Lessons learned in modeling forest responses to climate change

Richard Waring

College of Forestry
Oregon State University

OREGON STATE UNIVERSITY

NASA

UBC

Challenge

- Satellite-borne instruments can view current conditions, classify landscapes, and record change over time.
- They cannot predict the future…for that landscape-ecological models are required that predict responses of vegetation to changes in climate, soils, and management practices.

Approach

- Develop models, based on general principles, that can be widely tested, mainly on previously collected data

- Where models fail, evaluate cause, and, if possible, modify and continue to improve.

Seek common features to model

tropical rainforest

temperate deciduous

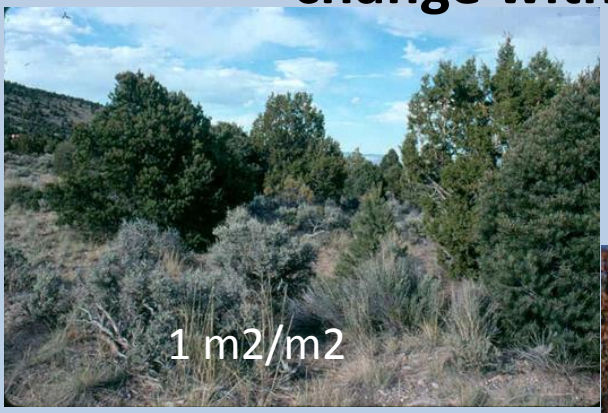
boreal conifers

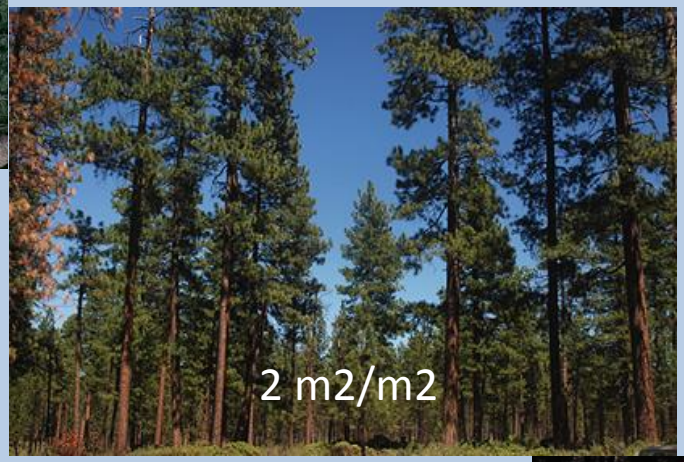
temperate rainforest

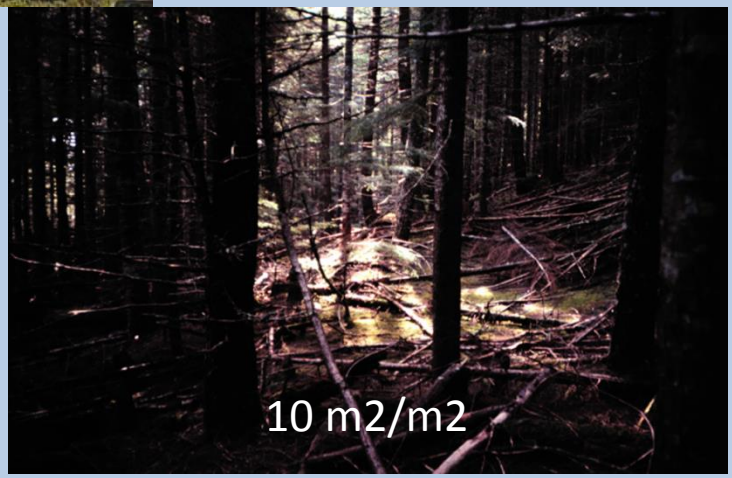
subtropical schlerophyll

high-yield plantations

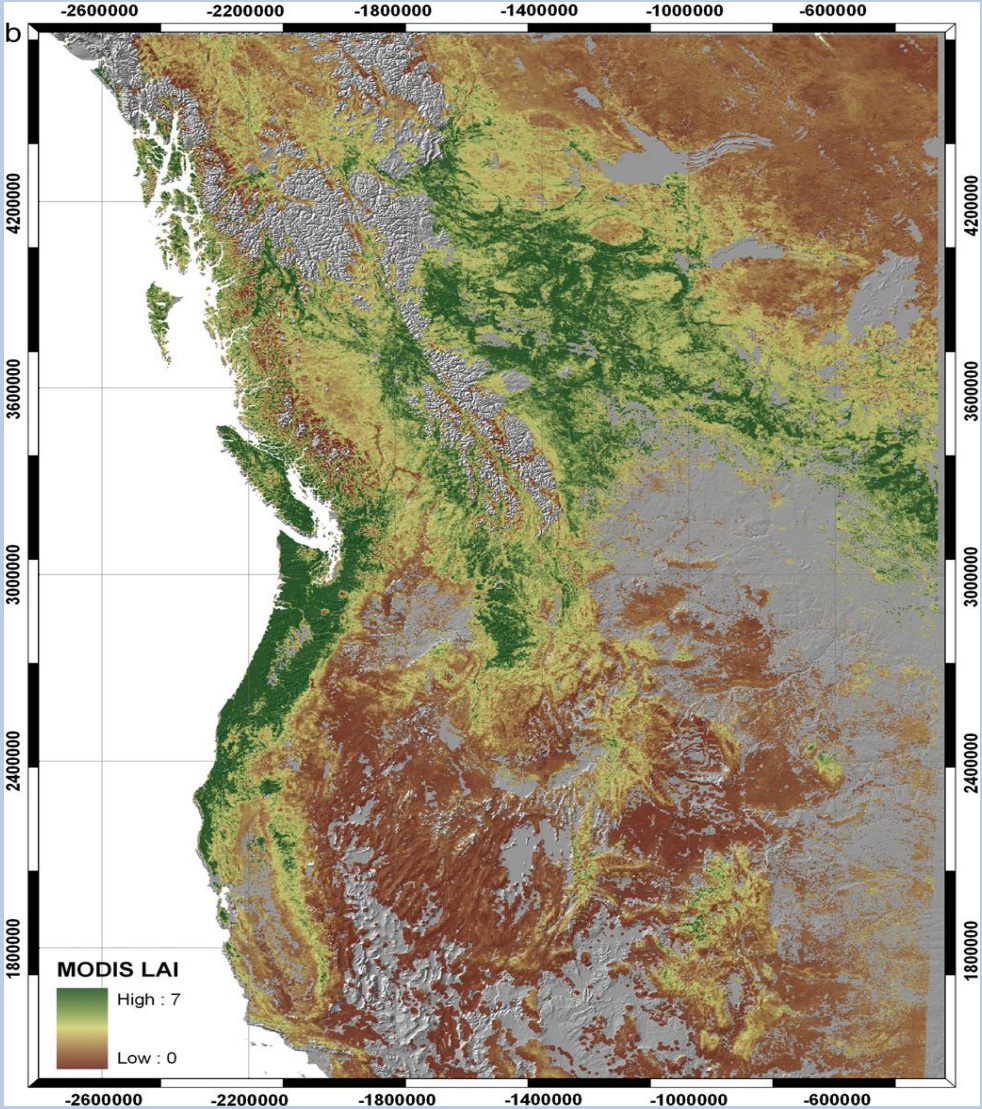
Chose leaf area index (layers of leaves) because this feature will change with climatic conditions and disturbance





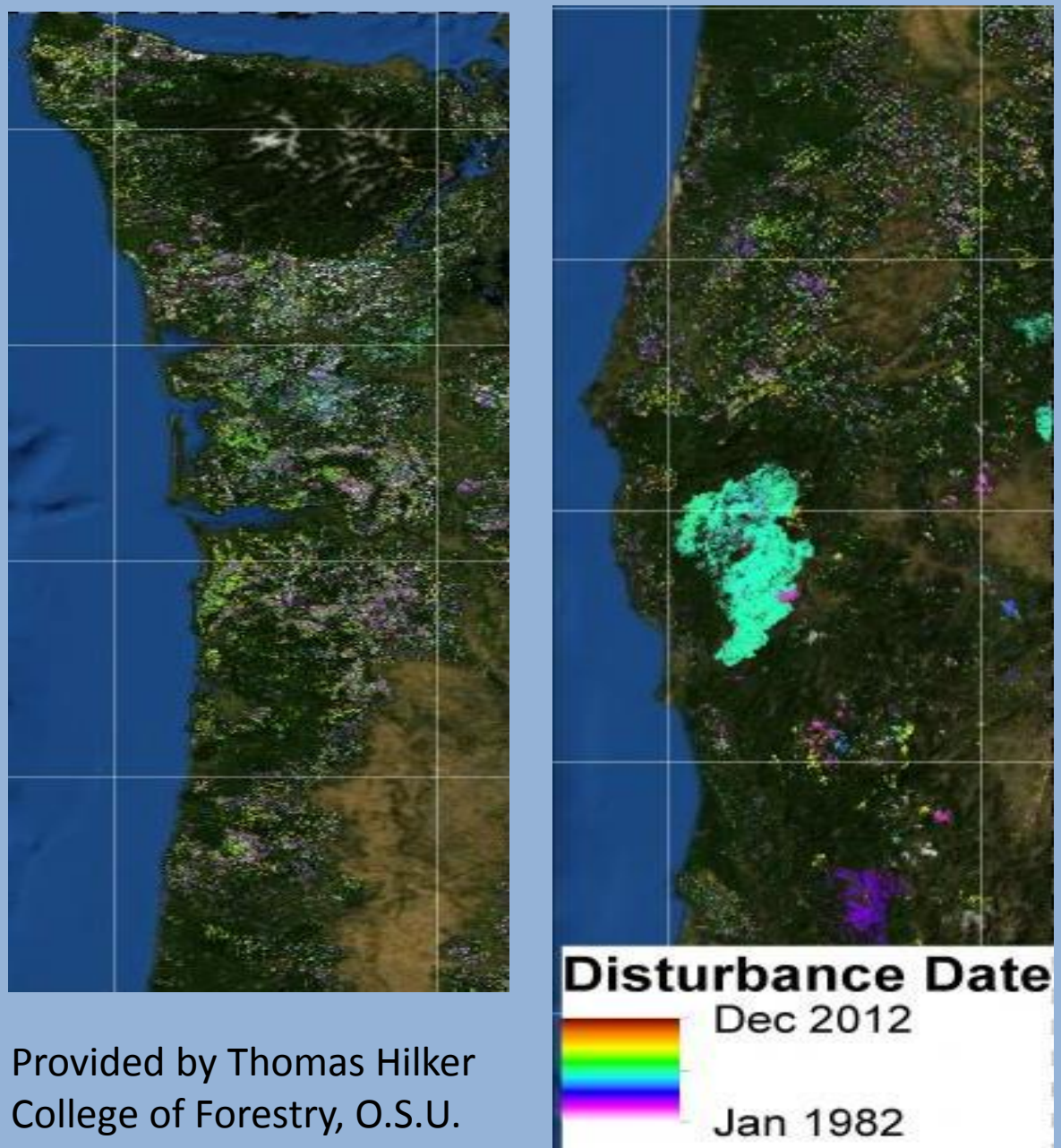


Max LAI is a surrogate for potential growth (r^2 = 0.98)



