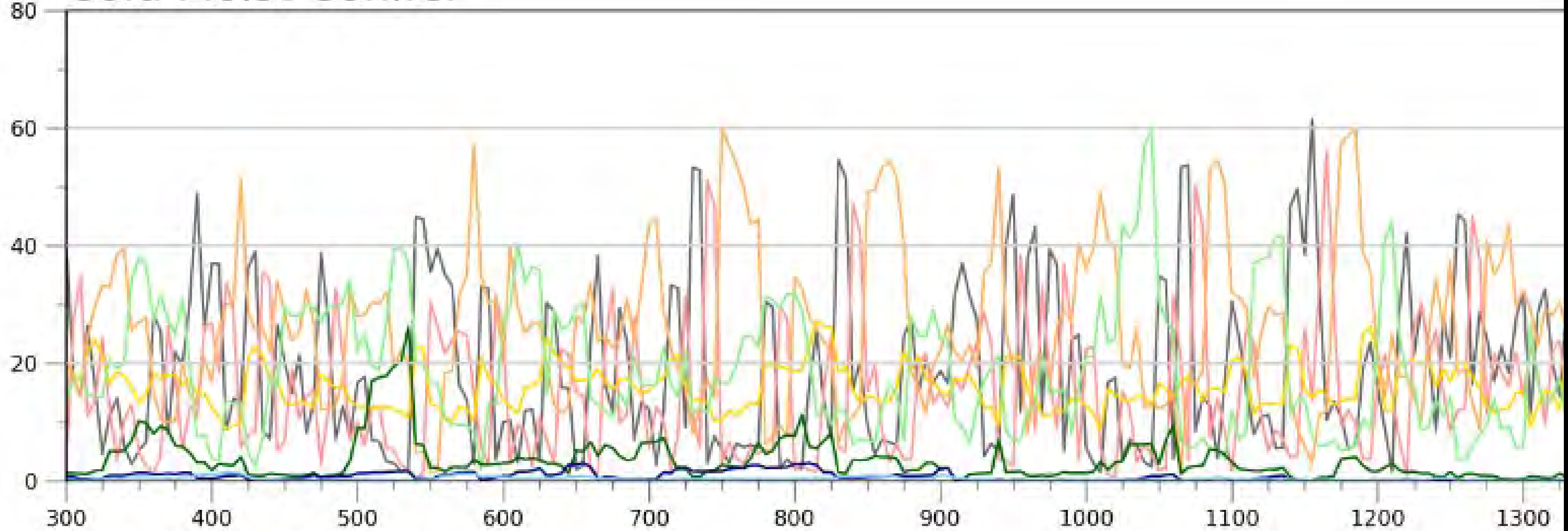
Tripod 3000 Year Simulation



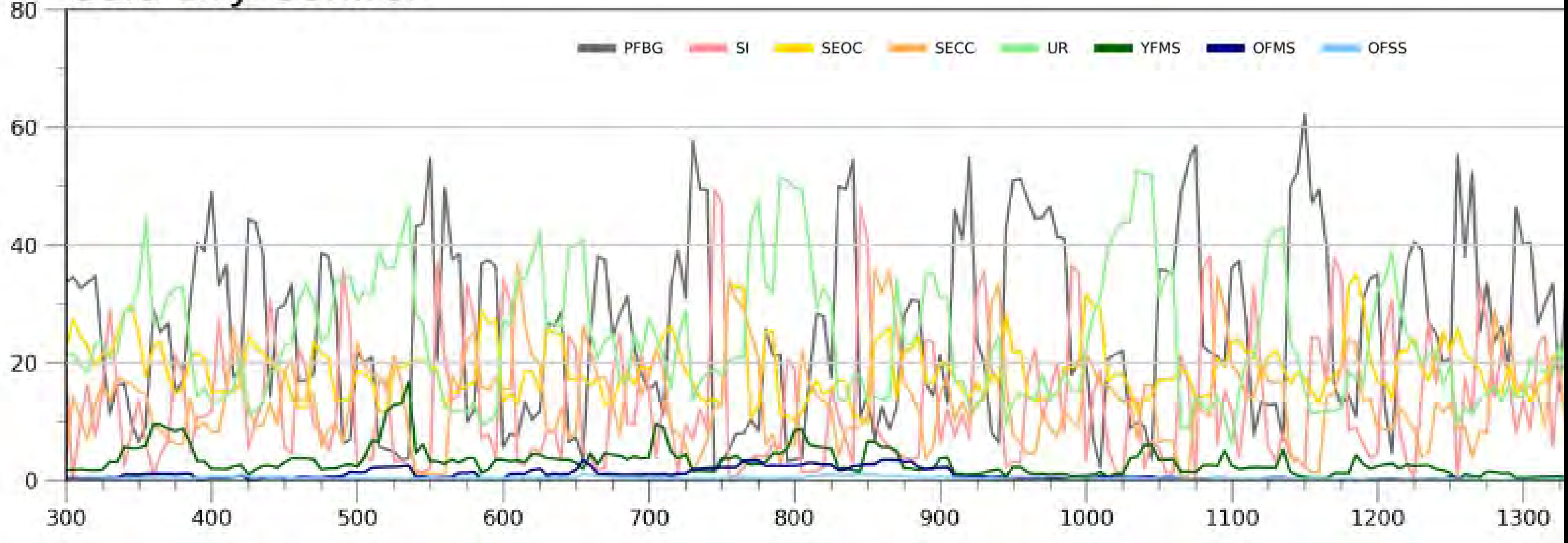

Dry Mixed Conifer
0
20
40
60
80
300
400
500
600
700
800
900
1000
1100
1200
1300


Moist Mixed Conifer
PFBG
SI
SEOC
