Use of the ZELIG Forest Simulation Model in the Coastal Landscape Analysis and Modeling Study (CLAMS)

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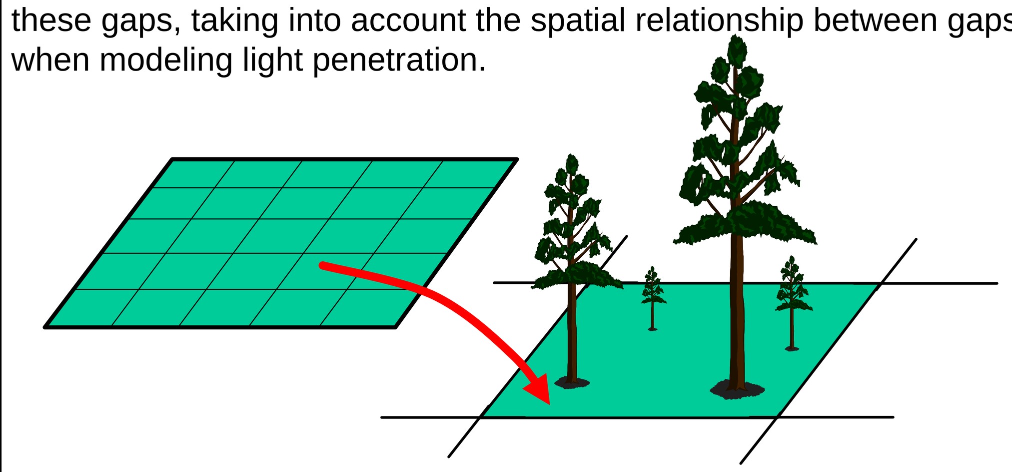
Introduction

Background

Simulating the development and distribution of forest types across the landscape is a key component of CLAMS, requiring robust models of stand-level dynamics. Two forest growth models are being used in CLAMS. ORGANON v.6.0 (Hann et al. 1997), an empirical growth and yield model, is used to simulate stands under private and tribal land ownerships. Stands on federal and state lands are modeled with ZELIG.PNW v.2.0 (Urban et al. 1993, Garman et al., in press). ZELIG is a gap model that can simulate a wide range of stand conditions and processes, thus it should be better suited than ORGANON to modeling forests on public lands where, in comparison to private lands, forest structure may be more complex, forest reserves exist, and alternative silviculture systems are often used. In this poster we present how we modified ZELIG for the Coast Range, how it performed with independent data sets, and its uses in CLAMS.

Model structure of ZELIG

ZELIG models the forest as a collection of gaps, with each gap representing the area potentially occupied by a canopy dominant tree (Urban and Shugart 1992). The model simulates each gap as it progresses through different phases of development, tracking all of the individual trees within it. ZELIG simulates a stand as a grid of these gaps, taking into account the spatial relationship between gaps when modeling light penetration.

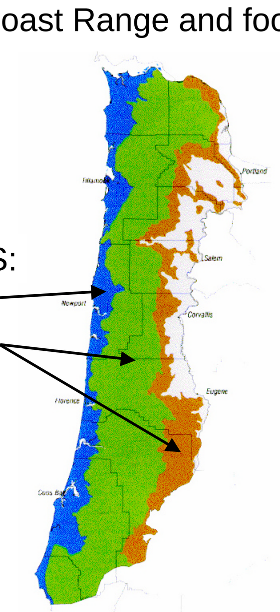


Three fundamental processes are simulated in ZELIG: tree growth, mortality, and regeneration. Each process is modeled by estimating maximum potential behavior and then constraining this potential by limiting resources such as light, soil moisture, soil fertility, and ambient temperature. Tree growth is a function of a tree's leaf area. Mortality includes both density-dependent mortality and density-independent mortality, the latter to account for other causes of mortality such as disease, insects, or windthrow. Regeneration is determined by a species' regeneration rank relative to other species.

Modifying ZELIG Parameters

ZELIG.PNW v 2.0 has been parameterized and used primarily for the western hemlock zone using data from the Oregon Cascades (Urban et al. 1993, Hansen et al. 1995). For CLAMS, we modified ZELIG to better simulate forest development in the Coast Range. In addition, we developed two variants of ZELIG, one for the "fog zone" along the coast, and another for the interior Coast Range and foothills.