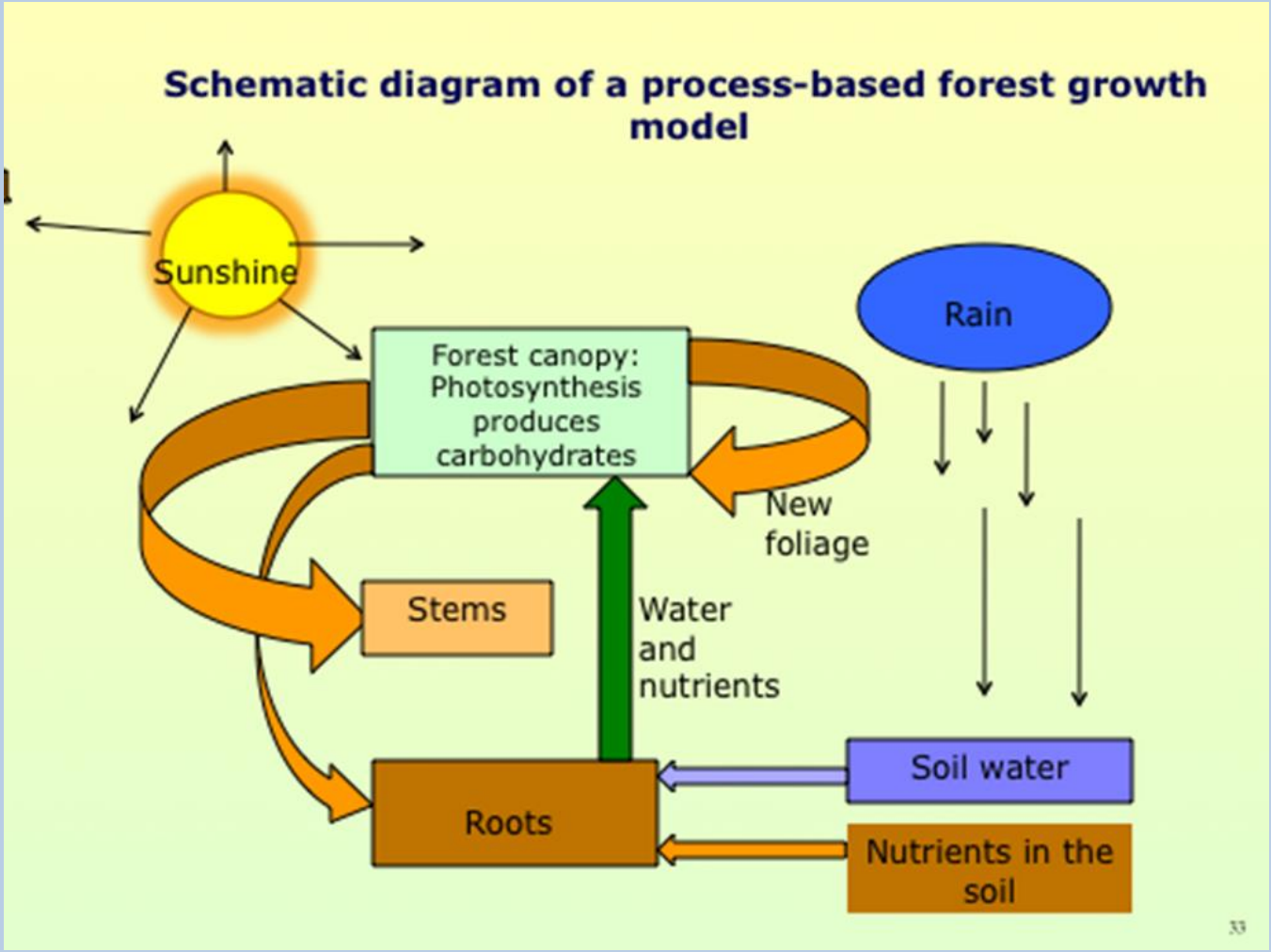
Waring et al. 2014. *Forests* 5:518-534

Twenty years of change from maximum LAI reconstructed from Landsat imagery

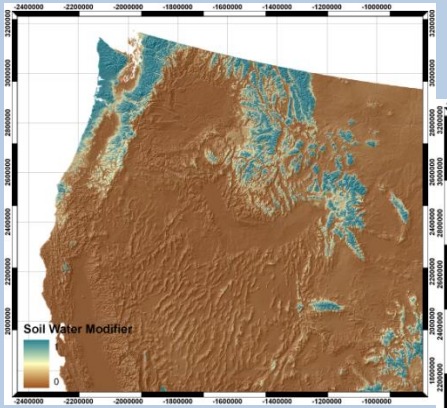


Provided by Thomas Hilker
College of Forestry, O.S.U.

