Representing prescribed fire and mechanical thinning in a demographic vegetation model: mechanisms driving forest structure, fuel, and demographic rates in Sierra mixed-conifer forests

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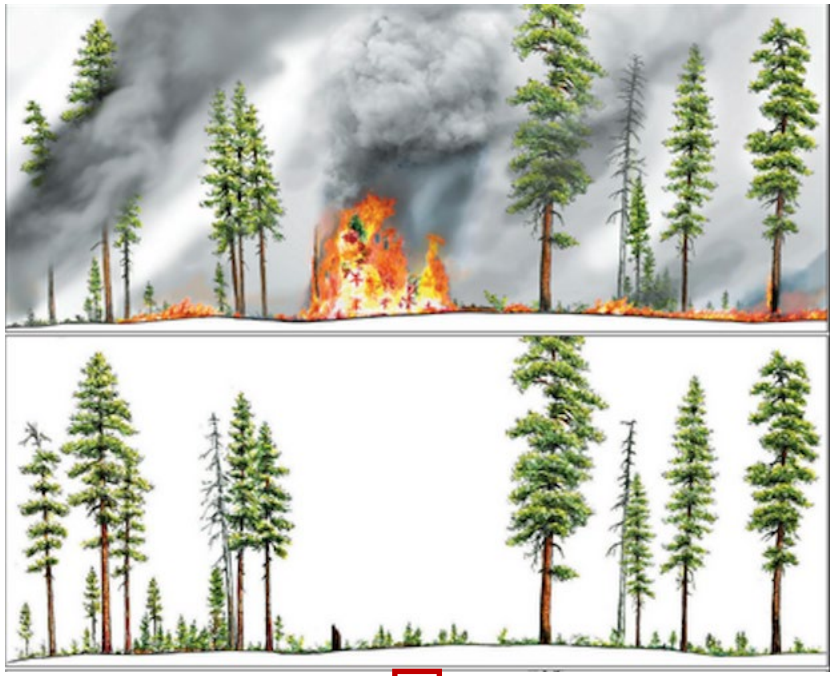
Fire as a management tool in California ecosystems

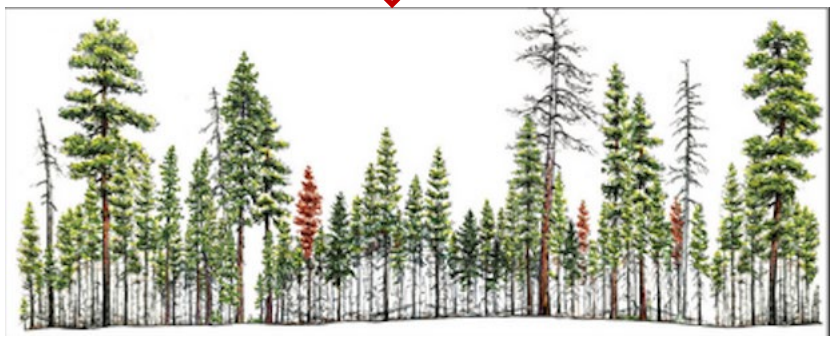
Historical fire regime: frequent, low-moderate severity fire under Indigenous stewardship.

- Keep canopy open
- Reduce wildfire risk
- Promote post-fire resprouting and tree regeneration