ZELIG variants for CLAMS:
- Fog zone
- Interior and foothills



Modifying species-specific parameters involved a three-pronged, iterative process in which ZELIG simulations were calibrated with:

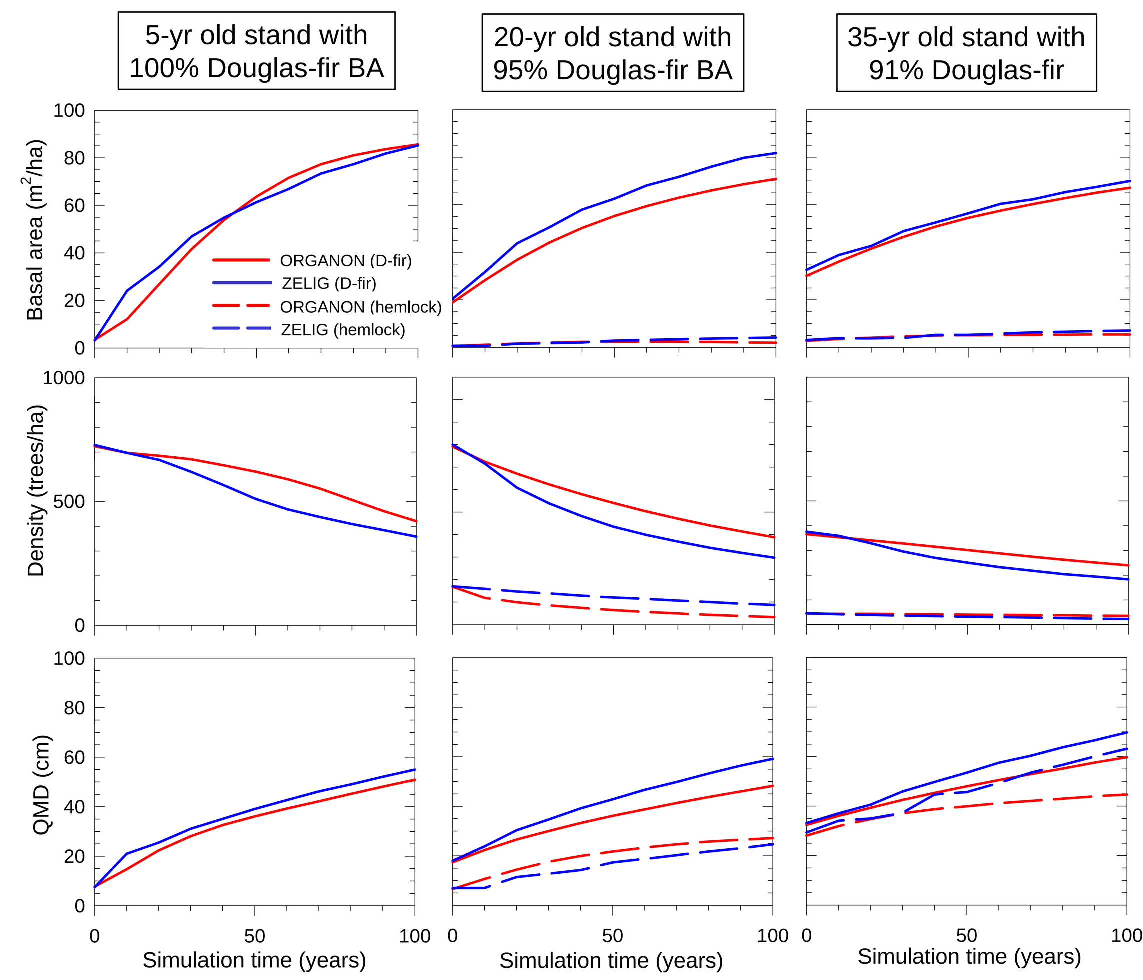
1) ORGANON simulations, for examining how ZELIG modeled even-aged stands (n=9) of Douglas-fir.
2) Long-term data sets (n=9) from Cascade Head, for evaluating ZELIG's simulation of red alder stands or mixed-species stands such as hemlock/spruce, D-fir/hemlock, and red alder/conifers.
3) Chronosequences constructed from more than 700 stand surveys in the Coast Range, to determine if ZELIG simulations were consistent across a wide range of stand ages and conditions.

