2016

Climate and Bark Beetle Effects on Forest Productivity — Linking Dendroecology with Forest Landscape Modeling

Alec M. Kretchun
Portland State University

E. Louise Loudermilk
United States Forest Service

Robert M. Scheller
Portland State University, rmschell@pdx.edu

Matthew Hurteau
University of New Mexico

Soumaya Belmecher
University of Arizona

Citation Details

Kretchun, A. M., Loudermilk, E. L., Scheller, R. M., Hurteau, M. D., & Belmecheri, S. (2016). Climate and bark beetle effects on forest productivity—linking dendroecology with forest landscape modeling. Canadian Journal of Forest Research, 46(8), 1026-1034.

Canadian Journal of Forest Research
Revue canadienne de recherche forestière

Climate and bark beetle effects on forest productivity: linking dendroecology with forest landscape modeling

Journal:	*Canadian Journal of Forest Research*
Manuscript ID	cjfr-2016-0103.R1
Manuscript Type:	Article
Date Submitted by the Author:	25-May-2016
Complete List of Authors:	Kretchun, Alec; Portland State University, Loudermilk, E. Louise; USDA Forest Service, Center for Forest Disturbance Science Scheller, Robert; Portland State University Hurteau, Matthew; University of New Mexico, Biology Belmecheri, Soumaya; The Pennsylvania State University, Meteorology
Keyword:	ANPP, net ecosystem production, increment cores, LANDIS-II, forest simulation model

Climate and bark beetle effects on forest productivity: linking dendroecology with forest landscape modeling

Alec M Kretchun[1], E. Louise Loudermilk[2], Robert M Scheller[1], Matthew D Hurteau[3], Soumaya Belmecheri[4]

[1] Portland State University, Dept of Environmental Science and Management, PO Box 751, Portland, OR

[2]USDA Forest Service, Center for Forest Disturbance Science, Southern Research Station, 320 Green St., Athens, GA

[3]University of New Mexico, Dept of Biology, Albuquerque, NM

[4]University of Arizona, Tucson, AZ

Running head: Stand to landscape level ANPP

Corresponding Author: Alec M. Kretchun

AlecKretchun@Gmail.com, Phone: +1 214-289-5763

Keywords: ANPP; net ecosystem production; increment cores; forest simulation model; LANDIS-II;

AMK performed simulations and primary analysis; SB performed data analysis; RMS, ELL, and MDH conceived of and designed the study and interpreted data. AMK, ELL, RMS, and MDH wrote the paper

Abstract

In forested systems throughout the world, climate influences tree growth and aboveground net primary productivity (ANPP). The effects of extreme climate events (i.e. drought) on ANPP can be compounded by biotic factors (e.g. insect outbreaks). Understanding the contribution of each of these influences on growth requires information at multiple spatial scales and is essential for understanding regional forest response to changing climate. The mixed conifer forests of the Lake Tahoe Basin, California and Nevada, provide an opportunity to analyze biotic and abiotic influences on ANPP. Our objective was to evaluate the influence of moisture stress (climatic water deficit, CWD) and bark beetles on basin-wide ANPP from 1987-2006, estimated through tree core increments and a landscape simulation model (LANDIS-II). Tree ring data revealed that ANPP increased throughout this period and had a nonlinear relationship to water demand. Simulation model results showed that despite increased complexity, simulations that include moderate moisture sensitivity and bark beetle outbreaks most closely approximated the field-derived ANPP ~ CWD relationship. Although bark beetle outbreaks and episodic drought-induced mortality events are often correlated, decoupling them within a simulation model offers insight into assessing model performance as well as examining how each contributes to total declines in productivity.

Introduction

Forests are an integral component of the global carbon (C) cycle, sequestering approximately 30% of annual anthropogenic C emissions (Pan et al. 2011 a). Estimates of forest C dynamics are dependent on reliable forest growth and productivity patterns as influenced by climate and disturbances. Forecasts of forest response to changing future climatic conditions require quantification of the relative importance of key influences on tree growth, mortality, and regeneration, which can vary regionally (Chen et al. 2010; Laura Suarez and Kitzberger 2010; Fisichelli et al. 2012). Regional and local disturbances such as wildfire, drought, or insect outbreaks, which are all influenced by climate variability, will interact to affect future forest dynamics in novel ways. Simulating these interactions is critical for understanding future forest trajectories (Kurz et al. 2008; Adams et al. 2009; Bentz et al. 2010).

Quantifying the response of forest productivity to climate variability and disturbances requires information at multiple scales. Individual tree growth is determined by inter- and intra-annual climate patterns, topographical and edaphic factors, age-related growth patterns, biotic interactions, and disturbances (Fritts and Swetnam 1989). Measures of annual growth increment at the individual tree scale are useful for determining site-specific factors affecting growth. While abiotic (climatic and edaphic) factors and endogenous biotic factors (e.g. ungulate browse) may be the primary determinants of growth during early succession (before canopy closure), in more closed canopy conditions, density-related competition may supersede abiotic influences on growth (Hurteau et al. 2007, Kuijper et al. 2010). At the landscape-wide scale, measures of growth help reveal the influence of regional climate patterns such as the Pacific North American pattern, rather than finer scale biotic determinants of productivity such as individual tree competition (Trouet and Taylor 2009).

Individual tree growth is also affected by disturbances in non-uniform ways as a result of physiological responses to stress, damage, or altered stand characteristics. Insects, such as bark beetles, alter tree growth patterns through increased mortality of older, larger trees, creating canopy gaps and releasing younger cohorts and understory vegetation (Klutsch et al. 2009). Species-specific differences in response to moisture stress can also result in substantial variability in forest growth and carbon (Earles et al. 2014; Hurteau et al. 2007). Moisture stress and bark beetles have also been shown to interact in nonlinear patterns, capable of enhancing or detracting from the effects of the other depending on forest condition and topographic setting (Temperli et al 2013). The combination of disturbance effects and individual tree species physiological response to changes in climate, particularly severe drought, creates complex overall forest growth patterns.

While empirically-derived relationships (e.g. site index curves) have been used for decades to predict tree growth, modeling forest productivity in a future climate requires capturing the underlying processes that govern regeneration, growth, and mortality (Bontemps and Bouriaud 2013; Gustafson 2013). Models of forest growth must integrate the most influential factors at the scale appropriate for the questions being asked. For instance, site productivity models of even-aged stands may need only basic soils and climate information to approximate observed patterns (Skovsgaard and Vanclay 2008). Ecosystem or landscape models rely on coarse-scale growth responses to temperature and precipitation fluctuations, as well as effects from disturbances (Law et al. 2004; Pan et al. 2011 b; Scheller et al. 2011; Loudermilk et al. 2013). Coupling fine-scale (individual tree) empirical estimates and landscape-scale model projections of productivity provides an opportunity to compare growth estimations across multiple scales.

The objective of this study was to quantify the influence of moisture availability, as measured by climatic water deficit (CWD), on forest productivity using tree core data and to compare those scaled *in situ* estimates of ANPP with outputs from a landscape simulation model (LANDIS-II) to evaluate two factors, moisture sensitivity and bark beetle outbreaks, that influence ANPP in the model. We examined the individual and additive effects from these two factors as simulated by our model and compared simulated ANPP to field-derived estimates of ANPP over a 20 year period. Additionally, we analyzed the merits of each ANPP estimation approach and discuss these in relation to the drivers of forest growth.

Materials and Methods

Study area

Our study area consisted of ~31,000 ha of low elevation forested land within the Lake Tahoe Basin (LTB), on the border of California and Nevada, USA (Figure 1). The climate is Mediterranean, with dry summers and precipitation, primarily winter snow, occurring mostly from October-May. Temperature and precipitation are largely controlled by the basin-like topography, which ranges in elevation from 1897 (lake level) to 3320 m; seasonal high and low temperatures decrease with increasing elevation. Soils are primarily of shallow granitic substrate with ancient volcanic bedrock lining the north shore (Rogers 1974). Primary tree species include Jeffrey pine (*Pinus jeffreyi*), sugar pine (*P. lambertiana*), white and red fir (*Abies concolor, A. magnifica*) and to a lesser extent incense-cedar (*Calocedrus decurrens*), whitebark pine (*P. albicaulis*), western white pine (*P. monticola*), and lodgepole pine (*P. contorta*) (Graf 1999). Within the basin there are several distinct forest types including mixed conifer-white fir stands (lake level to ~2100m elevation), Jeffrey pine dominated stands (lake level to ~2400m), mixed red fir-western white pine stands (~2100 to ~2600m), lodgepole pine-dominated stands (~2400+-3320 m) , and subalpine stands of whitebark pine or mountain hemlock (*Tsuga mertensiana*) (~2600-3320 m). Old-growth stands and stands dominated by sugar pine exist within the LTB, but are rare. Extensive logging during the 19th century, followed by aggressive fire suppression activities have shifted forest structure towards dense, young forests (<120 years old) (Beaty and Taylor 2008).