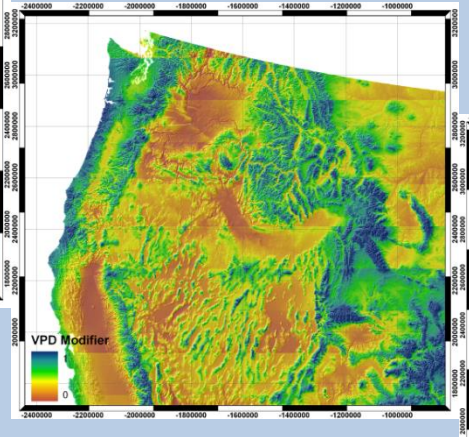
Process-based models can take into account variation in climate, soils, & disturbances



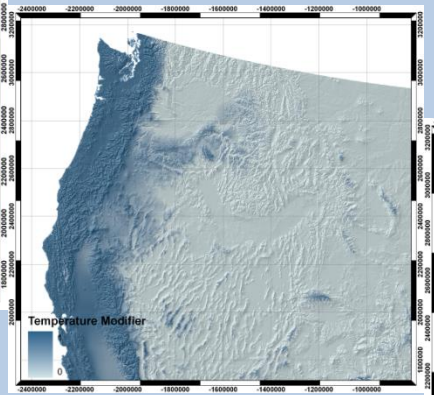
What controls photosynthesis controls productivity. These controlling variables change seasonally in their importance across the Pacific NW, U.S.A.