Calibration of ZELIG (*see next panel*) was based on numerous stand attributes, including basal area, tree density, quadratic mean diameter (qmd), diameter distributions, and tree mortality.

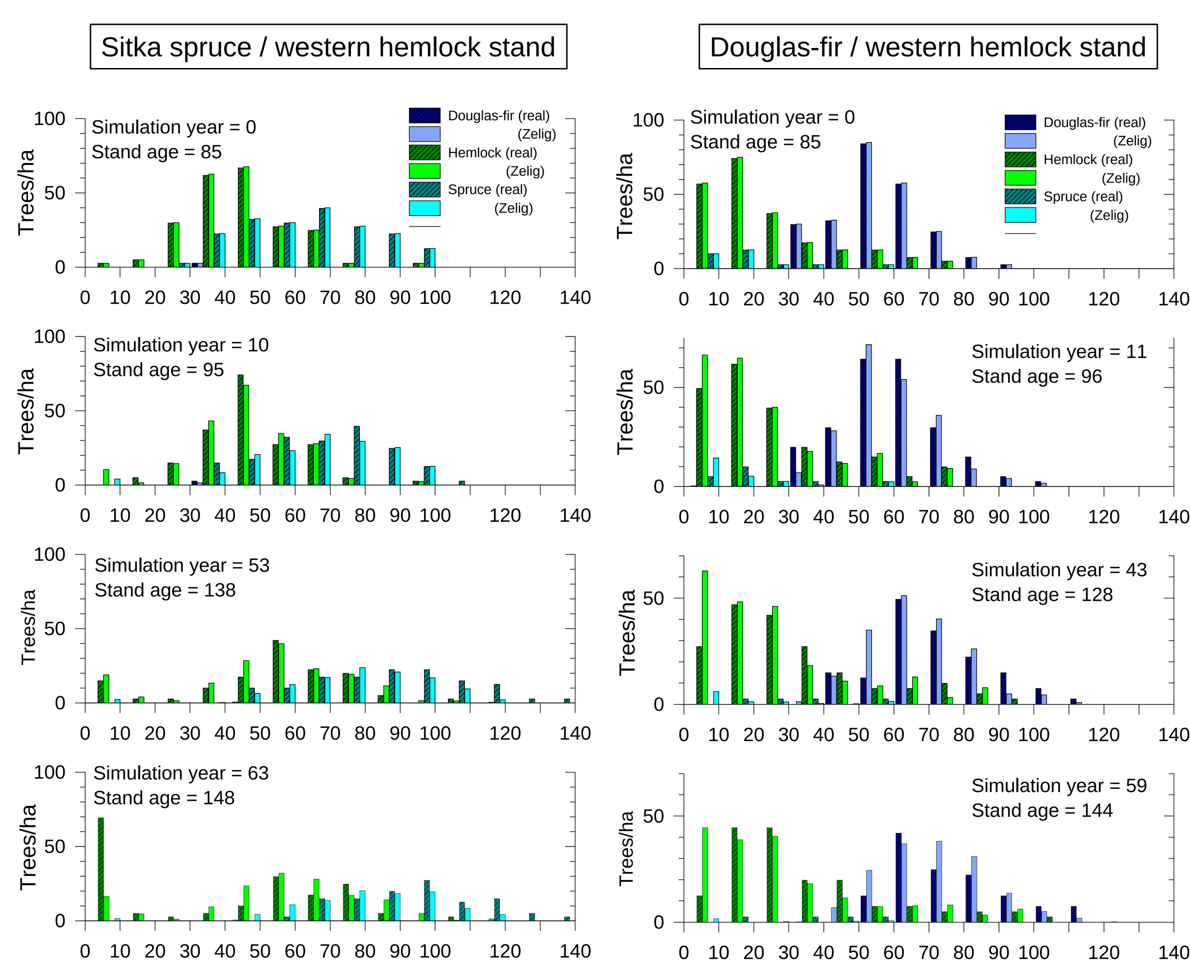
Calibrating ZELIG

(Examples of model performance with calibration data sets)