SECC
UR
YFMS
OFMS
OFSS
0
20
40
60
80
300
400
500
600
700
800
900
1000
1100
1200
1300

Cold Moist Conifer

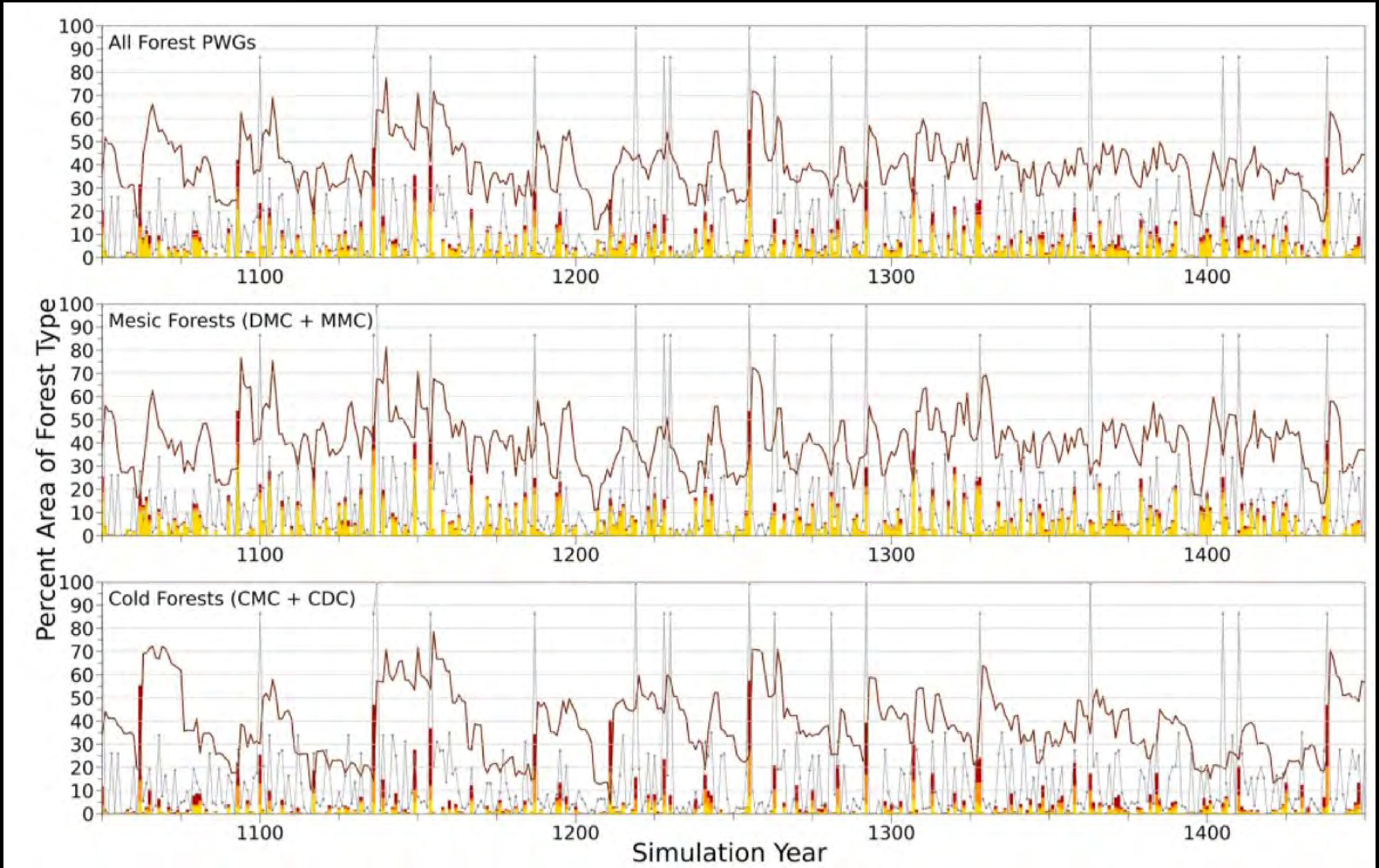


Cold Dry Conifer



Fire weather index

None – Area w/o surface fuels (fences)