Tree ring estimates of ANPP

We used field data collected at two to four plots in each of 21 creek drainages (52 total plots) ranging from 1900-2200 m elevation during summer 2009 to develop our empirical ANPP estimate (Figure 1) $_{\text{Table S1}}$. Forest structural attributes were measured using a nested design in which all trees $\geq$80 cm diameter-at-breast height (DBH) were measured in a 1/5th ha plot, all trees $\geq$ 50 cm DBH were measured in a 1/10th ha subplot, and all trees $\geq$ 5 cm DBH were measured in a 1/50th ha subplot, all with the same plot center. Within each plot two to three individual live trees were selected for coring from the five smallest and five largest individuals (Hurteau et al. 2014). Visual cross-dating of tree cores was conducted using characteristic rings and checked with COFECHA (Stokes and Smiley 1968, Holmes 1983). Summary statistics were calculated using the dplR package in R and are presented in supplemental material $_{\text{Table S2}}$ (R Core Team 2015, Bunn et al. 2015). The cored tree sample size by species approximated the proportional contribution of each species to mean basal area after excluding cores that could not be cross-dated $_{\text{Table S3}}$.

Annual ring widths were measured to the nearest 0.001 mm using Windendro (Regent Instruments, Inc) and error prone cores were re-measured using a Unislide TA measuring system

(Velmex, Bloomfield, NY). A total of 275 cross-dated raw tree-ring widths were then used to calculate the radius of each tree to account for cores that missed pith. To estimate ANPP for each tree, the inferred radius from the annual increment was then used to estimate DBH for each tree at each annual increment. Annual DBH values were then used to estimate annual biomass production (kg ha^{-1} yr^{-1}) using allometric equations from Jenkins et al. (2004).

To scale tree-level estimates of annual biomass production to the plot level, we matched individuals for which only DBH had been measures with cored individuals of the same species and similar diameter from the nearest plot. Growth patterns for uncored trees were assumed to be similar to cored individuals; annual increment data used from nearby plots had Pearson's correlation coefficients ≥ 0.9 $_{\text{Table S4}}$. Annual growth measurements from the cored individuals and genus-specific allometric equations were then used to estimate annual biomass production for the trees that were not cored. Plot-level estimates of annual ANPP were then scaled to the hectare level using the appropriate scaling factor (e.g., a tree > 50 cm DBH represents 50 trees ha^{-1}) from the nested plot design. Empirical ANPP estimates excluded trees smaller than 5 cm DBH in 2009 and any dead trees sampled within the plots. Mean basal area by species by sampling area for both live and dead trees is presented in the supplemental material $_{\text{Tables S5 and S6}}$.

Climate variables

We selected the period from 1987-2006 because it had the highest number of available tree core samples and high resolution data of a large basin-wide bark beetle outbreak that began in 1988 (discussed below). Over the study period, maximum summer temperature ranged from 14 to 18.5°C, and minimum January temperature ranged from -4.2 to 0.8°C, according to the 4km

Parameter-elevation Relationships on Independent Slopes Model (PRISM) dataset (Daly et al. 1997). Total annual precipitation ranged from 46.9 cm in 1991 to 151.0 cm in 1997 (Figure 2).

To estimate moisture demand and evaluate the influence of climate on basin-wide ANPP, we used climatic water deficit (CWD; the difference between actual and potential evapotranspiration) as estimated by the USGS California Basin Characterization Model (BCM) (Flint and Flint 2012, Flint et al. 2014). BCM combines downscaled 4km PRISM climate data with physical hydrological process models and produces water balance fractions (e.g. runoff, evapotranspiration, soil storage) at the HUC-8 basin scale. Each model output variable is produced by BCM at a spatial grid size of 270m x270m, a meaningful scale for site-level analysis. Monthly CWD values for the Lake Tahoe Basin (#16050101) for the years 1987-2006 were obtained from the USGS California Landscape Conservation Cooperative (2015). Higher CWD values indicate periods of greater moisture deficit. For the period of study, CWD values ranged from a high of 52.7 in 1988 to a low of 23.7 in 1998 (Figure 2).

Landscape projections of ANPP

We used the landscape disturbance and succession model, LANDIS-II, to model ANPP across the LTB (Figure 3) (Mladenoff et al. 1996; Scheller et al. 2007). The LANDIS-II model was previously parameterized for the LTB to simulate landscape carbon dynamics under contemporary and future changing climate (Loudermilk et al. 2013, 2014). LANDIS-II is a spatially explicit, raster-based process model and represents trees in species-age cohorts. The model incorporates tree species life history attributes (e.g. longevity, shade tolerance, drought tolerance, seed dispersal distance, etc.) that allow each species to respond uniquely to light, nutrient, and water availability, local climate, soil conditions, and disturbance. LANDIS-II has been applied in many forested ecosystems (Swanson 2009; Cantarello et al. 2011, Gustafson and Sturtevant 2012), and calibrated using a variety of available resources, including eddy flux towers (Scheller et al. 2011) and FIA-derived biomass estimates (Thompson et al. 2011). ANPP calibration in the LTB (Loudermilk et al. 2013) was based on literature values of ponderosa pine plantations in the Sierra Nevada (Campbell et al. 2009).

Century Succession extension

Carbon dynamics were modeled using the Century Succession extension (‘*Century*’) for LANDIS-II, which is based on the CENTURY soil model (Parton et al. 1983). *Century* was calibrated and validated with available data to satisfy five model output targets: aboveground net primary productivity (ANPP), Net Ecosystem Production (NEP), aboveground live biomass, soil organic C (SOC), and soil inorganic nitrogen (mineral N) (Loudermilk et al. 2013). Further details on model development, parameterization, and calibration are in Loudermilk et al. (2013) and Supplemental Materials.

Century utilizes monthly climate data, which influences tree establishment, growth, and regeneration (Scheller et al. 2011). Individual species’ growth response to available soil moisture is dictated by two parameters; these parameters are assigned to broader functional groups to which each species belongs and dictate moisture sensitivity by determining the ratio of available water content (AWC) to potential evapotranspiration (PET). The first parameter (‘DroughtIntercept’, in *Century*: ‘pprpts2’) determines the effect of AWC on the intercept of this relationship, therefore if this value is increased, the intercept is raised and higher AWC is required to achieve the same PET. The second parameter (‘DroughtRatio’, in *Century*: ‘pprpts3’) is the minimum ratio of AWC/PET at which there is no restriction on production, effectively determining the minimum AWC necessary for any growth to occur. The LANDIS-II *Century* extension requires calibration of these moisture-related parameters to accommodate unique species and soils combinations.

We simulated two levels of tree moisture sensitivity and two levels of bark beetle occurrence (with and without bark beetles, extension discussed below). We developed two levels of moisture sensitivity (low and high) by leaving DroughtIntercept constant and iteratively increasing and decreasing the DroughtRatio parameter by the minimum amount (0.1) demonstrated to have a significant effect on the response variable (ANPP) because this parameter is not empirically derived. 'Significant effect' in this context is defined as 50% increase or reduction in ANPP, well above the tolerance of the calibration targets in Loudermilk et al (2013). We simulated two levels of DroughtRatio with both levels of bark beetle occurrence and the scenarios were named as follows: low moisture sensitivity with no beetles (LowM-noBB), low moisture sensitivity with beetles (LowM-BB), high moisture sensitivity with no beetles (HiM-noBB), and high moisture sensitivity with beetles (HiM-BB).