1) ZELIG vs. ORGANON

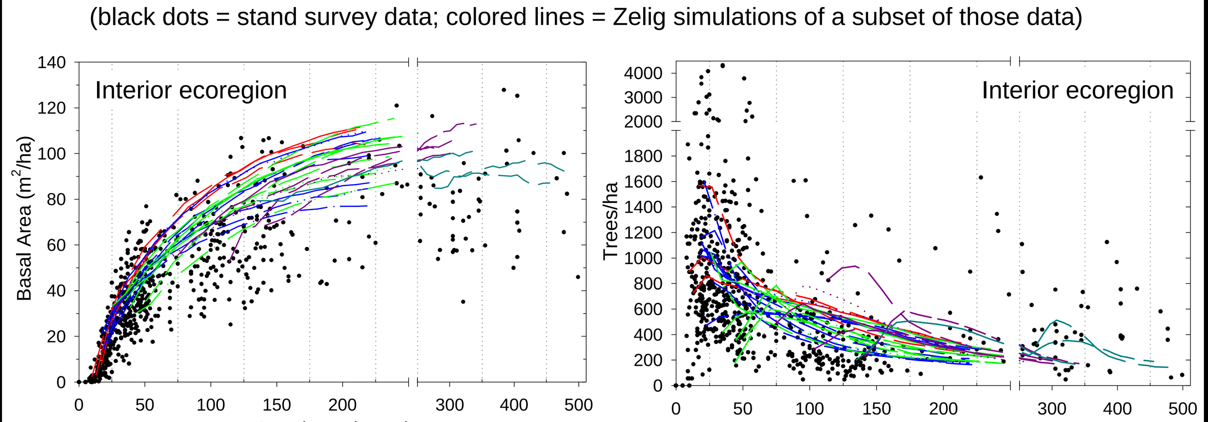


2) ZELIG vs. long-term data from Cascade Head Exp. For.



3) ZELIG vs. Coast Range chronosequences

(black dots = stand survey data; colored lines = Zelig simulations of a subset of those data)

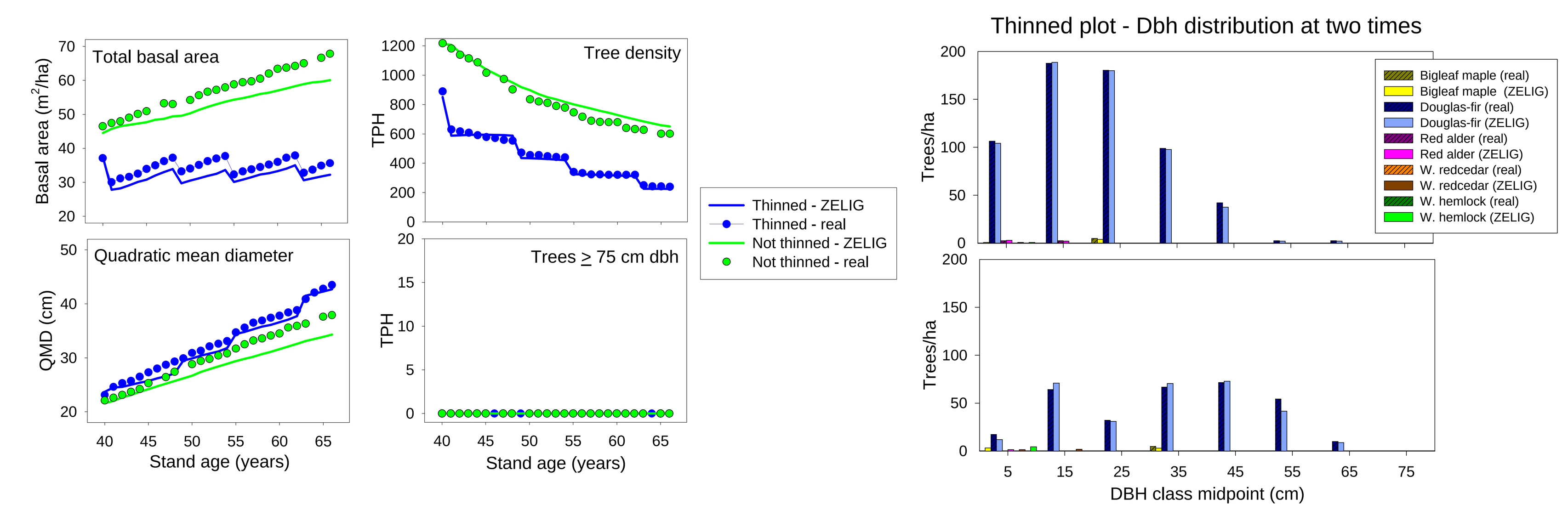


Testing ZELIG

(Examples of model performance with independent data sets)