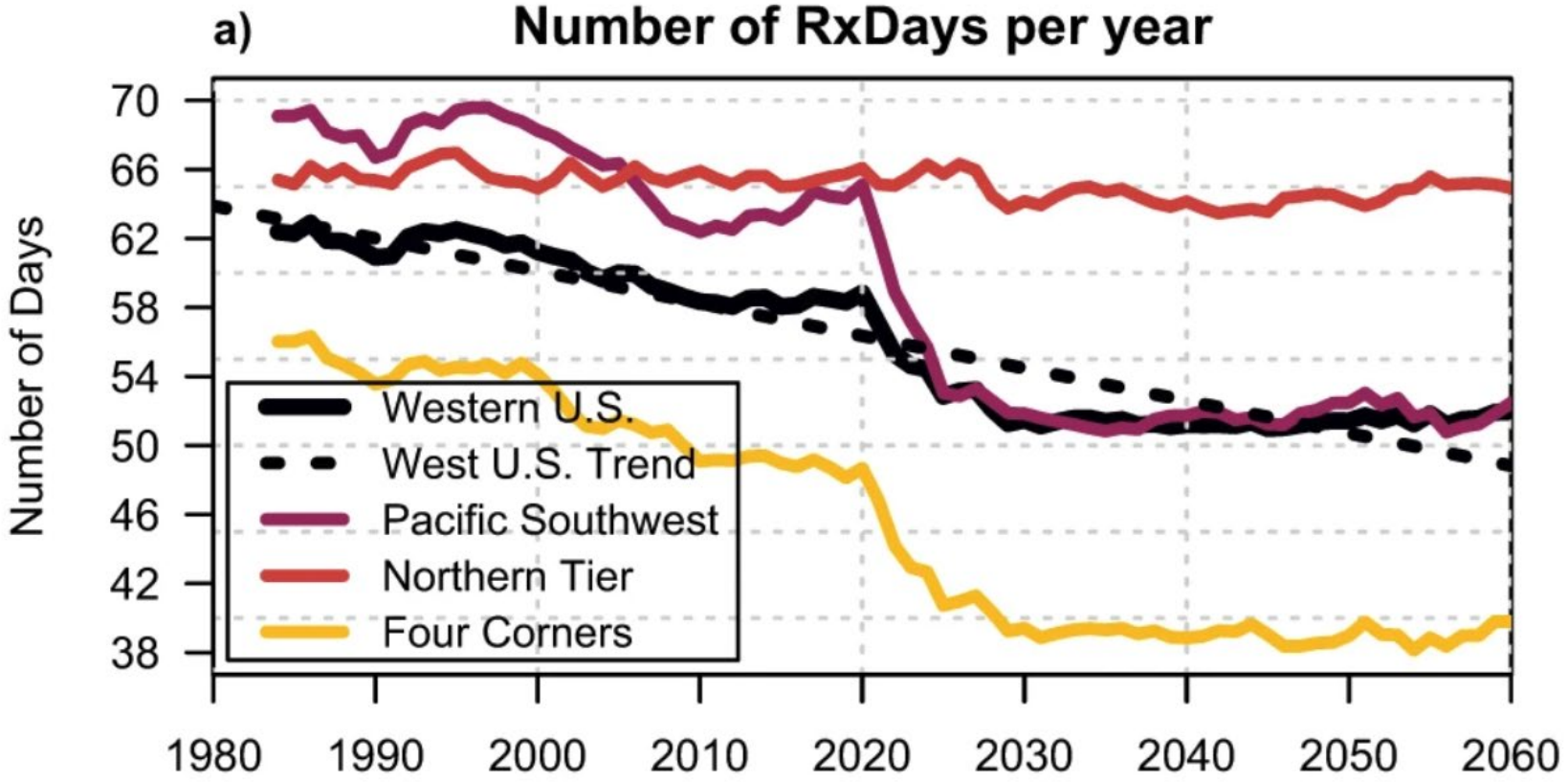
Mega fires in fire-suppressed forests



Fire suppression

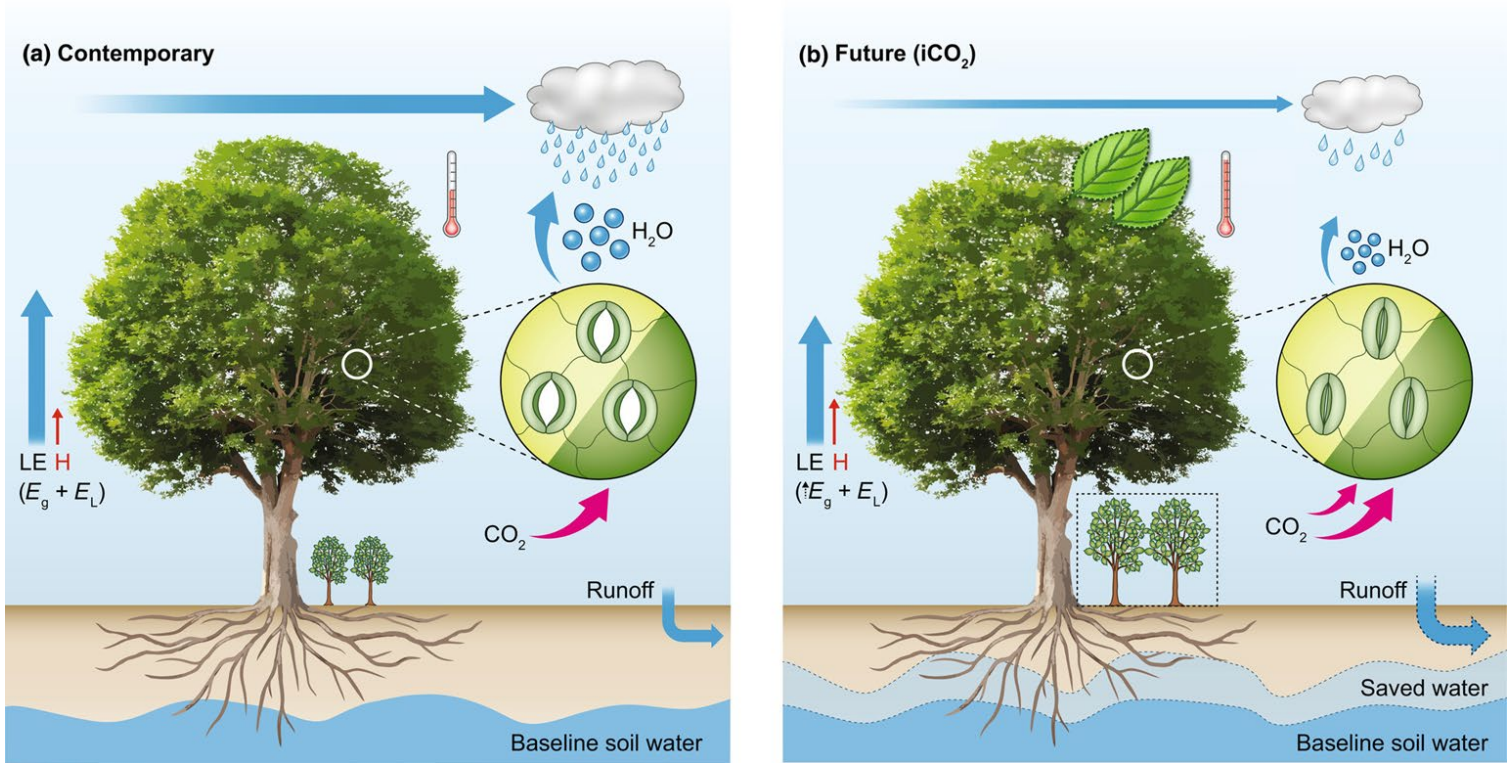


Prescribed fire under changing climate: a narrowing burn window



Adapted from Swain et al. 2023

Long-term management outcomes are unclear: complex interactions between climate and eCO_2



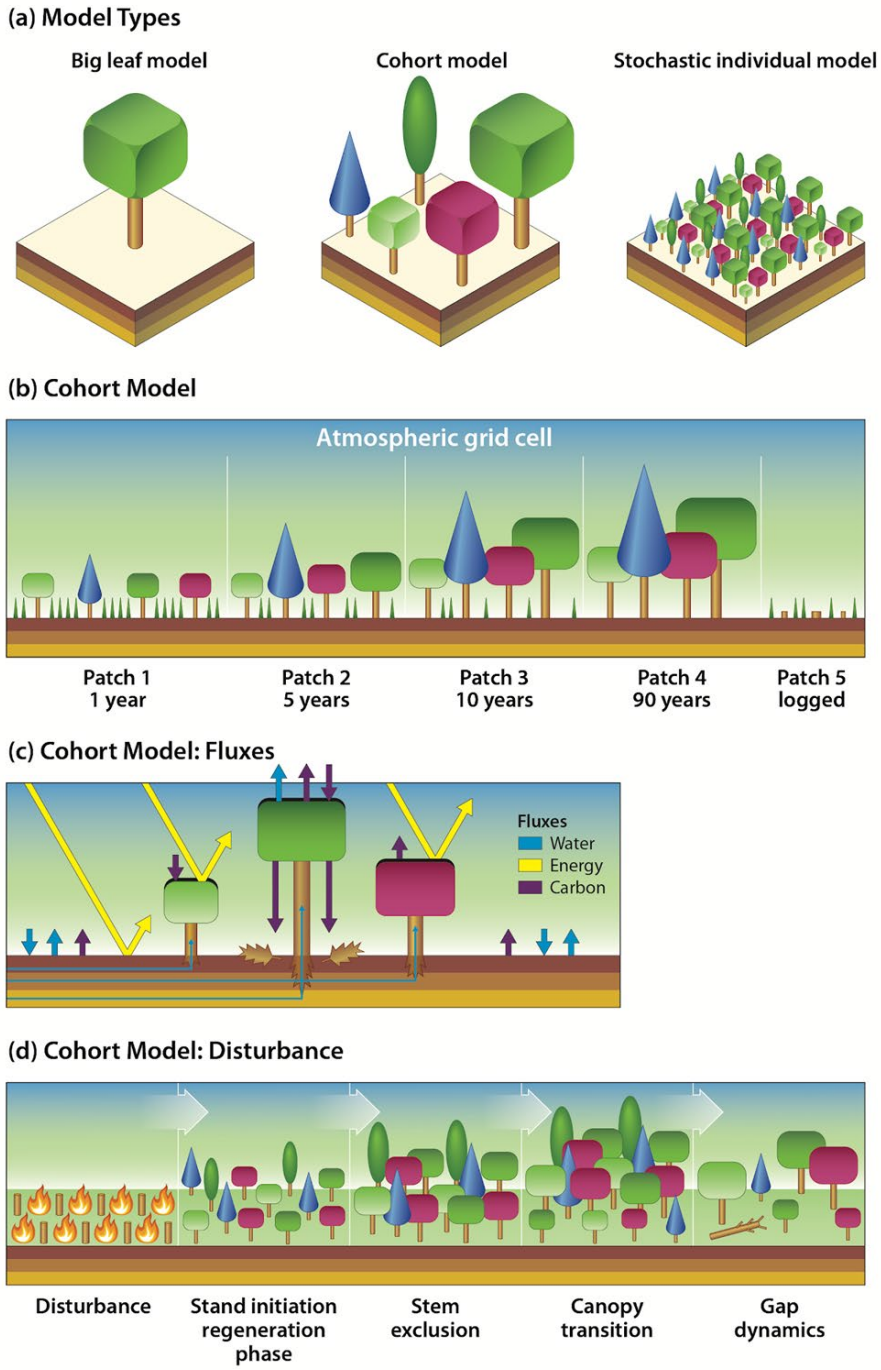
Live fuel moisture ↑
Biomass ↑
Net effect ?