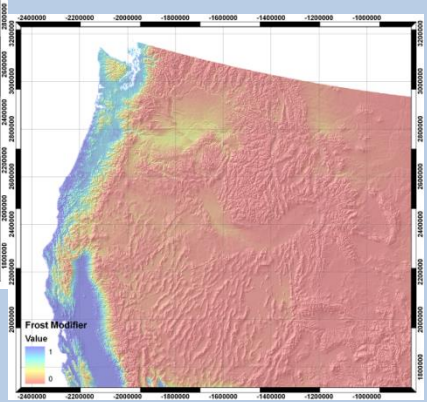
soil water



evaporative demand



suboptimal temperature



Frost limitations

Autumn

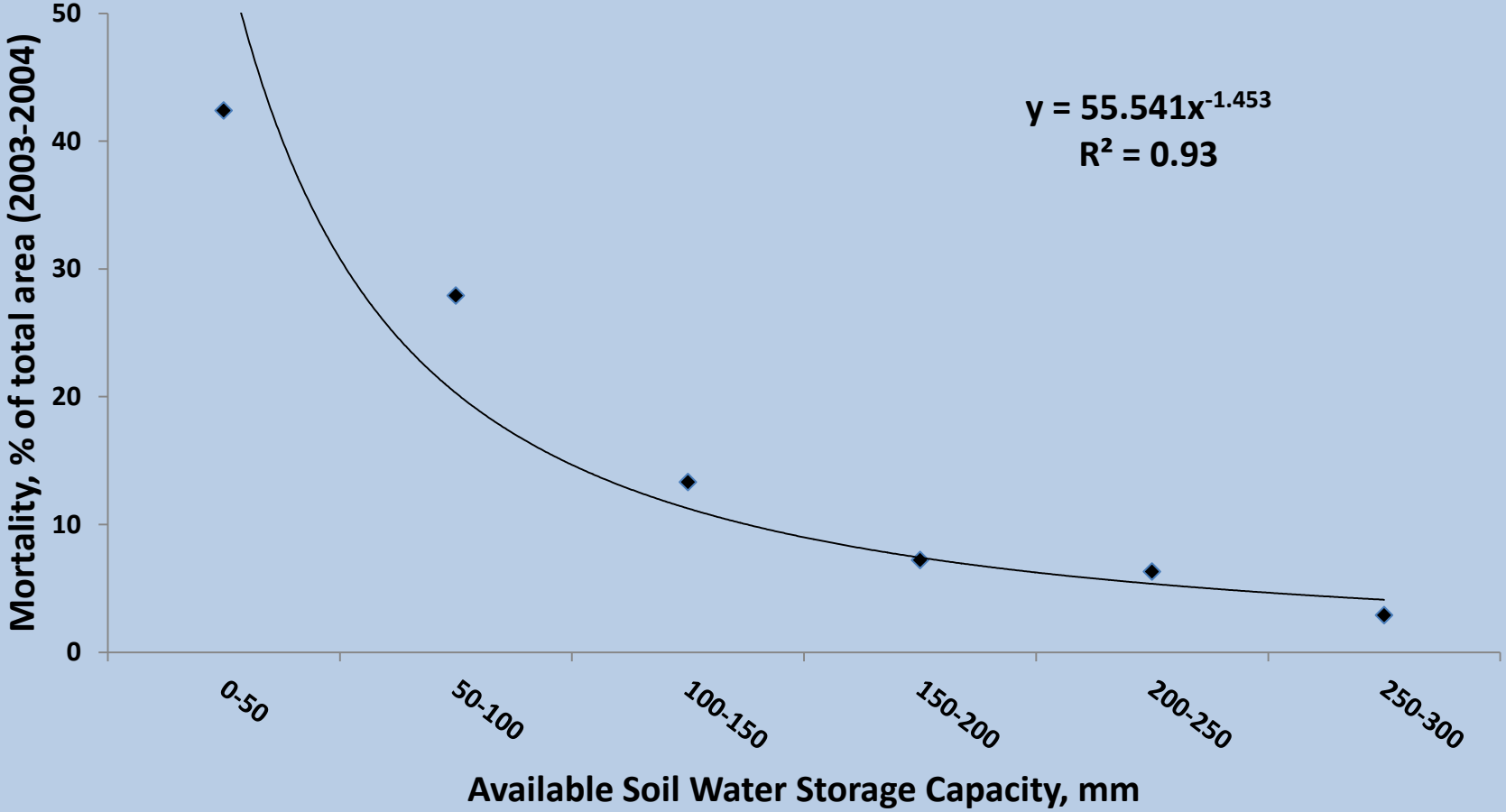
Summer

Winter

Spring

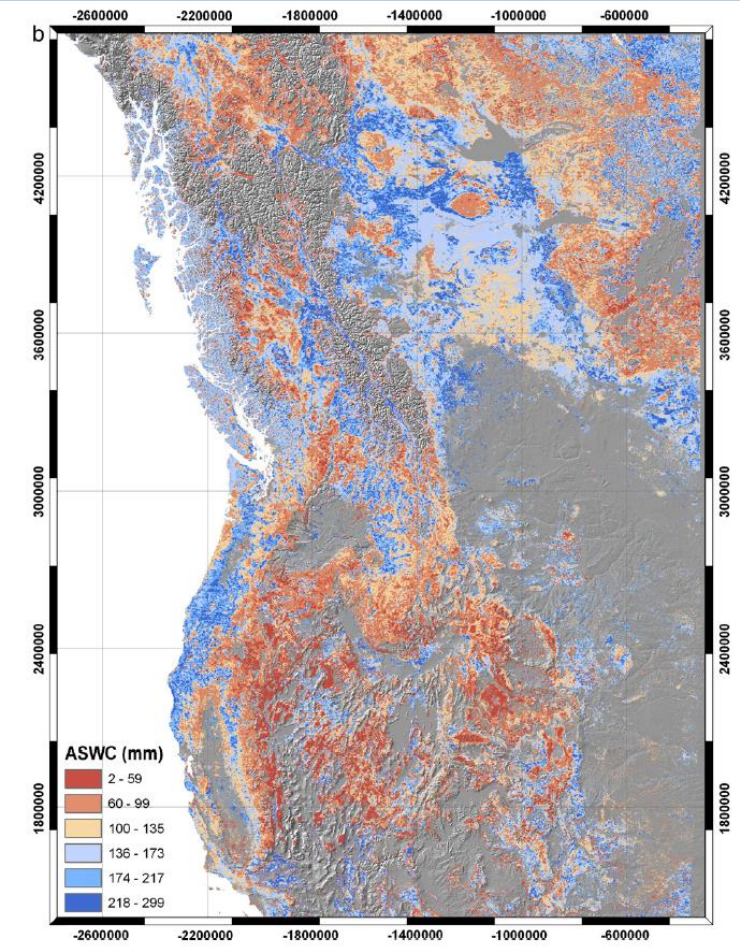
Can we predict when and where drought will lead to fires & bark beetle outbreaks?

Yes, but pinyon pine mortality can be predicted **only** if good estimates of soil water holding capacity are mapped along with LAI so that transpiration and soil water deficits can be calculated for consecutive growing seasons

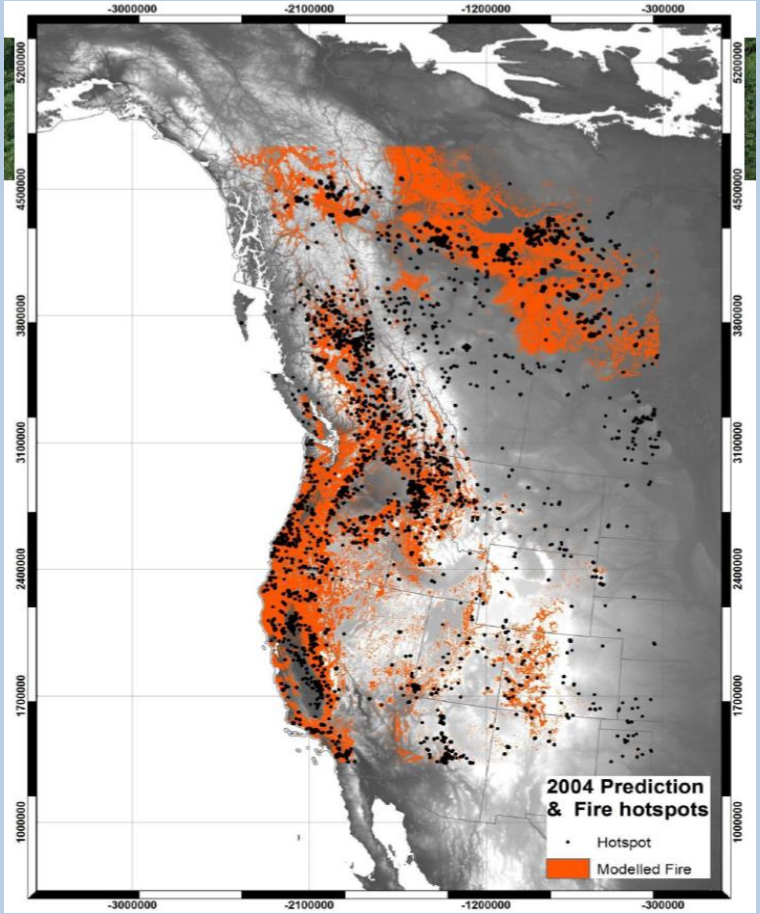


Peterman et al. 2013. *Ecohydrology* 6: 455-463.