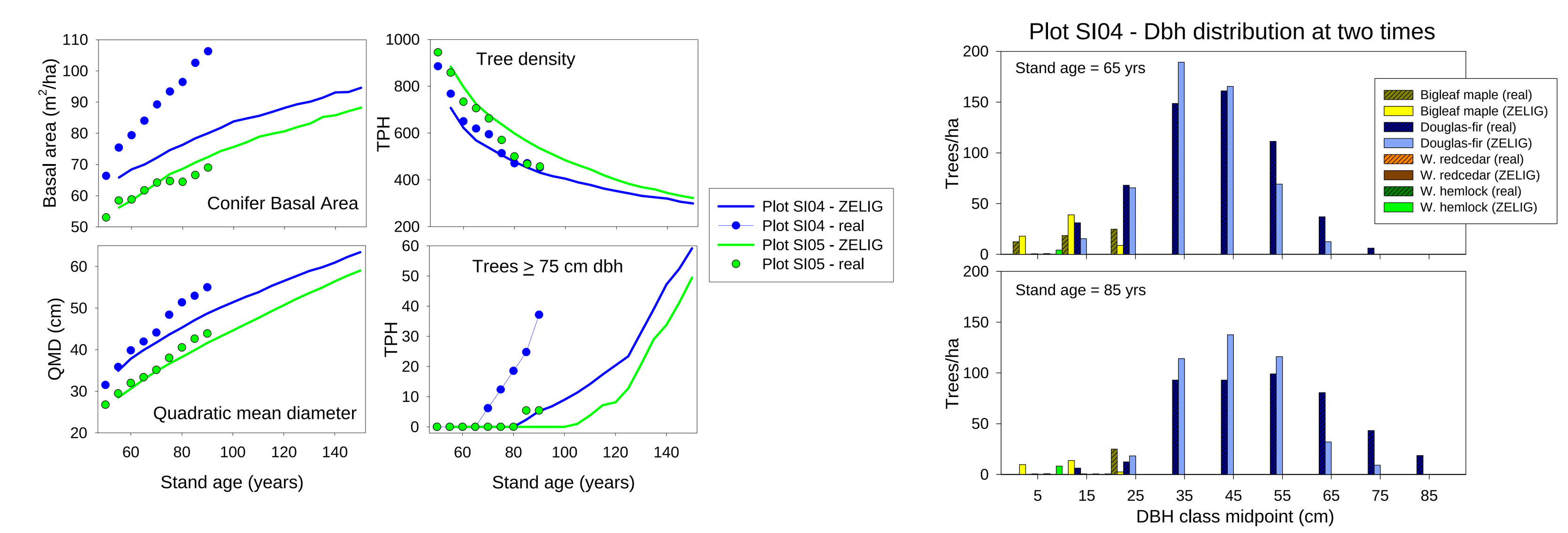
Black Rock Forest (State of Oregon)