Li 2024

What drives the long-term management outcomes in the context of changing climate and shifting fire regimes? Where does the uncertainty come from?

FATES model

- The Functionally Assembled Terrestrial Ecosystem Simulator
- Cohort-based model
- Light, water, nutrient, and space competition
- Various disturbances e.g. fire and logging
- Coupled to host land models including CLM and ELM
- From site to global scale

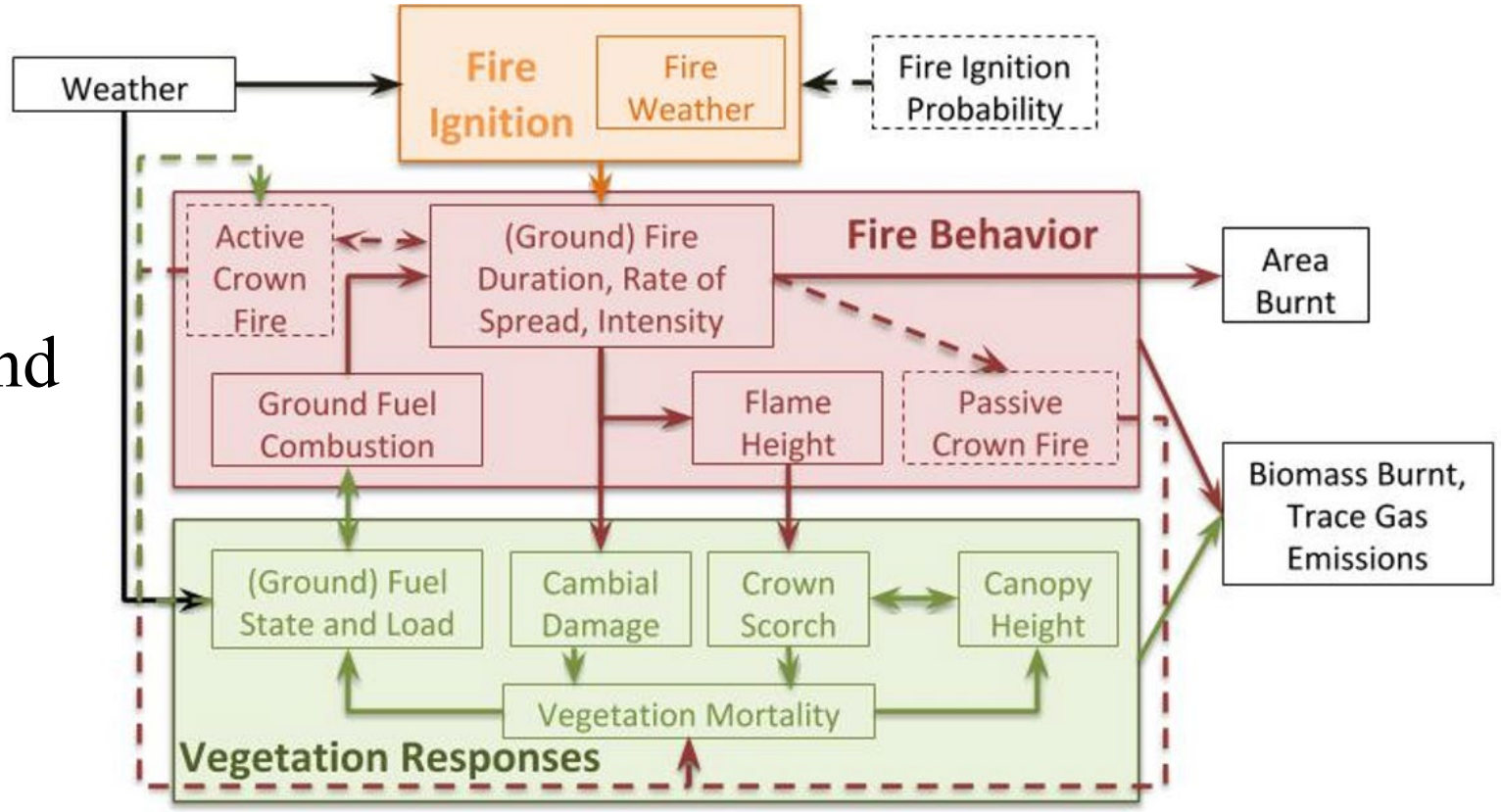


Project objectives

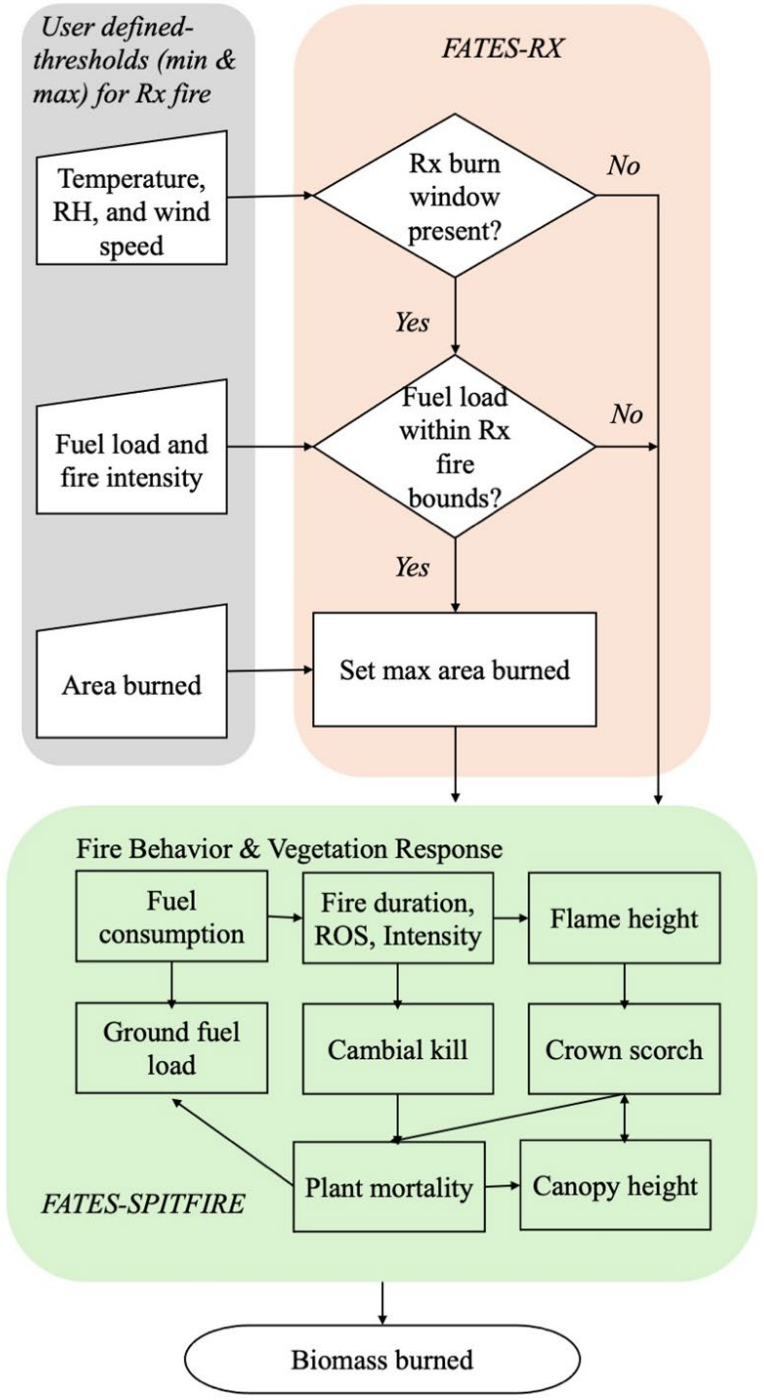
- Develop a mechanistic prescribed fire model and adapt a pre-existing logging model to represent prescribed fire and thinning as fuel management activities in FATES