Using LANDIS-II, we ran five replicate 20-year simulations of each scenario for the 31,291 ha study area using a 100m x 100m grid and climate data from 1987-2006. Monthly temperature and precipitation values for 1987-2006 were from the PRISM dataset for the LTB, at a 4-km resolution (18 PRISM tiles total across the study area). Although forest thinning operations and wildfires occurred in the LTB during 1987-2006 timeframe, there were no records or physical evidence of any recent fire (wildfire or prescribed burning) or thinning at the field locations where tree cores were collected. We excluded these disturbances from our simulations to be congruent with field site disturbance history over the study period.

Biological disturbance agent (BDA) extension

Bark beetle outbreaks were simulated using the Biological Disturbance Agent (BDA) extension for LANDIS-II (Sturtevant et al. 2004). This extension simulates tree mortality that results from outbreaks of insects and disease. We parameterized host species preferences for three bark beetle species active in the LTB, and deterministically set the length and initiation year of a simulated outbreak using a documented outbreak in the LTB that began in 1988. BDA does not utilize climate data to influence beetle activity; within this study it is used as a species-specific stochastic mortality agent parameterized and calibrated to match observed patterns of historical beetle disturbance. The details of this extension and its parameterization are discussed briefly below and in detail in the Supplemental Material.

Three bark beetle species were modeled: the Jeffrey Pine Beetle (‘JPB’), the Mountain Pine Beetle (*Dendroctonus ponderosae,* ‘MPB’), and the Fir Engraver Beetle (*Scolytus ventralis,* ‘FEB’). Although there are other beetles active in the area (e.g. Red turpentine beetle, (*Dendrocotonus valens*)), these three beetles are responsible for the majority of the recorded damage in the LTB and there is very little overlap in host species. Empirical data from the literature and expert opinion were used to determine host species and ages most preferred by each of the three modeled beetle species $_{\text{Table S7}}$. JPB and FEB are limited in their primary host selection (Jeffrey pine and red/white fir respectively), whereas MPB is more of a generalist, impacting a variety of pine species across the basin (Cole and Amman 1980; Ferrell 1994; Bradley and Tueller 2001; Walker et al. 2007; Egan et al. 2010). Beetle dispersal is modeled within BDA, defined at an annual rate (m year^{-1}).

A widespread outbreak of bark beetles occurred in the region, concurrent with a severe drought that began in 1988. USFS Aerial Detection Survey (ADS) maps of the basin indicated >15,000 ha of damaged area during the peak year of the outbreak (1993). ADS maps include attribution of damage to specific beetle species on an annual basis, allowing us to use these survey data to calibrate each of the three beetle species modeled in this study. Total forest area impacted over the study period for each beetle species was 15,785 ha: mountain pine beetle (933 ha), Jeffrey pine beetle (3,126 ha), and Fir engraver beetle (11,726 ha).

Within BDA, outbreaks are probabilistic at the site level, where the probability of a site being disturbed is based on the available hosts within site as well as neighboring host resources. Individual host tree species are ranked (primary, secondary, minor, and non-host) and described by both species and age. For instance, in the LTB the Jeffrey pine beetle (*Dendroctonus jeffreyi*) is an obligate of Jeffrey pine, though it prefers older cohorts (>60 years, primary host) much more than younger cohorts (<20 years old, minor host) (Egan et al., 2010). These host categorizations help determine 'site vulnerability' (Sturtevant et al., 2004). The severity of a simulated outbreak is a function of site vulnerability, classified as light, moderate, and severe. A 'light' outbreak kills all vulnerable tree cohorts; a 'moderate' outbreak kills all tolerant and vulnerable tree cohorts; and a 'severe' outbreak kills resistant, tolerant, and vulnerable tree cohorts. Outbreaks are synchronous across a landscape, and severity can be bounded by defining a minimum and maximum possible outbreak severity. The BDA extension reduces site and landscape ANPP through mortality of affected cohorts rather than direct reductions in cohort growth rates.

Tree Ring and Model Estimate Comparison

We calculated median ANPP values and 95% confidence intervals from empirical data using bootstrapping with 500 draws from all field sites (tree ring-derived ANPP estimates) and by using all grid cells from each scenario (31,291 grid cell landscape) for median values and confidence intervals from the simulation outputs. All replicate outputs for a particular modeling scenario were combined, such that all statistical analyses were applied to a 'sample' consisting of all five replicates simultaneously. Median ANPP values were also used to construct statistical relationships for each ANPP estimation method and the BCM-estimated annual average CWD. Regressions were constructed using a linearization technique for estimating regression lines with one or more unknown break points (Muggeo 2003). Upper and lower limits of these piece-wise regressions were set at the minimum and maximum CWD values (23.6, 52.7 respectively) for the study period. The number of break points was determined by the number of integers (29) between the minimum and maximum CWD values. ANOVA was used to compare ANPP above and below the CWD breakpoint value identified by the piece-wise regression within each model scenario. In the ANOVA test, ANPP was the response, while CWD was used as the predictor with an interaction term designating above or below the CWD threshold. Two ANCOVA tests were used to compare the slopes of ANPP ~ CWD relationships between scenarios. In the ANCOVA tests, the five scenarios were evaluated by statistically comparing the slope of the ANPP~CWD relationship between each scenario above the CWD threshold (test 1) and below the CWD threshold (test 2). All statistical and graphical analyses were done using the R statistical software platform (R Core Team 2015, Bivand et al. 2015, Hijmans 2015, Wickham 2009).

Results

Median ANPP derived from tree-cores was generally below 200 g C m^{-2} (Figure 4), with increasing variance over the 20-year study period. Over the study period, median ANPP values increased from 118.5 g C m^{-2} in 1987 to 207.1 g C m^{-2} in 2006, with temporal fluctuations throughout the 20-year period. Following a year of particularly high CWD in 2000, median ANPP dropped from 229.4 g C m-2 in 2000 to 150.2 g C m-2 in 2001. The overall increasing trend in ANPP is in part a function of an overall growth rate increase following the cessation of basin-wide logging in the 1880s (Loudermilk et al. 2013).

Simulated median ANPP values for all scenarios except LowM-noBB fell within the bootstrapped confidence interval of the tree ring derived data for all 20 years of the study (Fig 4). The LowM-BB and HiM-noBB median ANPP values were more consistent with empirical values over the study period than the LowM-noBB and HiM-BB scenarios. Consistent with the empirical data, median simulated ANPP values declined sharply in 2001 (Figure 4), which corresponded with high CWD (Figure 2; 2000 CWD=51.8 and 2001 CWD=49.0). Confidence intervals for the empirical data were much larger than those of any of the model scenarios, likely because of the discrepancy in sample size between the empirical (n=52 plots) and modeled data (n=~31,000 grid cells).

Median annual ANPP showed a nonlinear relationship with CWD. ANPP had a slightly positive relationship with increasing CWD until 41mm and a strong negative relationship with increasing CWD above 41mm (Figure 5), as determined through a piece-wise regression technique. This response was consistent for both empirical and simulated ANPP under all four modeling scenarios. ANOVA results demonstrate this differential response in ANPP above and below this CWD cutoff point is significant (F = 5.27, p = 0.024).

The LowM-noBB scenario consistently had the highest median ANPP values, while the HiM-BB had the lowest (Figure 5). The regression slopes of the two scenarios that did not include bark beetles had a stronger negative response to higher CWD values (slopes: LowM-noBB= -11.1, HiM-noBB= -9.9) than those scenarios that included bark beetles (slopes: LowM-BB= -7.3, HiM-BB= -6.8) as well as the tree ring scenario. ANCOVA results reveal that model scenarios ANPP ~CWD relationships are statistically different from one another, both below the CWD cutoff (F = 10.6, p <<0.005) and above it (F = 17.6, p <<0.005) $_{\text{Table S8}}$.

Discussion

Forest productivity is influenced by a number of biotic and abiotic factors in conifer forests of the Sierra Nevada, such as available soil moisture (Dolanc et al. 2013), natural disturbances (bark beetle outbreaks, wildfire), as well as land-use legacies (past clear-cutting), and management (forest thinning for fuels reduction). By comparing our simulated ANPP results to empirical ANPP estimates from tree-core data during a time period with multiple interacting disturbances, we were able to quantify how bark beetles and moisture sensitivity influenced the relationship of ANPP to moisture deficit (CWD).