Thinned and unthinned plots --- 39 years old at simulation time 0



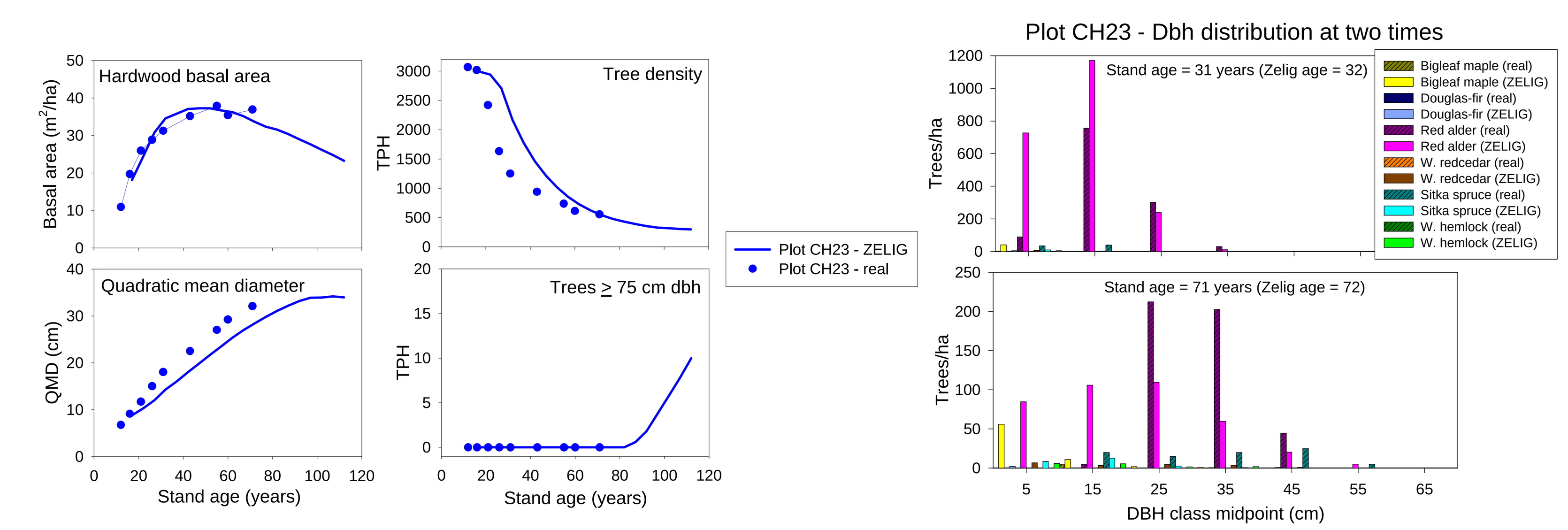
Siuslaw National Forest

Unthinned Douglas-fir growth and yield plots --- 50 years old at time 0



Cascade Head Experimental Forest

Unthinned alder/conifer plot --- 12 years old at simulation time 0



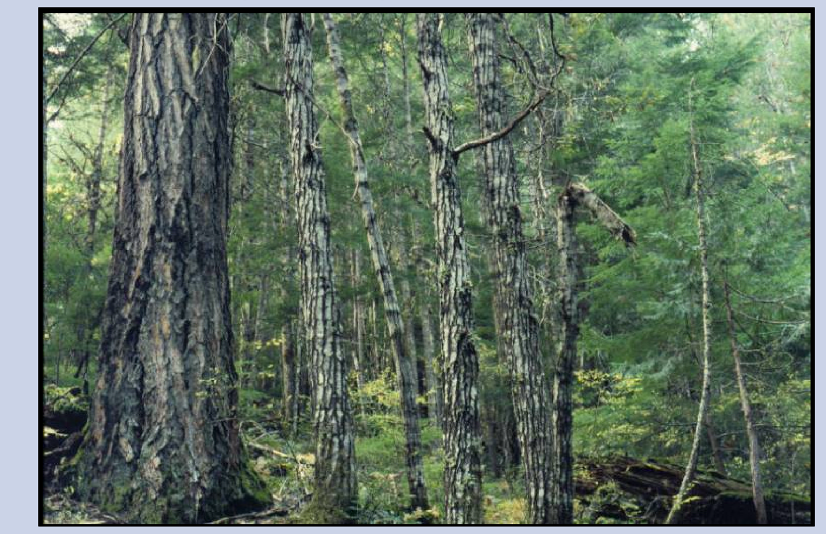
Summary of model calibration and testing

- Three data sets representing a diversity of stand ages, species compositions, stand histories, and regional climatic patterns were used to calibrate ZELIG parameters.
- ZELIG simulations closely matched ORGANON's in basal area of Douglas-fir stands. Qmd's in ZELIG were usually higher and tree densities lower than in ORGANON, possibly because of differences in the way mortality is simulated in the two models. Tree mortality in ZELIG arises from both density-dependent and density-independent functions, resulting in higher mortality (and commensurate volumes of dead wood) than in ORGANON (data not shown).
- Overall, simulations of independent data sets show that ZELIG does a good job tracking stand attributes, although discrepancies are evident in some individual stands. ZELIG tended to underestimate the rate of development of large Sitka spruce and Douglas-fir. Further adjustment of species growth parameters or temperature response functions in the model may be necessary.