- Test if model can capture the general ecological expectations by which Rx fire and thinning affect wildfire and vegetation dynamics

Fire in FATES

- Determined by weather, fuel, and ignition source
- Captures both fire behavior and fire effects on vegetation



FATES-SPITFIRE



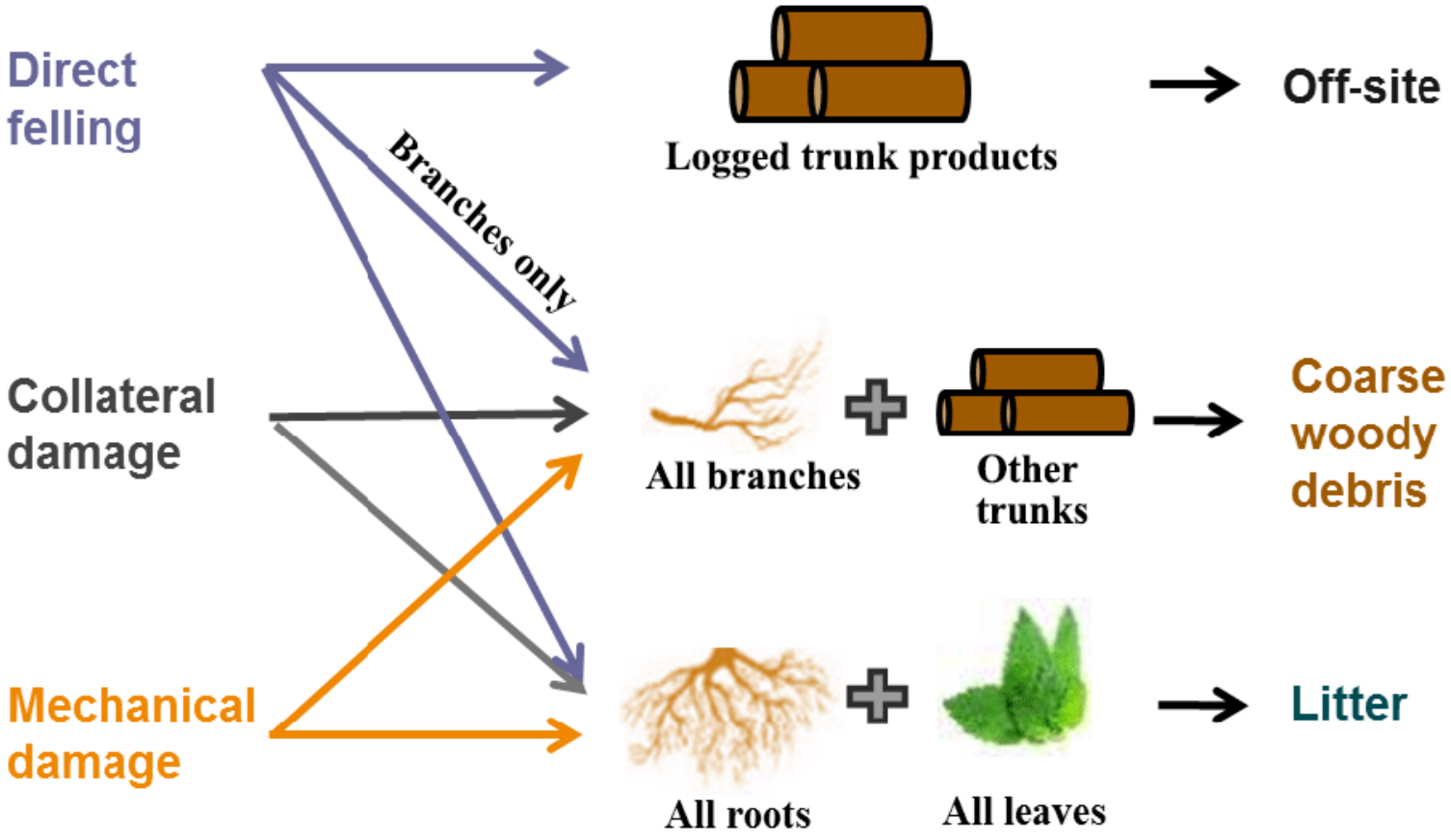
FATES-RX: the new management fire model

- User defined weather conditions for burn window
- Fuel and fire intensity checks
- User defined burning capacity
- Post-fire vegetation responses by FATES-SPITFIRE