If we can predict soil water availability, we can also predict where large fires are likely to occur (r^2 =0.70)



Predicted Soil Water Storage

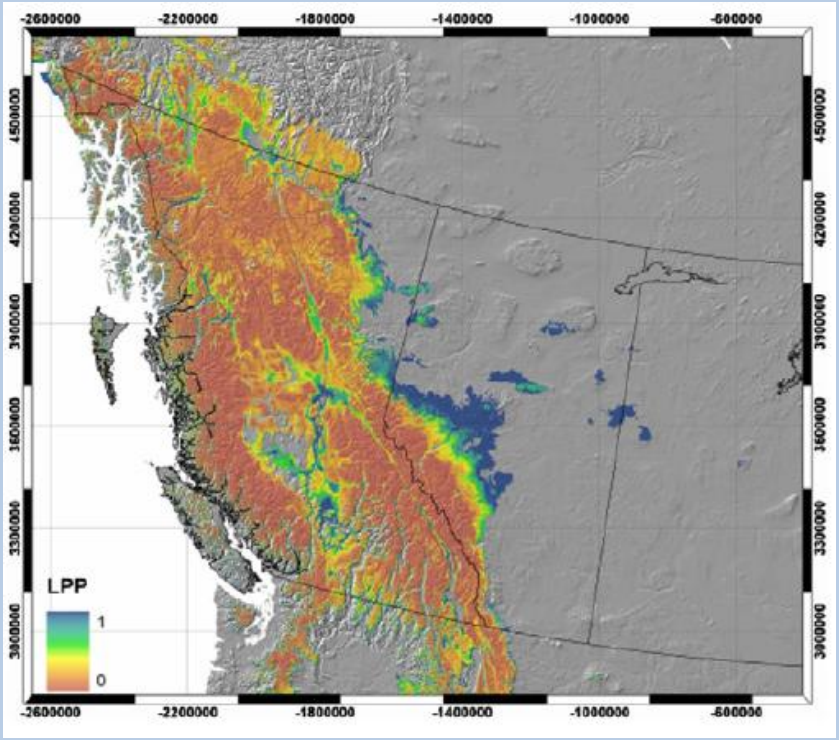


Predicted large fires (2004)

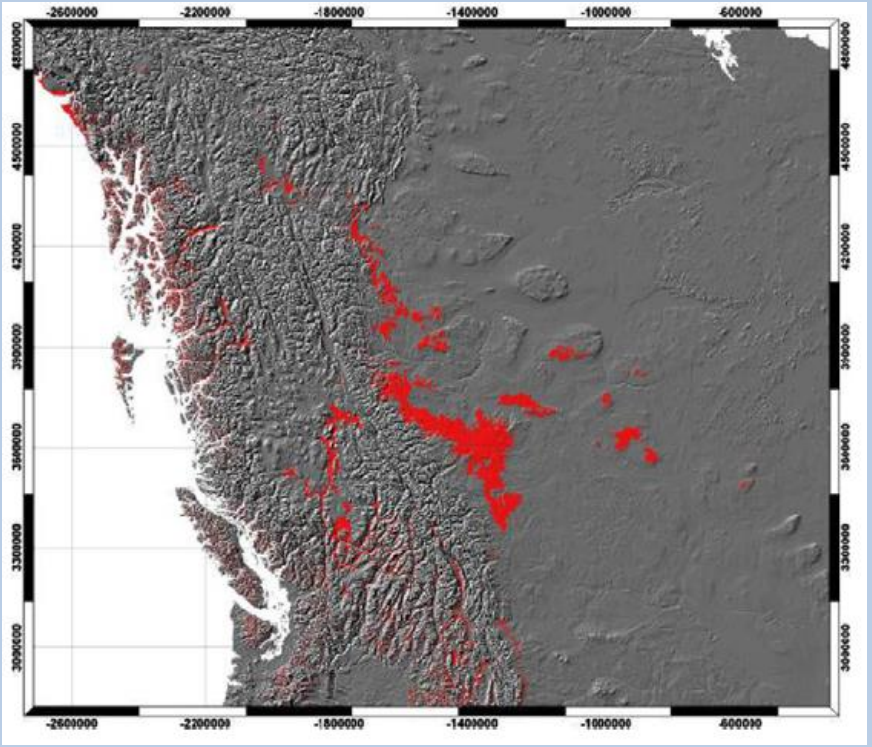
Coops et al. 2012 *Remote Sens.of Environ.*126:160-173. Waring &. Coops. 2016. *Climatic Change*135:325–339.

Process-based decision-tree models predict beetle outbreaks where less frost, not drought, is the cause

Lodgepole pine: probability of stress



Probability of bark beetle attack



Coops, Wulder,Waring. 2012. *For. Ecol. & Management* 274:161-171.

Climate change may result in selectively killing dominant trees with fragile plumbing or weak immune systems

