Benchmarking and parameter sensitivity of a vegetation demographic model in a mixed conifer forest of the Sierra Nevada Mountains, California

A Component of the California Ecosystem Futures Project

Polly Buotte[1], Lara Kueppers[1], Charlie Koven[2], Junyan Ding[2], Michael Goulden[3], Chonggang Xu[4]

[1]University of California, Berkeley; [2]Lawrence Berkeley National Lab; [3]University of California, Irvine; [4]Los Alamos National Lab

The Need: Understand and plan for forest responses to novel future climate conditions and disturbance regimes

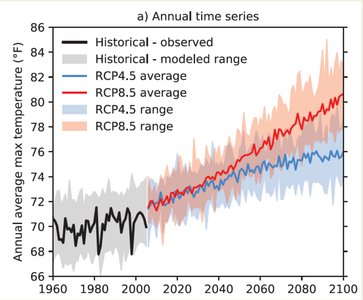
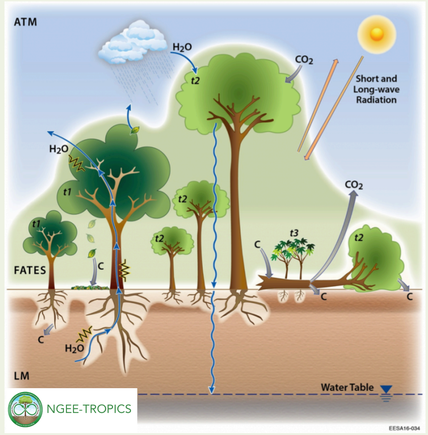


Figure from: Bedsworth, L. et al. 2018. Statewide Summary Report. California's Fourth Climate Change Assessment. : SUMCCCA4-2018-013.

Will novel climate conditions, CO_2 levels, and disturbance regimes lead to novel ecosystems?

Photo Credit: Keri Greer, In: Evans et al. 2011. Comprehensive fuels treatment practices guide for mixed conifer forests: California, central and southern Rockies, and the Southwest. Forest Guild.

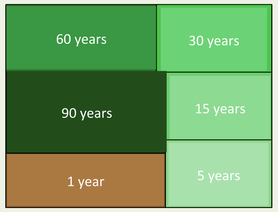
The Framework: The Functionally Assembled Terrestrial Ecosystem Simulator (FATES)

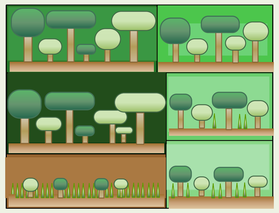


- Explicit physiology drives carbon and water balance, demography, and forest structure
- Effects of elevated CO_2 incorporated
- Flexible plant functional type definitions
- Heterogeneity in light availability
- Physical environment and competition determine plant coexistence
- Plant type distribution is emergent
- Ignitions, weather, and vegetation types interact to determine fire occurrence, intensity, area burned, and plant mortality
- Option for explicit hydrodynamics modulated by plant traits

Vegetation structure in FATES

Each time since disturbance tile contains cohorts of identical plants defined by functional type and size



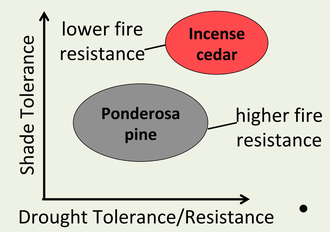


To date, FATES has been exercised in the tropics, the eastern US, the arctic, and the boreal forest, but not in western US forests.

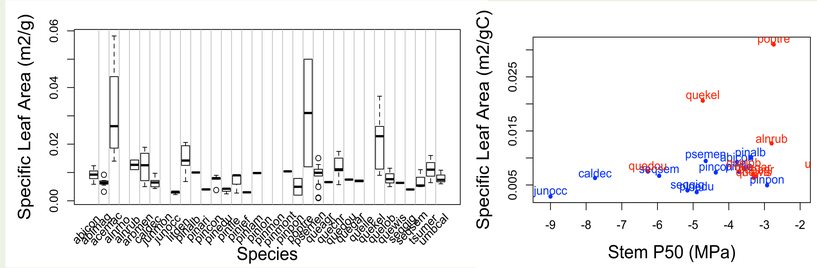
Bringing FATES to California: An iterative process of parameterization and benchmarking

Plant Functional Type definition

- Compiled observations of 16 plant traits for 33 tree species



Example of two PFT definitions

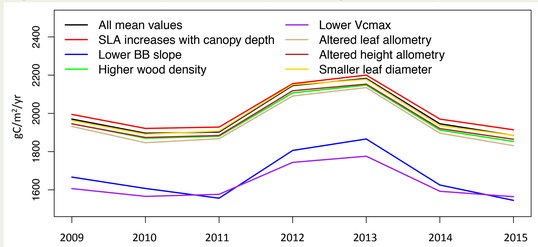


Example of trait data, showing specific leaf area, and the relationship between SLA and stem P50

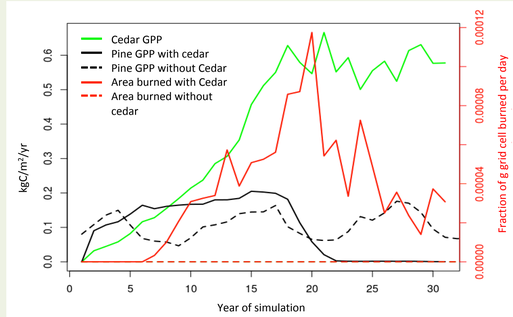
- Defined PFTs by shade tolerance, drought tolerance, and fire resistance
- Refined through sensitivity analysis and benchmarking

Parameter Sensitivity Analysis:

- One-by-one parameters perturbations inadequate to disentangle the interactions among plant traits, climate, competition, and fire



Multiple parameters affect annual GPP in simulations with initialized stands and one PFT

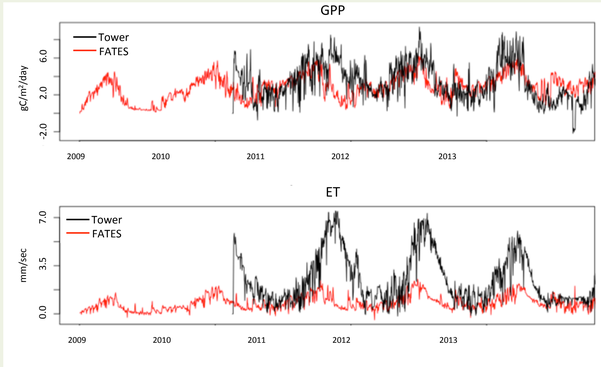


Complex interactions affect model outcomes

- Currently running 5,000 member ensemble varying 50 parameters that affect mortality, recruitment, allometry, physiology, fire, and patch dynamics

Initial Benchmarking

- Seasonal GPP simulated well
- ET underestimation likely due to incorrect rooting distribution, or lack of simulated tree diversity and understory vegetation
- Will expand to include multiple PFTs and additional towers spanning an elevational and forest type gradient
- Iteratively refine trait parameters within the range of trait observations



Comparison of Southern Sierra CZ2 tower data and fluxes simulated with one pine PFT starting from initialized stand conditions

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