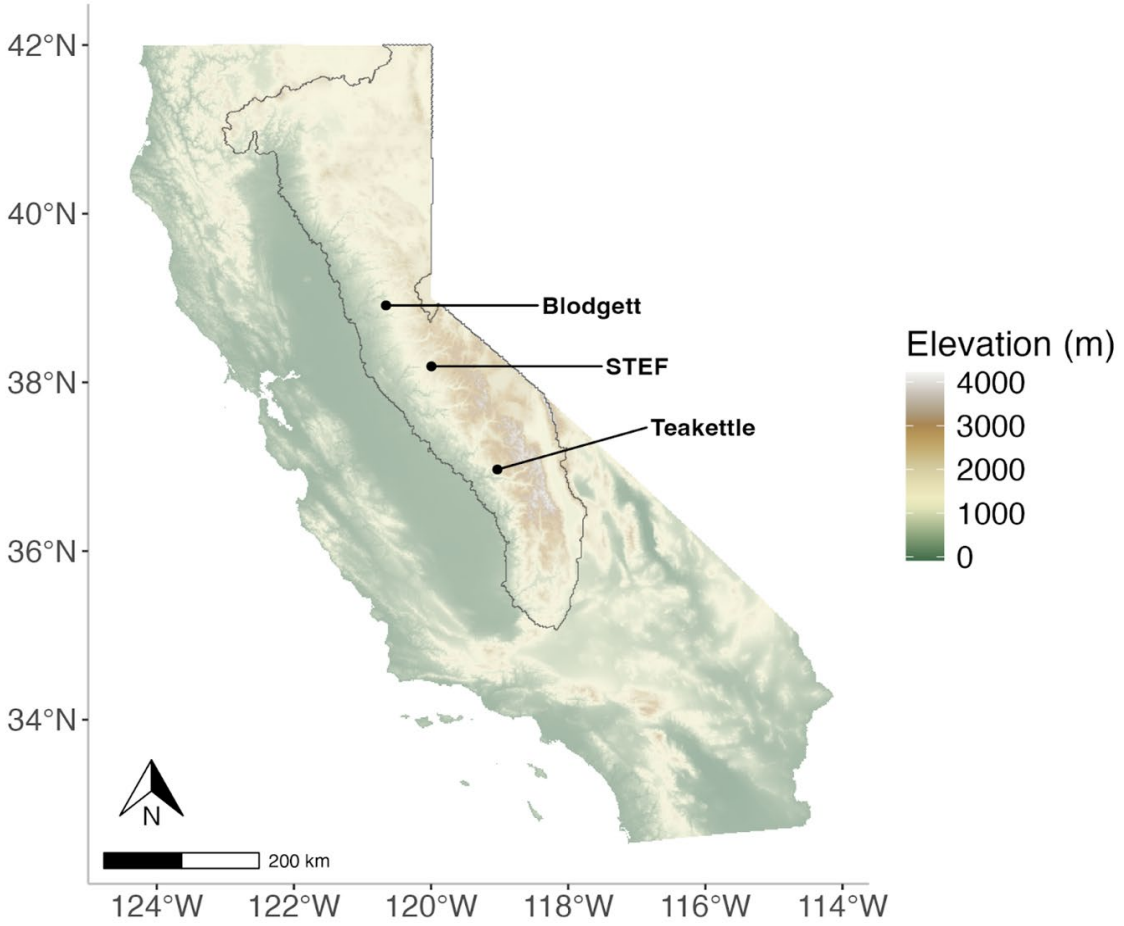
Gao et al. in prep

FATES logging model

- Direct and indirect effects
- Influences on litter influx
- New feature: prioritize removal of small- and medium-sized trees