Prop of HSF

Prop of MSF

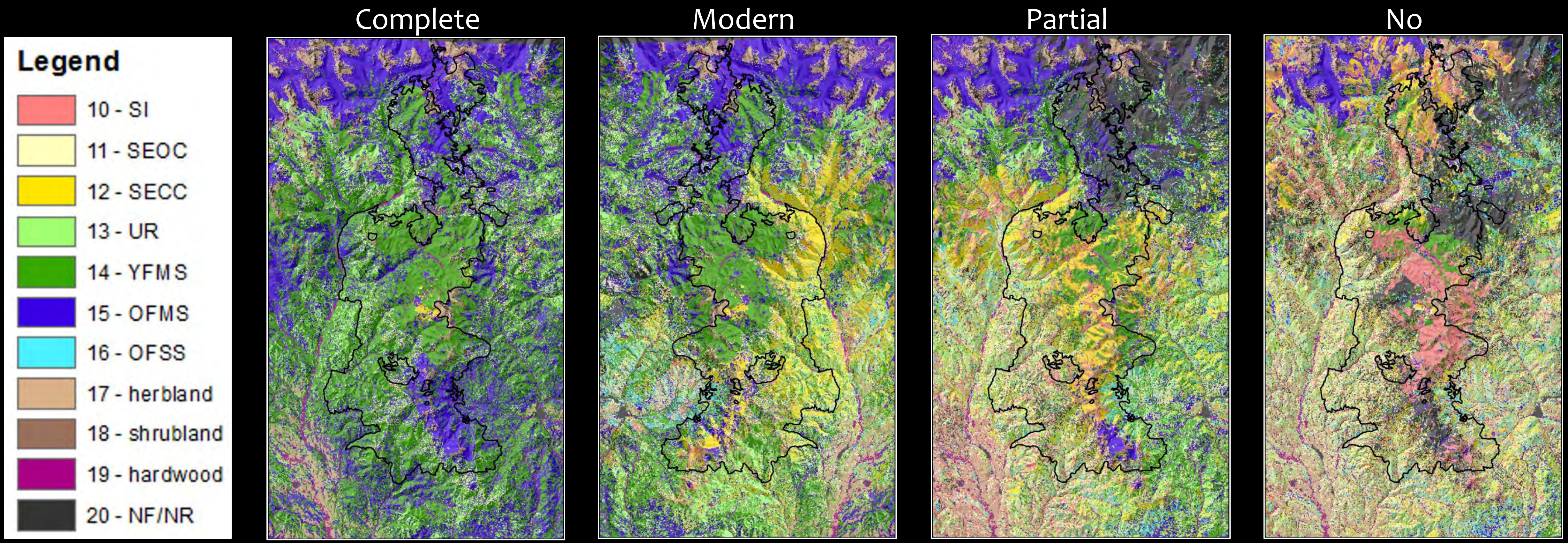
Prop of LSF

Main Findings

1) Systems with active fire regimes stabilize under climate change
2) Fire weather mainly determines annual area burned
3) Fire severity mainly determine fuel supply in dead and down wood and forest density and species composition
4) Ignition locations & temporary barriers to fire flow provided strong controls on fire size & severity.
5) Large fires are integral to the system, their frequency is regulated by the smaller fires and their severity patterns
6) Large fires derived from middling conditions, where unique configurations of those conditions are the driver
7) Non-forest elements are vital to stability, often occupying 35-50% of resilient landscapes, 40% is a good average.