Photo by Steve Wondzell
Research Scientist, USFS
Corvallis, OR

Photo by Burke Greer
Ph.D. candidate, Oreg. State Univ

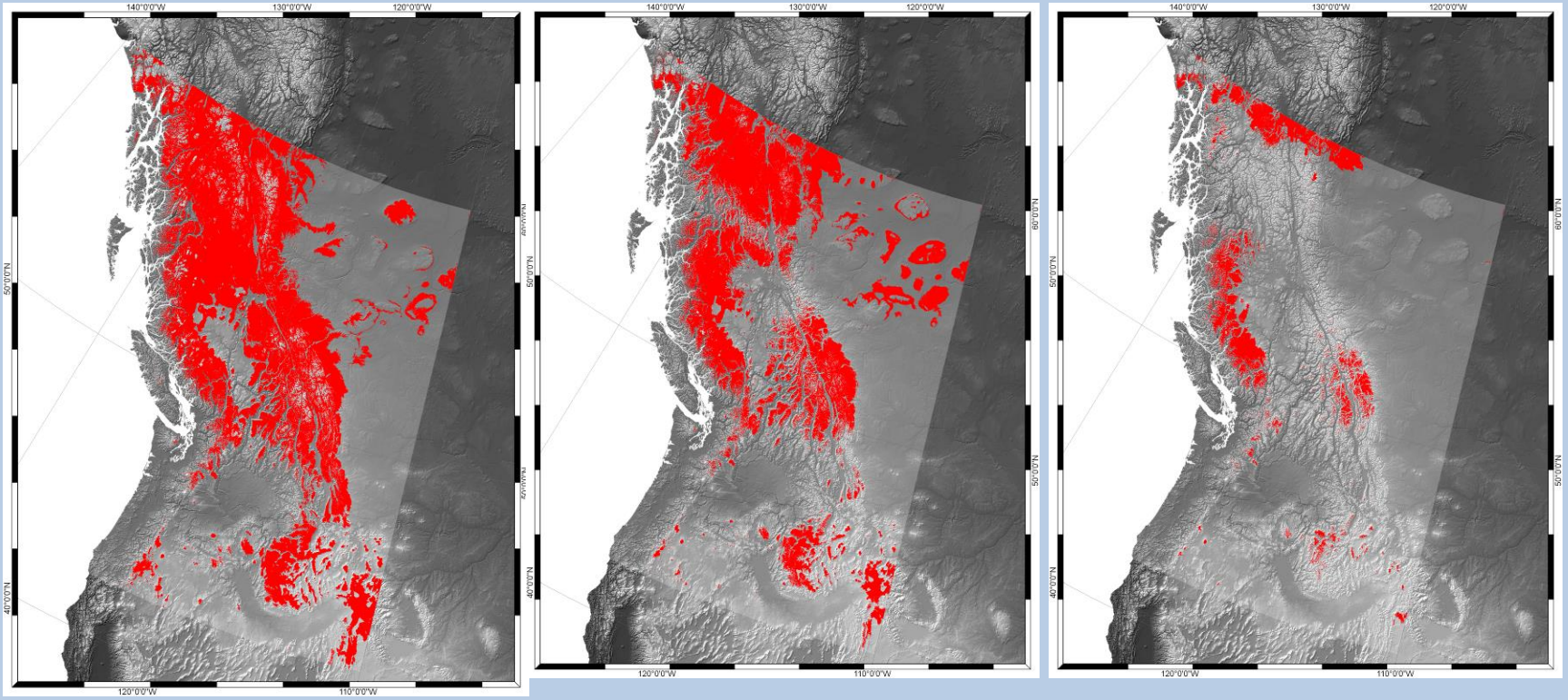
Model accuracy depends on management decisions to thin and stand age as well as climate change

Heavily thinned 120-year old lodgepole stand: immune to bark beetles if no drought

Dense young stand of lodgepole: immune to bark beetle attack

Coops et al. 2009. *Remote Sens. Environ.* 12:1058-1066.

Future : our models predict progressive reduction in the current distribution of lodgepole pine with climate change favoring replacement by other species