CWD thresholds for mortality via cavitation have been demonstrated in certain species in western mixed conifer forests, and predictive models of species mortality built on these thresholds perform well at landscape scales (Anderegg et al. 2015). Similarly, our tree ring-derived ANPP estimates indicate a similar inflection point when CWD~41, beyond which moisture stress causes a rapid decrease in site-scale growth rate across this landscape (Figure 5).

The relationship between growth rate and moisture stress becomes strongly negative above this value, suggesting that moisture availability becomes the primary limiting factor. Though simulated with different drought and beetle parameterizations, the ANPP~CWD relationships calculated from the four LANDIS-II scenarios show a similar change at the same CWD values.

There is a fundamental difference in approach among our model scenarios that include bark beetles ('BB') and those that do not ('noBB'). Physiological responses to climate alone drove ANPP in the absence of bark beetles, whereas climate and beetle-induced mortality drove ANPP in scenarios that included bark beetles. Therefore a fundamental question about the chosen complexity of the modeling approach must be answered – what is gained by including bark beetles and the attendant uncertainty? Landscape models require difficult choices and tradeoffs (e.g. complexity vs. parsimony), and with increased complexity comes increased interaction of processes and potential for unintended system outcomes (Gustafson 2013). However, increased complexity is also able to address the emergence of multi-scale drivers and incorporate ecological processes that may be more important in the future than they are now. This balance is particularly important if landscape models are to be used to gain meaningful insights into the effects of global climate change (Gustafson 2013).

Year to year, the two scenarios that most closely approximated the field-based ANPP data were the 'LowM-BB' and 'HiM-noBB' scenarios (Figure 4). However, when looking at growth rate as a function of moisture stress, the 'LowM-BB' scenario had a more similar response to empirical ANPP with increasing CWD than the 'HiM-noBB' scenario (Figure 5). Further, the regression slopes of the two scenarios that excluded bark beetles (LowM-noBB= -11.1, HiM-noBB= -9.9) were more negative with increasing CWD than the scenarios that included beetles (LowM-BB= -7.3, HiM-BB= -6.1) and the slope for the empirical relationship (-7.5). ANPP differences between the no beetle and beetle scenarios, averaged 53.2 g C m^{-2} over the course of the 20-year period, which is within the range of productivity reduction observed by MODIS in beetle outbreaks in mixed conifer systems in Colorado (Bright et al. 2013).

Lower parameterized moisture sensitivity, coupled with the simulation of bark beetles (‘LowM-BB scenario’) provides a more mechanistic representation of the coupled processes affecting forest productivity during this timeframe because of the clear biological link of drought and beetle attack (Guarín and Taylor 2005; Hebertson and Jenkins 2008; Creeden et al. 2013) and the prevalence of bark beetles in the LTB (Bradley and Tueller 2001; Walker et al. 2007; Egan et al. 2010). Excluding bark beetles, given their known occurrence, fails to capture the biological feedbacks in the system, and ignores a critical disturbance agent that causes forest mortality with subsequent long-term effects on succession and species composition. This is supported by other inventory-based studies, which demonstrate that mountain pine beetle in particular is an episodic control on forest growth and carbon sequestration (Stinson et al. 2011). And although the ‘HiM-noBB’ scenario may be a more parsimonious model than the ‘LowM-BB scenario’, it may be misleading to represent this landscape as both a highly moisture sensitive system not influenced by bark beetle outbreaks rather than the opposite, despite the increased model complexity. Furthermore, where drought-induced bark beetle outbreaks are common, the inclusion of both factors is important for long-term simulations of realistic climate-forest dynamics. For instance, the ‘pulse’ type disturbance of bark beetle outbreaks and insect-host specificity can create landscape patterns of mortality, recovery, and ANPP different from those from a ‘press’ type disturbance, such as climate-induced moisture stress (e.g. Simard et al 2012).

Finally, our use of tree-ring estimates of ANPP provide a novel and critical validation for projections of ANPP, particularly where eddy covariance flux towers (e.g., Scheller et al. 2011) are lacking or inventory sampling is too infrequent to capture important year-to-year variation. Such data assimilation approaches provide the opportunity to improve models and their forecasts by leveraging information on past and current states of an ecosystem (Luo et al. 2011), and are becoming increasingly critical as expectations for model projections of management outcomes increase (Clark et al. 2001).

Our results should be considered in the context of the limitations of both the empirical and simulation approaches. Our empirical ANPP estimates are potentially limited because they do not account for trees that died within plots prior to the sampling period. Live tree mean basal area was 44.2 (se = 12.8) m^2 ha^{-1} and standing dead tree mean basal area was 8.8 (s.e. = 7.9) m^2 ha^{-1}. Our empirical ANPP estimates do not include productivity from trees that were alive for only part of the 20 year period because many of the standing dead trees were not physically sound and able to be extracted. This may account for the three years in which the 'LowM-BB' and 'HiM-noBB' were higher than the empirical estimate.

Although we explored two processes that influence ANPP at multiple scales, many critical processes were excluded by design or necessity in the simulation model. Wildfires and forest thinning were not included in our simulations because there was no evidence of recent fire or thinning practices within the stands selected for tree coring. Though dispersal and host preferences are included, insect physiology is not directly modeled within the BDA extension. Therefore climate influence on insect population development and dynamics are absent from this study. In our study, we sought to match the temporal and overall spatial patterns of an observed outbreak, therefore, the known drought trigger of beetle outbreaks was incorporated. By deterministically setting outbreak duration, our simulations do not include beetle climate sensitivities, which could have revealed significant changes to reproductive success during warmer periods similar to Jonsson et al (2012). Stochastic behavior was expressed through site selection of beetle mortality, which is influenced by food resources on and around that site. Previous research has shown mortality rates differ amongst tree size and age classes, effects which are further augmented by stand density (Egan et al 2016). Our simulations account for these differences, by determining different susceptibility rates of species-age classes. However, factors that determine an individual tree's likelihood of being killed (e.g., infestation by red turpentine beetle, placement in a particularly dense stand, microsite enhancement of drought stress) are not explicitly represented within our model, which operates on species-age cohorts. Were these factors taken into consideration, we likely would have seen higher variability of within-stand mortality emerge, as individual trees would have been affected rather than entire cohorts.

Management Relevance

Our results are particularly relevant to basin-wide management given the additive effects of disturbance and climate on white fir-dominated areas – the primary target species for extensive fuel treatments (Syphard et al. 2011). In many of the stands with the highest potential ANPP, white fir comprises greater than 50% of the basal area. This highly productive and prolific seeder is more sensitive to drought conditions compared to other species in the region, though fir reproduction in the region continues to be substantial (Hurteau et al. 2007; Earles et al. 2014). Fir-dominated stands in general show a rapid growth potential, yet sensitivity to moisture limitation and insects add a layer of complexity to the existing goals of fuels reduction and carbon sequestration. Management decision making is further complicated by the more frequent and prolonged periods of moisture stress projected for the region (Coats et al. 2013), notwithstanding the potential for more climate-disturbance feedbacks (Loudermilk et al. 2013).

Conclusions

Our cross-scale comparison demonstrates that representing the effects of both climate and bark beetles on tree growth produces a high level of agreement between simulated and empirical estimates of ANPP. Furthermore, our forest growth analysis suggests that both climatic and disturbance influences should be considered when estimating or projecting ANPP. The limitations on forest growth at the landscape scale are complex, with biotic and abiotic factors playing unique, yet often confounding roles. Regional climate trends may influence productivity over large areas, but this is often coupled with biotic triggers of insect outbreaks that induce mortality and shift community composition at sub-regional scales. Deconstructing the relative contributions of each of these factors is important for evaluating model robustness, and using the combination of empirical and simulated data improves projections of future forest dynamics. Ecosystem models can capture the effects of these various influences at scales unavailable to most field studies – a critical capacity for projecting growth patterns into the future changing world.

Acknowledgements

This research was supported using funds provided by the Bureau of Land Management through the sale of public lands as authorized by the Southern Nevada Public Lands Management Act (SNPLMA). The USDA Forest Service, particularly Tiffany van Huysen and Carl Skinner of the Pacific Southwest Research Station, were integral to this work through their support and guidance. We thank Drs Peter Weisberg, University of Nevada-Reno, and Megan Creutzberg, Portland State University, as well as colleagues at the Dynamic Ecosystems and Landscapes Lab at Portland State University. The analysis and writing of this paper was funded in part by the Strategic Environmental Research and Development Program (project RC-2243). We would also like to thank Portland State University for administrative support.