Uses of ZELIG in CLAMS

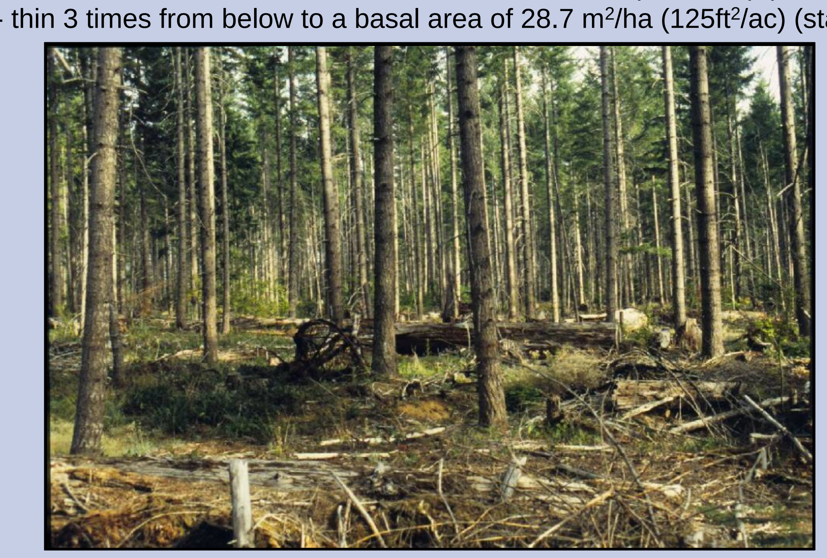
ZELIG is used to simulate a variety of management practices and natural forest processes, primarily on federal and state lands.

- Unmanaged ("let it grow"): forest development in reserves, wilderness areas, and in managed stands prior to thinning.

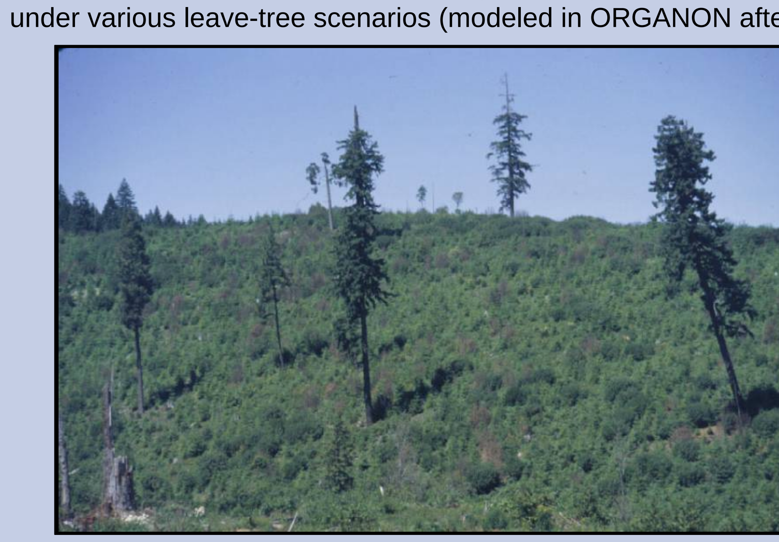


- Response to gap formation: forest development within canopy gaps of varying sizes (0.04 ha, 0.24 ha, and 1.0 ha).

- Thinning strategies in young to mature stands:
  - single- or multi-entry heavy thinning in 20-60 year-old plantations (target densities range from 74-247 trees/ha (30-100 trees/ac))
  - thin once from below to a basal area of 18.4 m^2/ha (80 ft^2/ac) (federal)
  - thin once from below to a basal area of 34.4 m^2/ha (150ft^2/ac) (state)
  - thin 3 times from below to a basal area of 28.7 m^2/ha (125ft^2/ac) (state)



- Green-tree retention: simulate 15 years of growth in new plantations under various leave-tree scenarios (modeled in ORGANON after that)



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