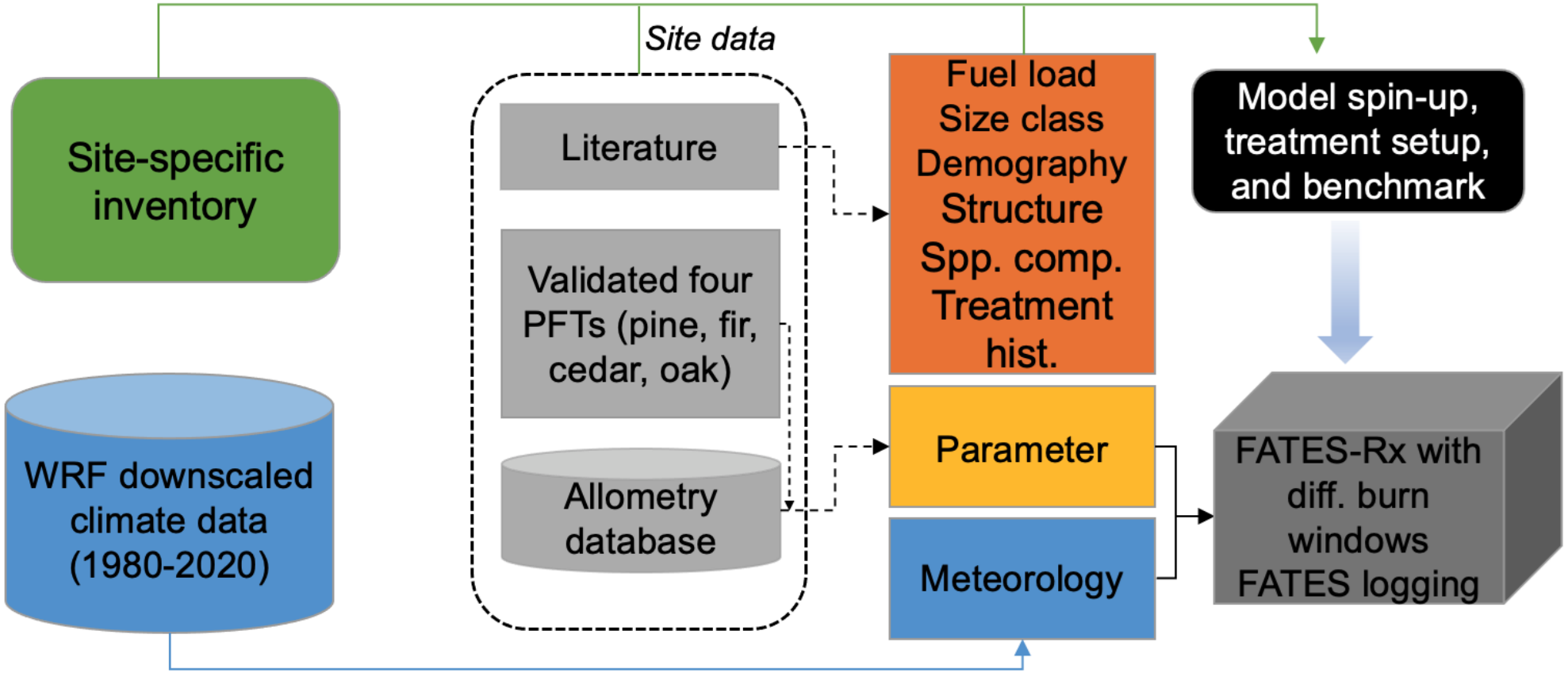


Model validation sites

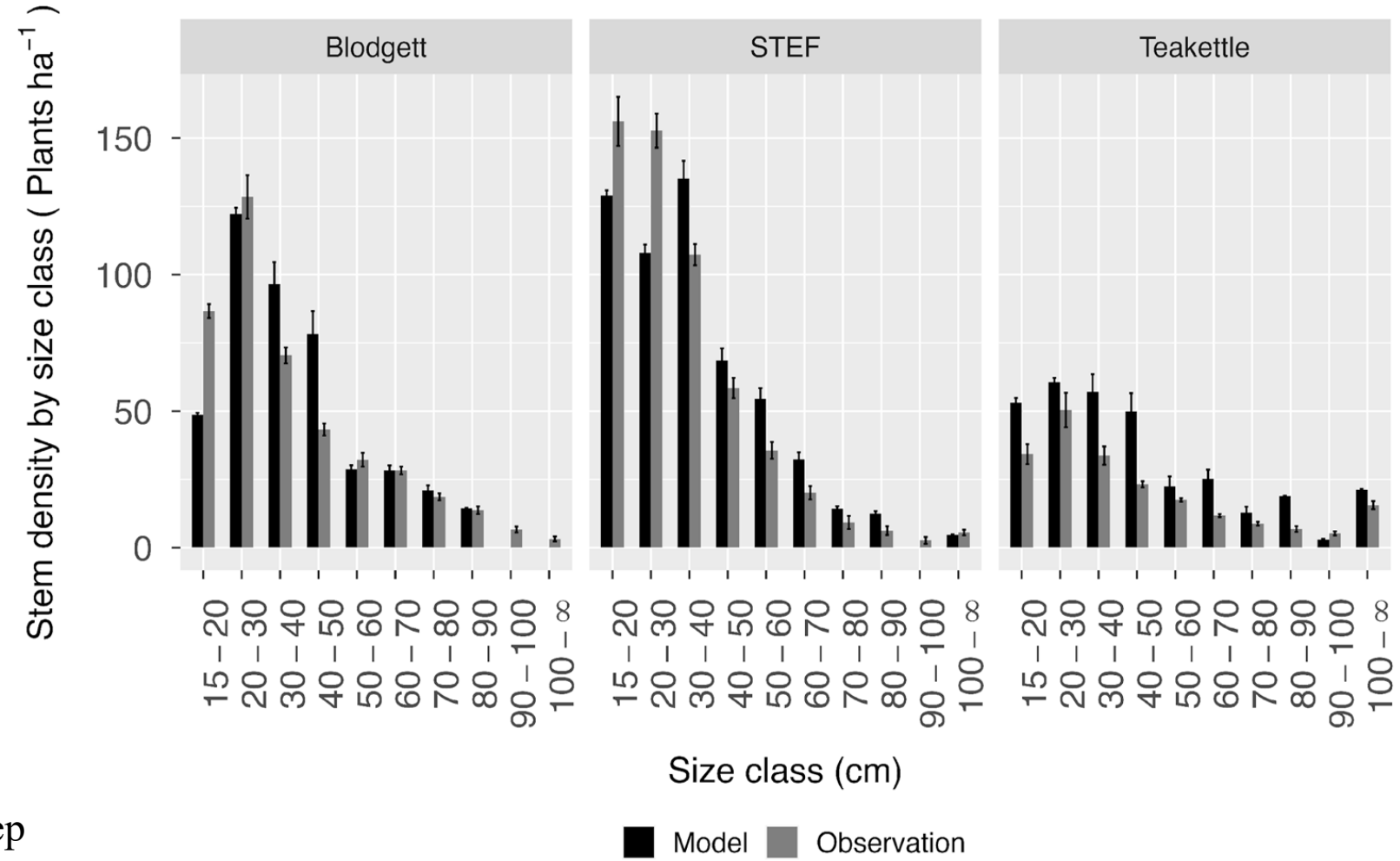


Blodgett: Stephens et al. 2005; STEF: Knapp et al. 2017; Teakettle: North et al. 2002

Modeling experiment setup



Using inventory initialization, FATES can well represent stand structure in the control units



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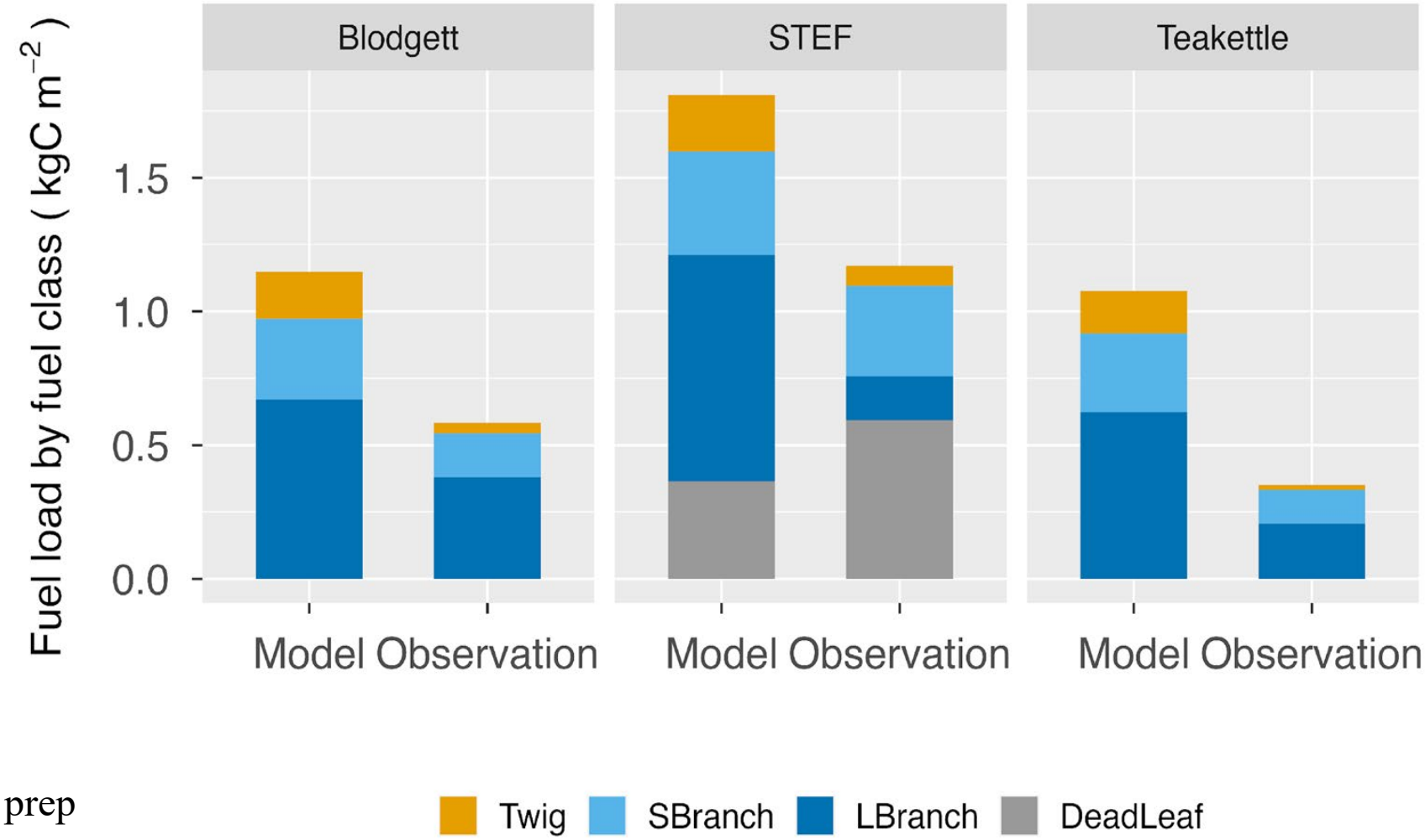
But it overestimates fuel load of the control