References

Adams HD, Guardiola-Claramonte M, Barron-Gafford GA, Villegas JC, Breshears DD, Zou CB, Troch PA, Huxman TE. 2009. Temperature sensitivity of drought-induced tree mortality portends increased regional die-off under global-change-type drought. Proceedings of the National Academy of Sciences of the United States of America 106:7063–6.

Anderegg W, Flint A, Huang C, Flint L, Berry J, David F, Sperry J, Field,C. 2015. Tree mortality predicted from drought-induced vascular damage. Nature GeoScience 8, 367:371.

R Core Team. 2015. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL http://www.R-project.org/

Beaty RM, Taylor AH. 2008. Fire history and the structure and dynamics of a mixed conifer forest landscape in the northern Sierra Nevada, Lake Tahoe Basin, California, USA. Forest Ecology and Management 255:707–19.

Bentz BJ, Régnière J, Fettig CJ, Hansen EM, Hayes JL, Hicke J a., Kelsey RG, Negrón JF, Seybold SJ. 2010. Climate change and bark beetles of the Western United States and Canada: direct and indirect Effects. BioScience 60:602–13.

Bivand, R, Keitt, T, Rowlingson, B. 2015. rgdal: Bindings for the Geospatial Data Abstraction Library. R package version 0.9-2. http://CRAN.R-project.org/package=rgdal

Bontemps JD, Bouriaud O. 2013. Predictive approaches to forest site productivity: recent trends, challenges and future perspectives. Forestry 87:109–28.

Bradley T, Tueller P. 2001. Effects of fire on bark beetle presence on Jeffrey pine in the Lake Tahoe Basin. Forest Ecology and Management 142(1-3): 205-214.Bunn A, Korpela M, Biondi F, Campelo F, Merian P, Qeadan F, Zang C. 2015. dplR: Dendrochronology Program Library in R. R package version 1.6.3. http://R-Forge.R-project.org/projects/dplr/

Bright, CB, Hicke, JA, Meddens, AJH. 2013. Effects of bark beetle-caused mortality on biogeochemical and biogeophysical MODIS products. Journal of Geophysical Research 118(3): 974-982.

California Landscape Conservation Cooperative. 2011 California Basin Characterization Model (BCM) Downscaled Climate and Hydrolo 30-year Summaries. http://climate.calcommons.org/dataset/10. Accessed November 2015.

Campbell J, Alberti G, Martin J, Law BE. 2009. Carbon dynamics of a ponderosa pine plantation following a thinning treatment in the northern Sierra Nevada. Forest Ecology and Management 257: 453–63.

Cantarello, E, Newton, AC, Hill, RA, Tejedor-Garavito, N, Williams-Linera, G, López-Barrera, F, Manson, RH, Golicher, DJ 2011. Simulating the potential for ecological restoration of dryland forests in Mexico under different disturbance regimes. Ecological Modelling 222: 1112-1128.

Chen PY, Welsh C, Hamann A. 2010. Geographic variation in growth response of Douglas-fir to interannual climate variability and projected climate change. Global Change Biology 16: 3374–85.

Clark, JS, Carpenter, SR, Barber, M, Collins, S, Dobson, A, Foley, JA, & Pringle, C. (2001). Ecological forecasts: an emerging imperative. Science, 293(5530): 657-660.

Coats, R, Costa-Cabral, M, Riverson, J, Reuter, J, Sahoo, G, Schladow, G, Wolfe, B. 2013. Projected 21st century trends in hydroclimatology of the Tahoe Basin. Climatic Change 116: 51-69.

Cole WE, Amman GD. 1980. Mountain Pine Beetle Dynamics in Lodgepole Pine Forests , Part 1: Course of an Infestation. USDA Forest Service, Intermountain Forest and Range Experiment Station, General Technical Report INT-89, 56 pp.

Creeden EP, Hicke JA, Buotte PC. 2013. Climate, weather, and recent mountain pine beetle outbreaks in the western United States. Forest Ecology and Management 312: 239-251.

Daly C, Taylor G, Gibson W. 1997. The Prism Approach to Mapping Precipitation and Temperature. Oregon State University, Corvallis, OR.

Dolanc CR, Thorne JH, Safford HD. 2013. Widespread shifts in the demographic structure of subalpine forests in the Sierra Nevada, California, 1934 to 2007. Global Ecology and Biogeography 22: 264–76.

Earles JM, North MP, Hurteau MD. 2014. Wildfire and drought dynamics destabilize carbon stores of fire-suppressed forests. Ecological Applications 24: 732–40.

Egan JM, Sloughter, JM, Cardoso T, Trainor P, Wu K, Safford H, Fournier D. 2016. Multi-temporal ecological analysis of Jeffrey pine beetle outbreak dynamics within the Lake Tahoe Basin. Population Ecology. DOI 10.1007/s10144-016-0545-2

Egan JM, Jacobi WR, Negron JF, Smith SL, Cluck DR. 2010. Forest Ecology and Management Forest thinning and subsequent bark beetle-caused mortality in Northeastern California. Forest Ecology and Management 260:1832–42.

Ferrell GT. 1994. Predicting susceptibility of white fir during a drought-associated outbreak of the fir engraver, Scolytus ventralis, in California. Canadian Journal of Forest Research 24(2): 302-305.

Fisichelli NA, Frelich LE, Reich PB. 2012. Climate and interrelated tree regeneration drivers in mixed temperate–boreal forests. Landscape Ecology 28:149–59.

Flint L., and Flint A. 2012. Downscaling future climate scenarios to fine scales for hydrologic and ecological modeling and analysis. Ecological Processes **1**(1): 2.

Flint L, Flint A, Thorne J, Boynton R. 2013. Fine-scale hydrologic modeling for regional landscape applications: the California Basin Characterization Model development and performance. Ecological Processes 2(1): 25.

Fritts HC, Swetname TW. 1989. Dendroecology: A tool for evaluating variations in past and present forest environments. Advances in Ecological Research 19:111–88.

Graf M. 1999. Plants of the Tahoe Basin. Sacramento, CA: California Native Plant Society Press

Guarín A, Taylor AH. 2005. Drought triggered tree mortality in mixed conifer forests in Yosemite National Park, California, USA. Forest Ecology and Management 218: 229–44.

Gustafson EJ, Sturtevant BR. 2012. Modeling Forest Mortality Caused by Drought Stress: Implications for Climate Change. Ecosystems 16: 60–74.

Gustafson EJ. 2013. When relationships estimated in the past cannot be used to predict the future: using mechanistic models to predict landscape ecological dynamics in a changing world. Landscape Ecology 28:1429–37.

Hebertson EG, Jenkins MJ. 2008. Climate Factors Associated with Historic Spruce Beetle (Coleoptera: Curculionidae) Outbreaks in Utah and Colorado. Environmental Entomology 37: 281–92.

Hijmans RJ. 2015. raster: Geographic Data Analysis and Modeling. R package version 2.3-33. http://CRAN.R-project.org/package=raster

Holmes RL. 1983. Computer-assisted quality control in tree-ring dating and measurement. Tree-Ring Bulletin 43: 69-78.

Hurteau M, Zald H, North M. 2007. Species-specific response to climate reconstruction in upper-elevation mixed-conifer forests of the western Sierra Nevada, California. Canadian Journal of Forest Research 37: 1681–91.

Hurteau MD, Robards TA, Stevens D, Saah D, North M, Koch GW. 2014. Modeling climate and fuel reduction impacts on mixed-conifer forest carbon stocks in the Sierra Nevada, California. Forest Ecology and Management 315: 30–42.

Jenkins JC, Chojnacky DC, Heath LS, Birdsey RA. 2004. Comprehensive Database of Diameter-based Biomass Regressions for North American Tree Species. USDA Forest Service General Technical Report NE-319.

Jonsson AM, Schroeder LM, Lagergren F, Anderbrant O, Smith B. 2012. Guess the impact of *Ips typographus* - An ecosystem modelling approach for simulating spruce bark beetle outbreaks. Agricultural and Forest Meteorology 166-167: 188-200

Kerhoulas LP, Kolb TE, Hurteau MD, Koch GW. 2013. Managing climate change adaptation in forests: a case study from the U.S. Southwest. Journal of Applied Ecology 50: 1311–20.