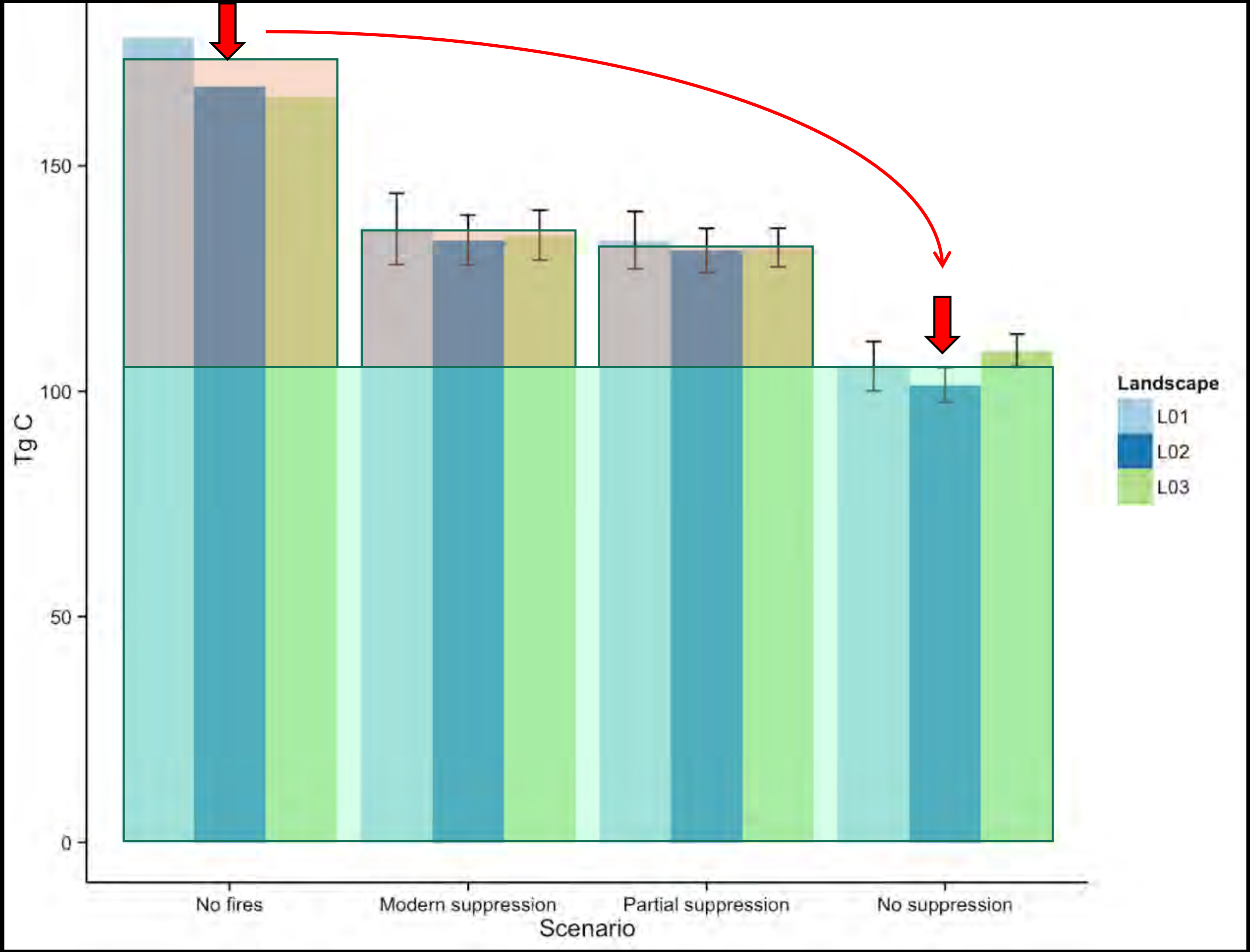
Wildland Fire Management Scenarios

1) Complete absence of fire – no ignitions, no fires
2) Modern Suppression –worst 2% of fires escape suppression, ≥ 98th-percentile fire weather conditions
3) Partial Suppression – managed wildfires in the late-summer and fall fire seasons & worst 2% still escape
4) No Suppression – all ignitions that meet thresholds to burning – burn, approx. historical fire regime



Future directions

- What configurations of forest and nonforest will stabilize landscape resilience under CC?
  - ✓ Implement 21st-century CCs
  - ✓ How much nonforest occurs by forest type in stabilized landscapes?
- Ongoing tug-of-war btw factors growing & burning forests
  - ✓ What is the reburn area that increases the forest that can be stored under CC?
    - o Note that reburning decouples the dead & down wood from developing forests for several decades
    - o These forest patches are much harder to burn
- What is the hardwood/mixedwood forest area under CC?
- What ranges of habitat conditions can exist in forests with active fire regimes & re-stabilized conditions?
  - ✓ How are habitats networked under a reburn ecology?
- What changes in forest C stocks occur when comparing 20th and 21st century climates?



There was 50 to 60% more Carbon stored in live and dead biomass on the Tripod landscape after the period of fire exclusion than before it.

Thank you