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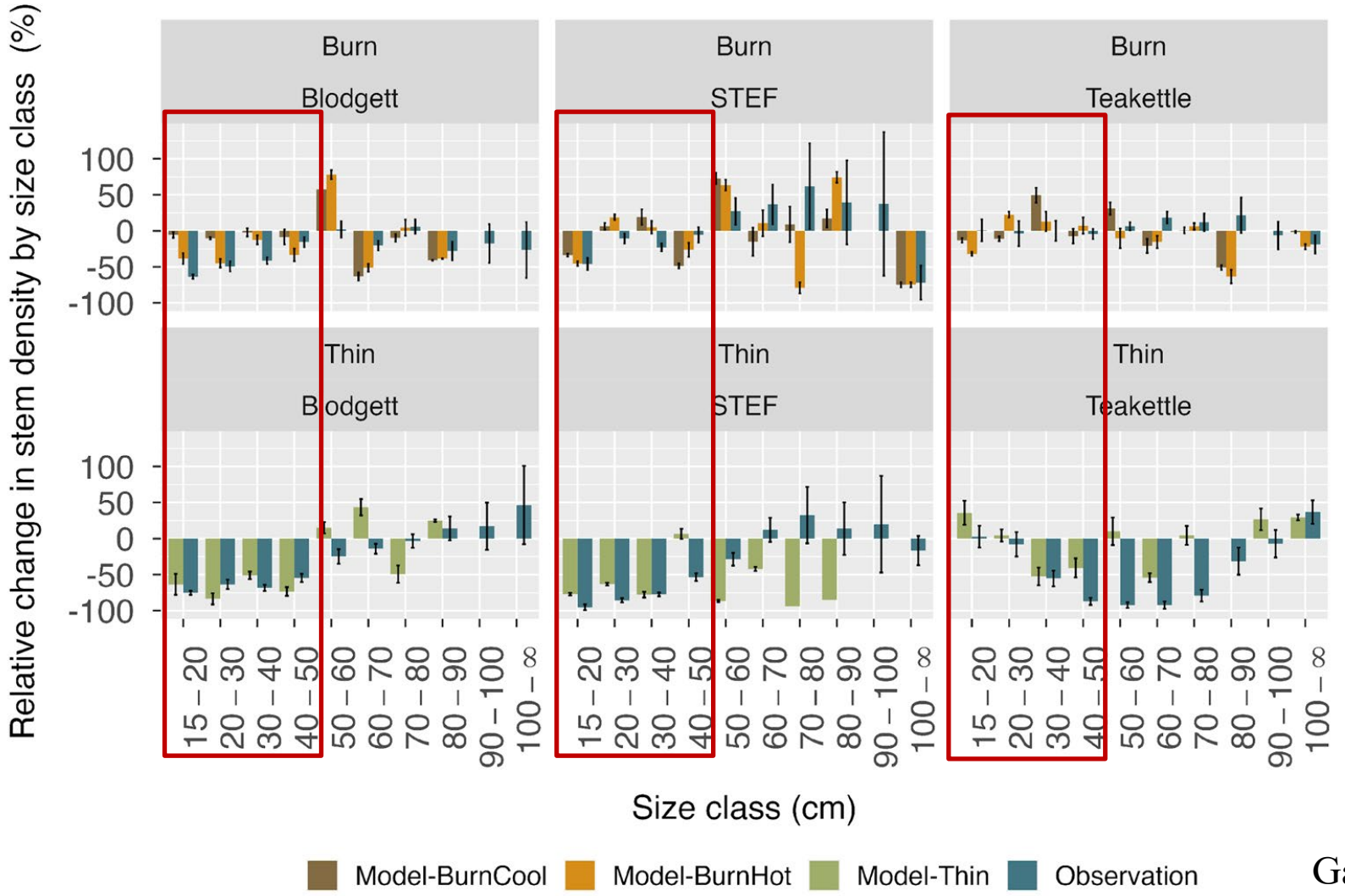
In general, FATES captures the observed decrease in small- and medium-sized trees after Rx fire and thinning