Klutsch JG, Negrón JF, Costello SL, Rhoades CC, West DR, Popp J, Caissie R. 2009. Stand characteristics and downed woody debris accumulations associated with a mountain pine beetle (*Dendroctonus ponderosae* Hopkins) outbreak in Colorado. Forest Ecology and Management 258: 641–9.

Kuijper DPJ, Cromsigt JPGM, Jedrzejewska B, Miscicki S, Churski M, Jedrzejewski W, Kweczlich I. 2012. Bottom-up versus top-down control of tree regeneration in the Bialowieza Primeval Forest, Poland. Journal of Ecology 98: 888-889. doi: 10.1111/j.1365-2745.2010.01656.x

Kurz W, Dymond CC, Stinson G, Rampley GJ, Neilson ET, Carroll a L, Ebata T, Safranyik L. 2008. Mountain pine beetle and forest carbon feedback to climate change. Nature 452: 987–90.

Laura Suarez M, Kitzberger T. 2010. Differential effects of climate variability on forest dynamics along a precipitation gradient in northern Patagonia. Journal of Ecology 98: 1023–34.

Law BE, Turner D, Campbell J, Sun OJ, Van Tuyl S, Ritts WD, Cohen WB. 2004. Disturbance and climate effects on carbon stocks and fluxes across Western Oregon USA. Global Change Biology 10:1429–44.

Loudermilk EL, Scheller RM, Weisberg PJ, Yang J, Dilts TE, Karam SL, Skinner C. 2013. Carbon dynamics in the future forest: the importance of long-term successional legacy and climate-fire interactions. Global Change Biology 19: 3502–15.

Loudermilk EL, Stanton A, Scheller RM, Dilts TE, Weisberg PJ, Skinner C, Yang J. 2014. Effectiveness of fuel treatments for mitigating wildfire risk and sequestering forest carbon: A case study in the Lake Tahoe Basin. Forest Ecology and Management 323: 114–25.

Luo Y, Ogle K, Tucker C, Fei S, Gao C, LaDeau S, Clark JS, Schimel DS. 2011. Ecological forecasting and data assimilation in a data-rich era. Ecological Applications 21: 1429-1442.

Mladenoff DJ, Host GE, Boeder J, Crow TR. 1996. LANDIS: A spatial model of forest landscape disturbance, succession, and management. In: GIS and Environmental Modeling. pp 175–80. MIchael F Goodchild, Louis T Steyart, Bradley O Parks, Carol Johnston, David Maidment, Michael Crane, and Sandi Glendinning, Editors. Gis World Books, Publisher.

Muggeo, VM. 2003. Estimating regression models with unknown break points. Stat Med 22(19): 3055-71.

Pan Y, Birdsey RA, Fang J, Houghton R, Kauppi PE, Kurz W, Phillips OL, Shvidenko A, Lewis SL, Canadell JG, Ciais P, Jackson RB, Pacala SW, McGuire a D, Piao S, Rautiainen A, Sitch S, Hayes D. 2011 a. A large and persistent carbon sink in the world's forests. Science 333: 988–93.

Pan Y, Chen JM, Birdsey R, McCullough K, He L, Deng F. 2011 b. Age structure and disturbance legacy of North American forests. Biogeosciences 8: 715–32.

Parton WJ, Anderson, DW, Cole, CV. 1983. Simulation of soil organic matter formation and ineralization in semiarid agroecosystems. Athens, Georgia: The 436 University of Georgia, College of Agriculture Experiment Stations:533–50.

Rogers JH. 1974. Soil survey Tahoe Basin Area: California and Nevada. Washington, DC

Scheller RM, Domingo JB, Sturtevant BR, Williams JS, Rudy A, Gustafson EJ, Mladenoff DJ. 2007. Design, development, and application of LANDIS-II, a spatial landscape simulation model with flexible temporal and spatial resolution. Ecological Modelling 201:409–19.

Scheller RM, Van Tuyl S, Clark K, Hayden NG, Hom J, Mladenoff DJ. 2008. Simulation of forest change in the New Jersey Pine Barrens under current and pre-colonial conditions. Forest Ecology and Management 255:1489–500.

Scheller RM, Van Tuyl S, Clark KL, Hom J, La Puma I. 2011. Carbon Sequestration in the New Jersey Pine Barrens Under Different Scenarios of Fire Management. Ecosystems 14:987–1004.

Simard M, Powell EN, Raffa KF, Turner MG. 2012. What explains landscape patterns of tree mortality caused by bark beetle outbreaks in Greater Yellowstone? Global Ecology and Biogeography 21: 556-567

Skovsgaard JP, Vanclay JK. 2008. Forest site productivity: a review of the evolution of dendrometric concepts for even-aged stands. Forestry 81: 13–31.

Stinson, G, Kurz, WA, Smyth, CE, Neilson, ET, Dymond, CC, Metsaranta, JM, Boisvenue, C, Rampley, GJ, Li, Q, White, TM, Blain, D. 2011. An inventiry-based analysis of Canada's managed forest carbon dynamics, 1990-2008. Global Change Biology 17: 2227-2244.

Stokes MA, Smiley TL. 1968. An introduction to tree ring dating. The University of Chicago Press, Chicago, IL.

Sturtevant BR, Gustafson EJ, Li W, He HS. 2004. Modeling biological disturbances in LANDIS: a module description and demonstration using spruce budworm. Ecological Modelling 180:153–74.

Swanson ME. 2009. Modeling the effects of alternative management strategies on forest carbon in the Nothofagus forests of Tierra del Fuego, Chile. Forest Ecology and Management: 257(8): 1740-1750.

Syphard AD, Scheller RM, Ward BC, Spencer WD, Strittholt JR. 2011. Simulating landscae-scale effects of fuels treatments in the Sierra Nevada, California, USA. International Journal of Wildland Fire 20: 364-383

Temperli C, Bugmann H, Elkin C. 2013. Cross-scale interactions among bark beetles, climate change, and wind disturbance: a landscape modeling approach. Ecological Monographs 83(3): 383-402. doi:10.1890/12-1503.1

Thompson JR, Foster DR, Scheller R, Kittredge D. 2011. The influence of land use and climate change on forest biomass and composition in Massachusetts, USA. Ecological Applications 21:2425–44.

Trouet V, Taylor AH. 2009. Multi-century variability in the Pacific North American circulation pattern reconstructed from tree rings. Climate Dynamics 35:953–63.

Walker RF, Fecko RM, Frederick WB, Johnson DW, Miller WW. 2007. Forest Health Impacts of Bark Beetles, Dwarf Mistletoe, and Blister Rust in a Lake Tahoe Basin Mixed Conifer Stand. Western North American Naturalist 67:562–71.

Wickham, H. 2009. ggplot2: elegant principles for data analysis. Springer New York.

Figure legends

Figure 1: Study area map. Dots signify field site locations of tree core sampling; the orange area represents LANDIS-II modeling extent; the grey area is the entire Lake Tahoe Basin.

Figure 2: Temperature and average annual precipitation for the Lake Tahoe Basin for the study period of 1986-2007. Temperature and precipitation data were estimated by 4km Parameter-elevation Relationships on Independent Slopes Model (PRISM) data, averaged across 18 tiles; Climatic water deficit (CWD) data is the average of the Basin Characterization Model (BCM) tiles. Average annual precipitation is average total precipitation for calendar year. Dotted lines above and below-average temperature represent average annual maximum temperature and average annual minimum temperature.

Figure 3: Conceptual diagram of LANDIS-II.

Figure 4: Comparison of empirical ANPP data with four LANDIS-II model scenarios: 'LowM-noBB' (low moisture sensitivity, no bark beetle outbreaks), 'LowM-BB' (low moisture sensitivity, bark beetle outbreaks), 'HiM-noBB' (high moisture sensitivity, no bark beetle outbreaks), and 'HiM-BB' (high moisture sensitivity, bark beetle outbreaks). Each line represents the median ANPP (tree ring n=52, LANDIS-II scenarios n=31,291), shaded areas around each median line represent bootstrapped 95% confidence intervals, 500 draws each.