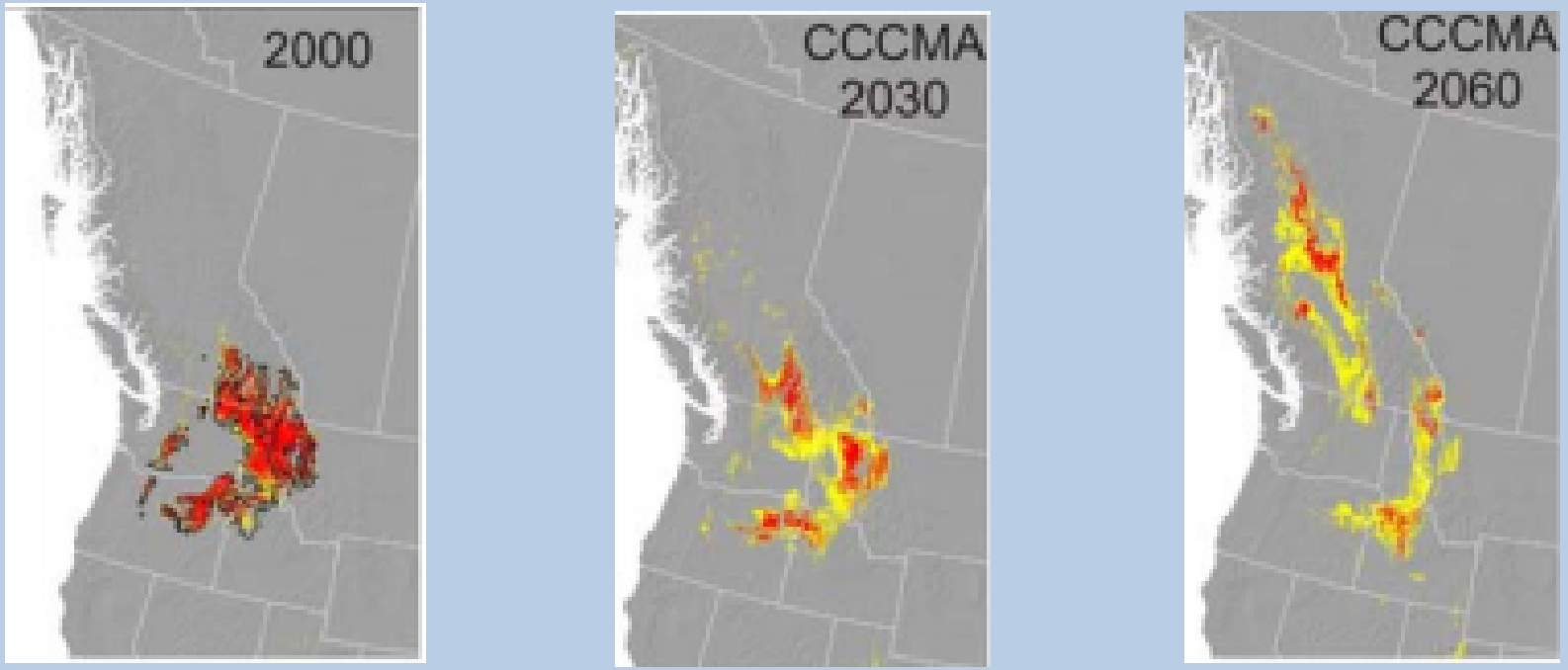


2020 **2050** **2080**

Coops & Waring. 2011. *Climatic Change* 105:313-328.

"Tree species with their northern range limit in British Columbia gain potential habitat at a pace of at least 100 km per decade."

Hamann & Wang (2006) Ecology 87: 2773-2786



Ponderosa pine

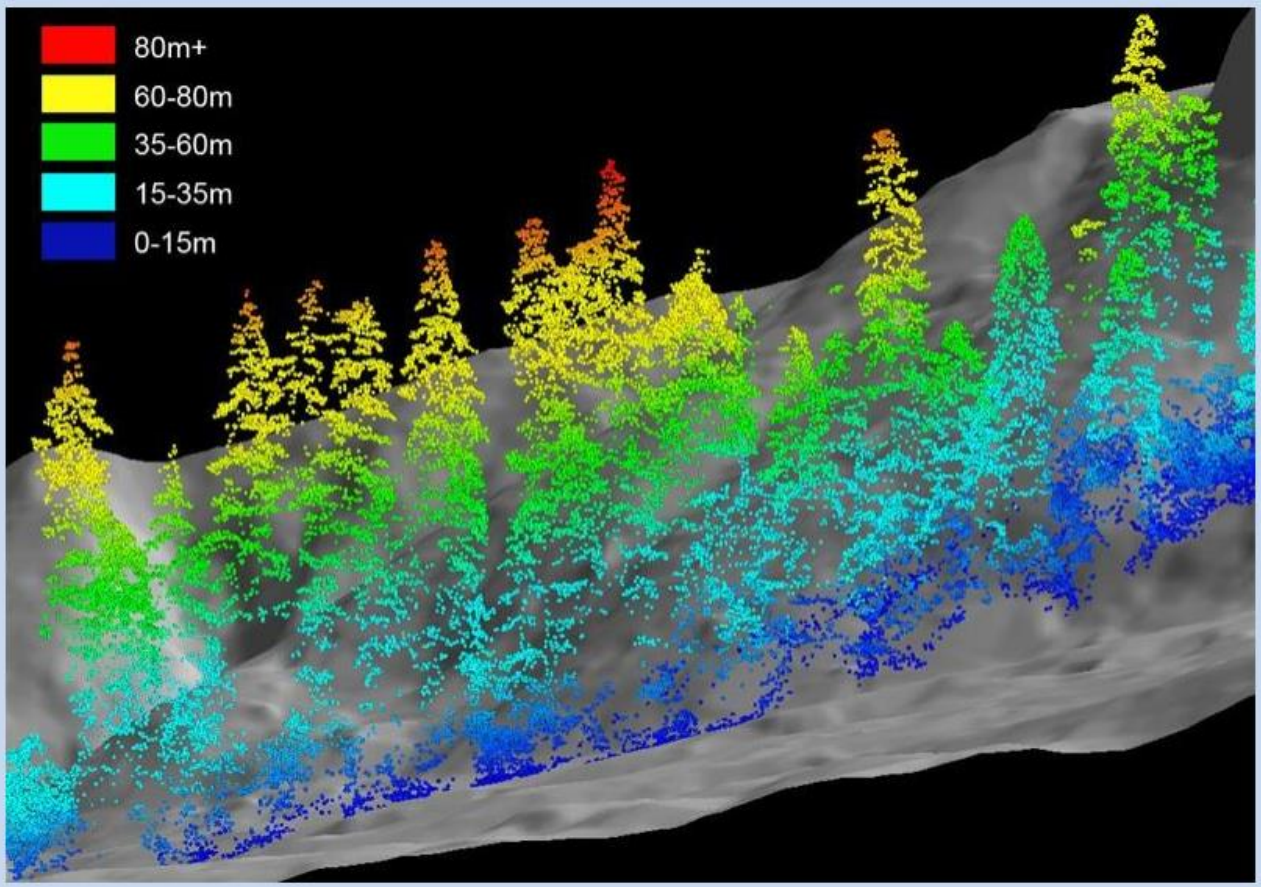
Rehfeldt and Jaquish. 2010. Mitig. Adapt Strategy. Global Change 15: 283-306

Major lessons learned

- Advantages of selecting common properties of vegetation to model with established causal links to growth & survival
- Quality of data affects model accuracy
- Make scale of predictions compatible with measurements
- Easier to model changes in ecosystem properties than the fate of individual tree species
- Recognize need for accurate estimates of stand age, current distributions of species, and knowledge of management practices to predict future growth and survival, as well as routes of migration

Advances in remote sensing

.idar analysis of multi-layered old-growth Douglas-fir/hemlock on the H.J. Andrews Expt. Fores



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