Inclusive burn window: Model-BurnCool

Exclusive burn window: Model-BurnHot

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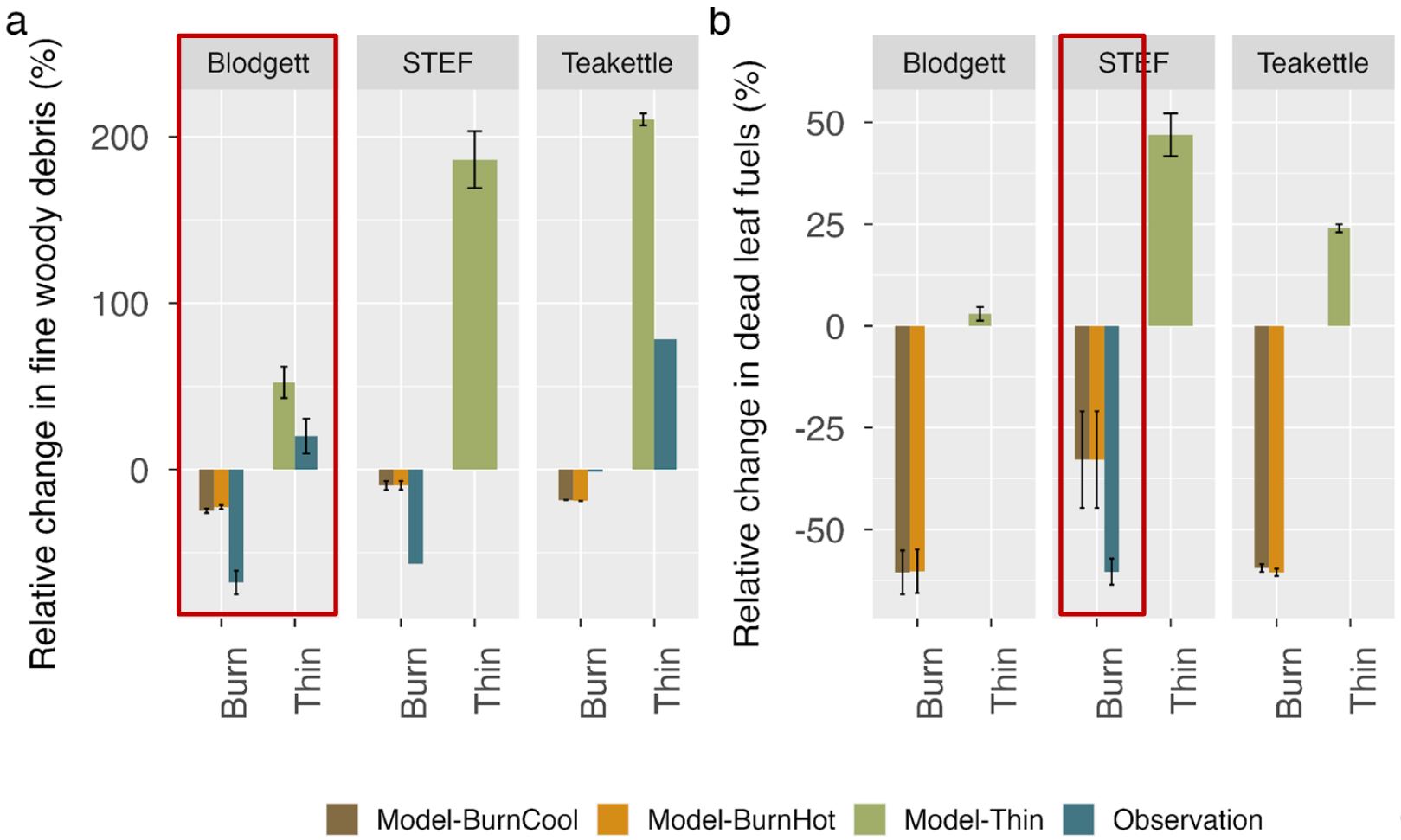
FATES captures the tendency of prescribed fire to remove surface fuel and thinning to increase it



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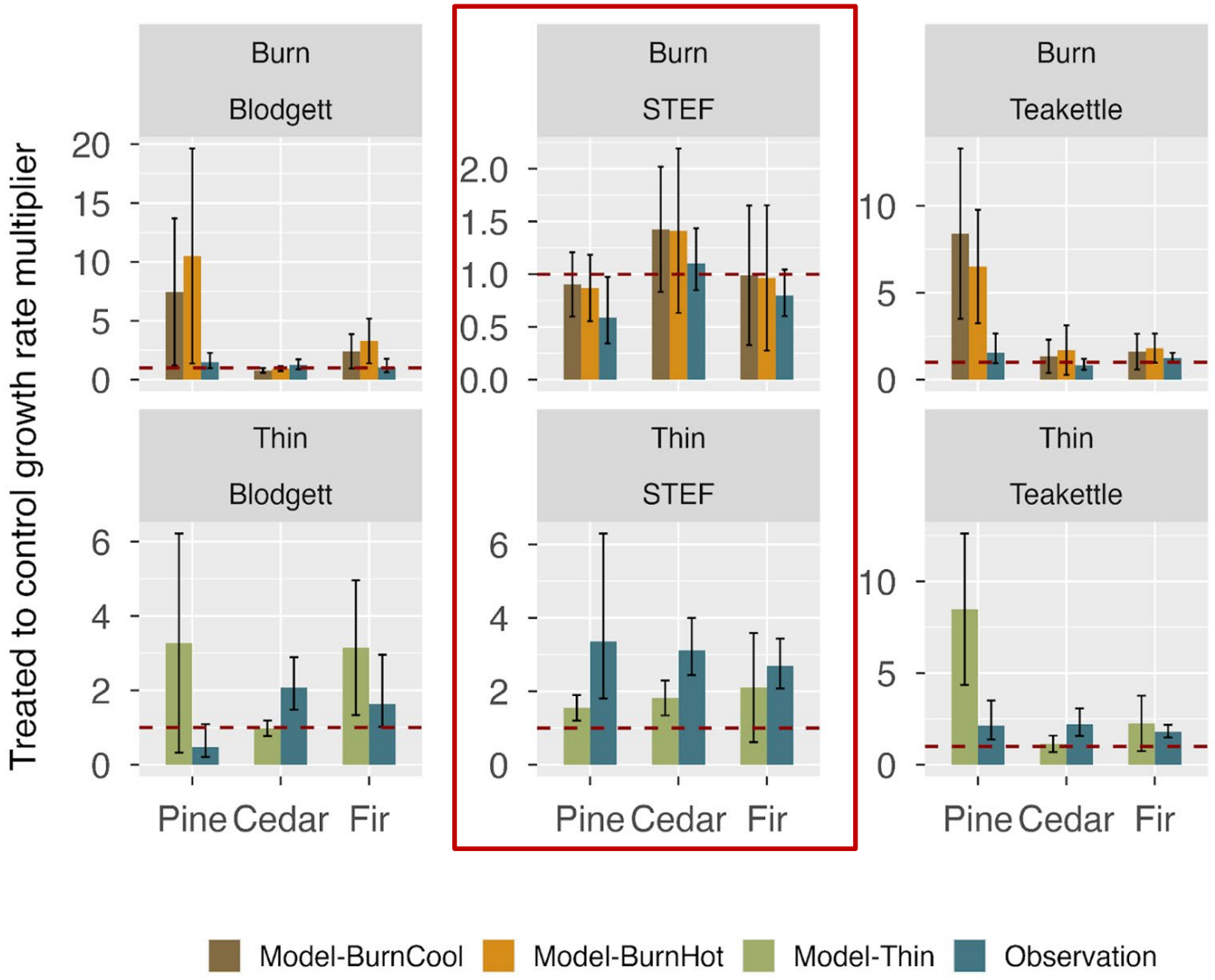
FATES captures the observed positive growth response to thinning; modeled and observed Rx fire effect on growth varies by PFT and site



Gao et al. in prep

Take-home messages

- With inventory initialization, FATES can well represent stand structure but tends to overestimate fuel load
- Both model and observations show decrease in small- and medium-sized trees after treatments; suggesting Rx fire and thinning can effectively remove ladder fuels; Rx fire is more effective in reducing surface fuels
- Thinning tends to stimulate growth while Rx fire effects on post-treatment growth can vary
- We benchmarked FATES according to established theories to ensure accurate model projections of the long-term management outcomes under global change (an ongoing modeling effort)