Figure 5: Median ANPP as a function of average annual climatic water deficit (CWD), as calculated by the Basin Characterization Model. Regression lines show distinction between moisture sensitivity at low moisture stress levels (low CWD) and high moisture stress levels (high CWD).

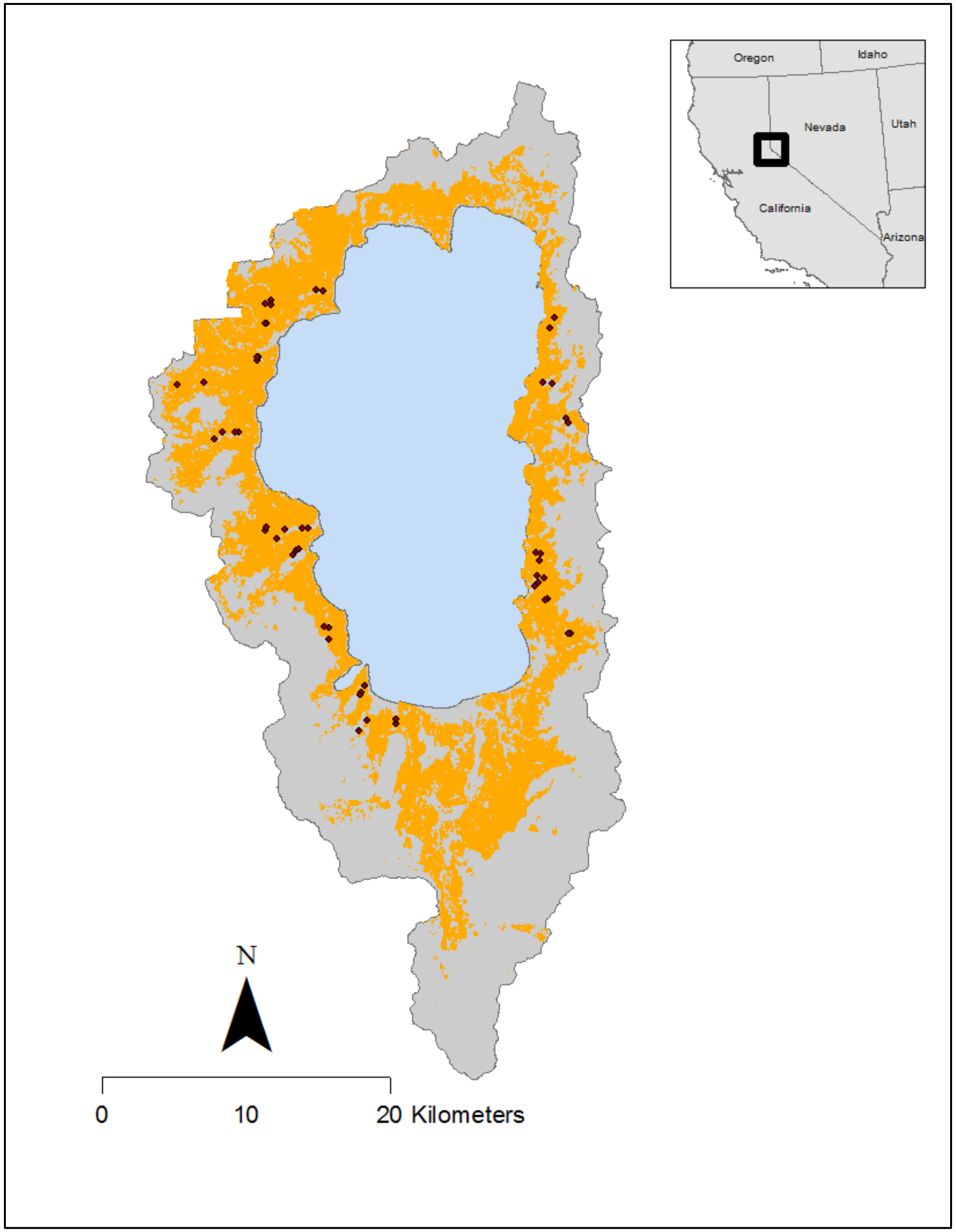

Oregon
Idaho
Nevada
Utah
California
Arizona
N
0
10
20 Kilometers

Fig 1

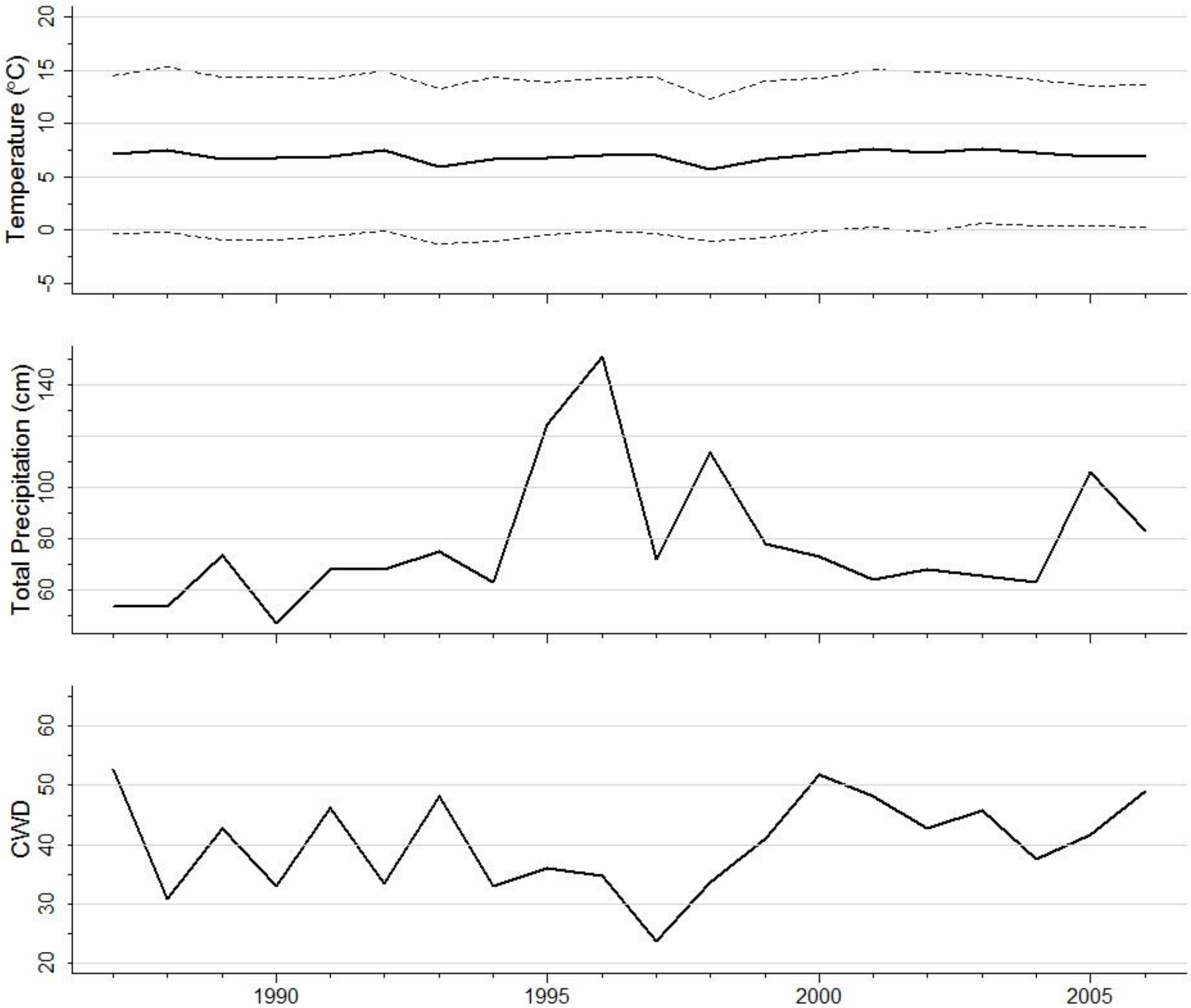
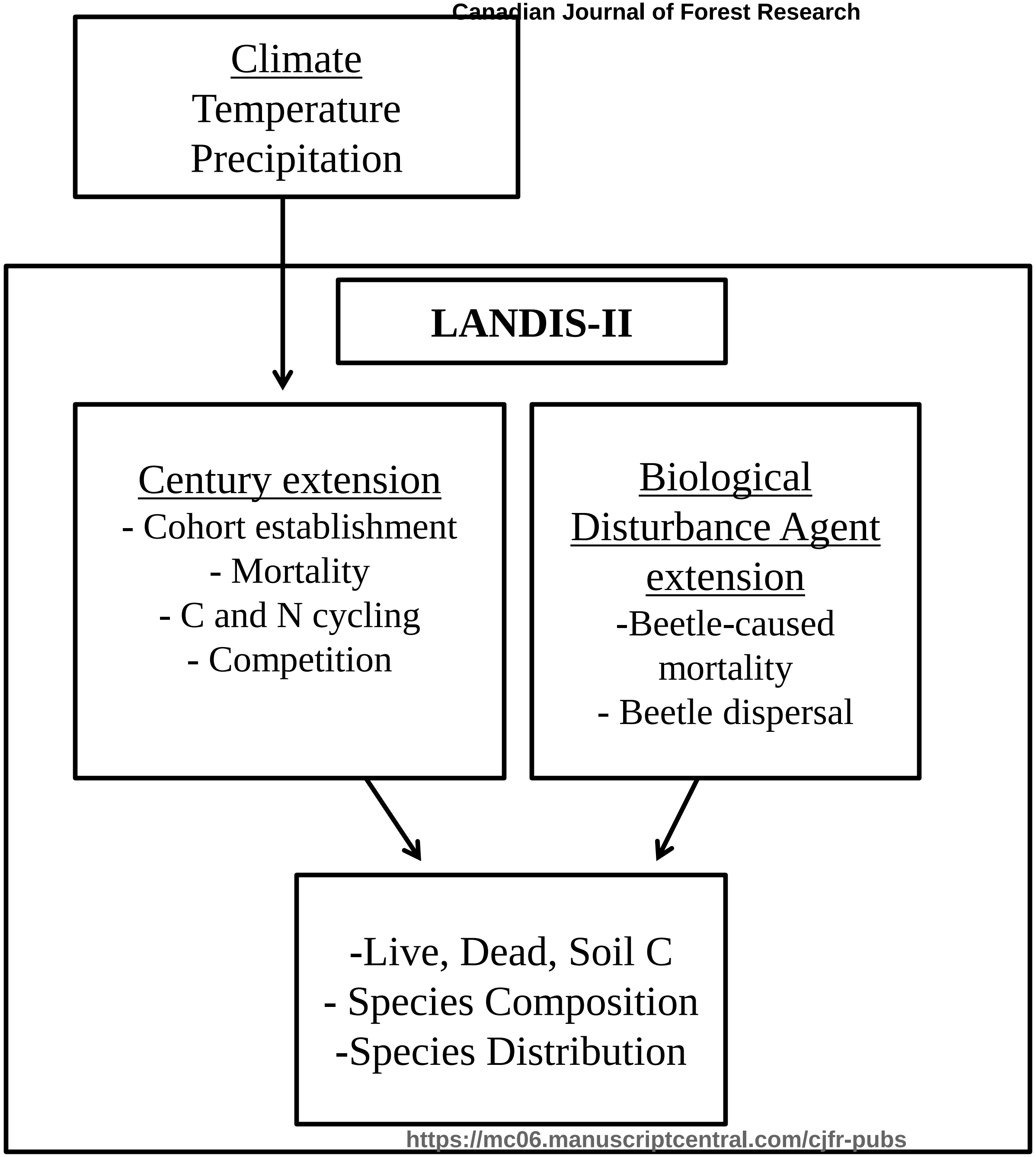

Temperature (°C)
20
15
10
5
0
-5
Total Precipitation (cm)
140
100
80
60
CWD
60
50
40
30
20
1990
1995
2000
2005

Fig 2



Climate
Temperature
Precipitation
LANDIS-II
Century extension
- Cohort establishment
- Mortality
- C and N cycling
- Competition
Biological Disturbance Agent extension
-Beetle-caused mortality
- Beetle dispersal
-Live, Dead, Soil C
- Species Composition
-Species Distribution

Fig 3

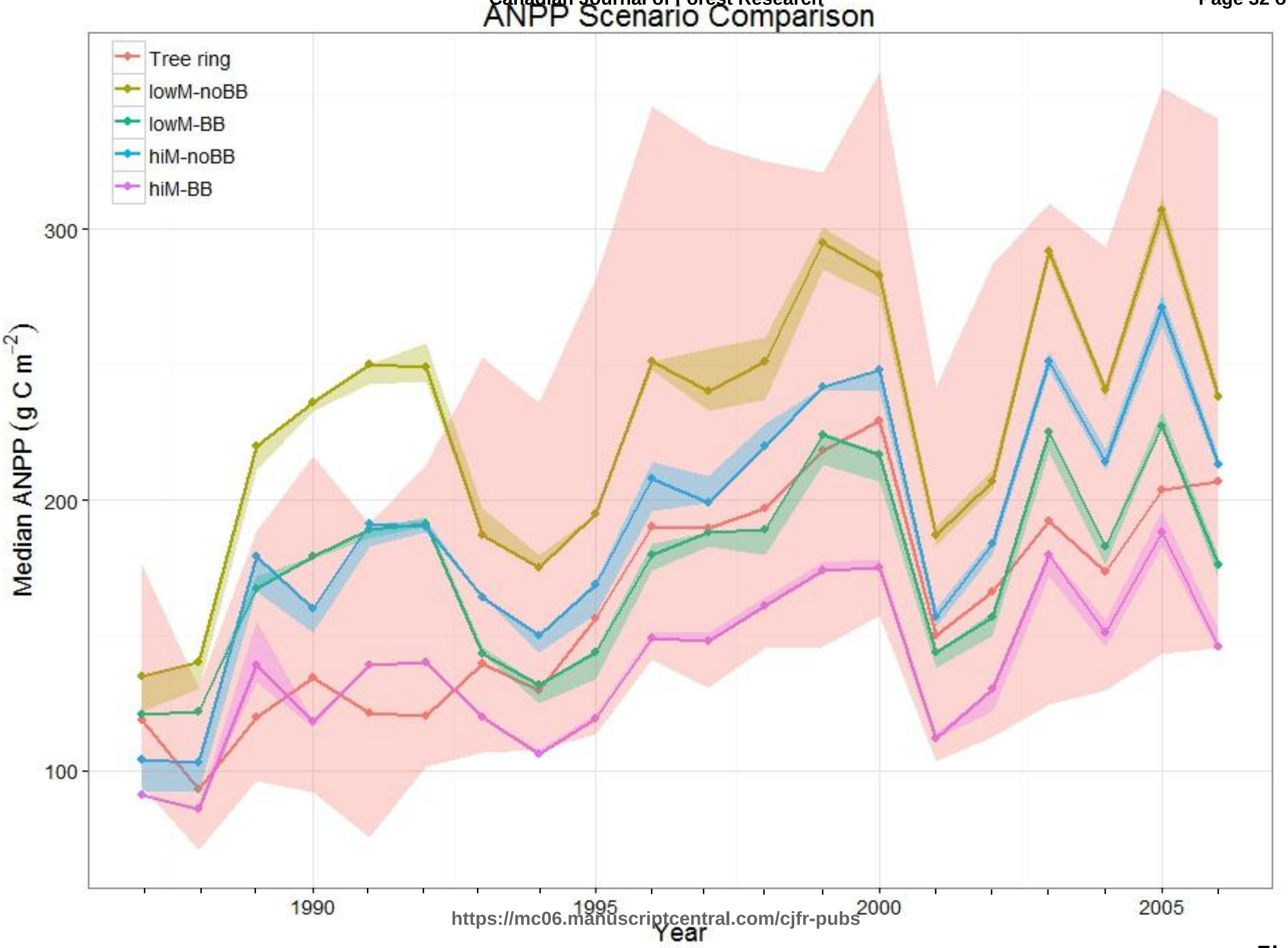

ANPP Scenario Comparison
Tree ring
lowM-noBB
lowM-BB
hiM-noBB
hiM-BB
Median ANPP ($g\ C\ m^{-2}$)
300
200
100
1990
1995
2000
2005
Year

Fig 4

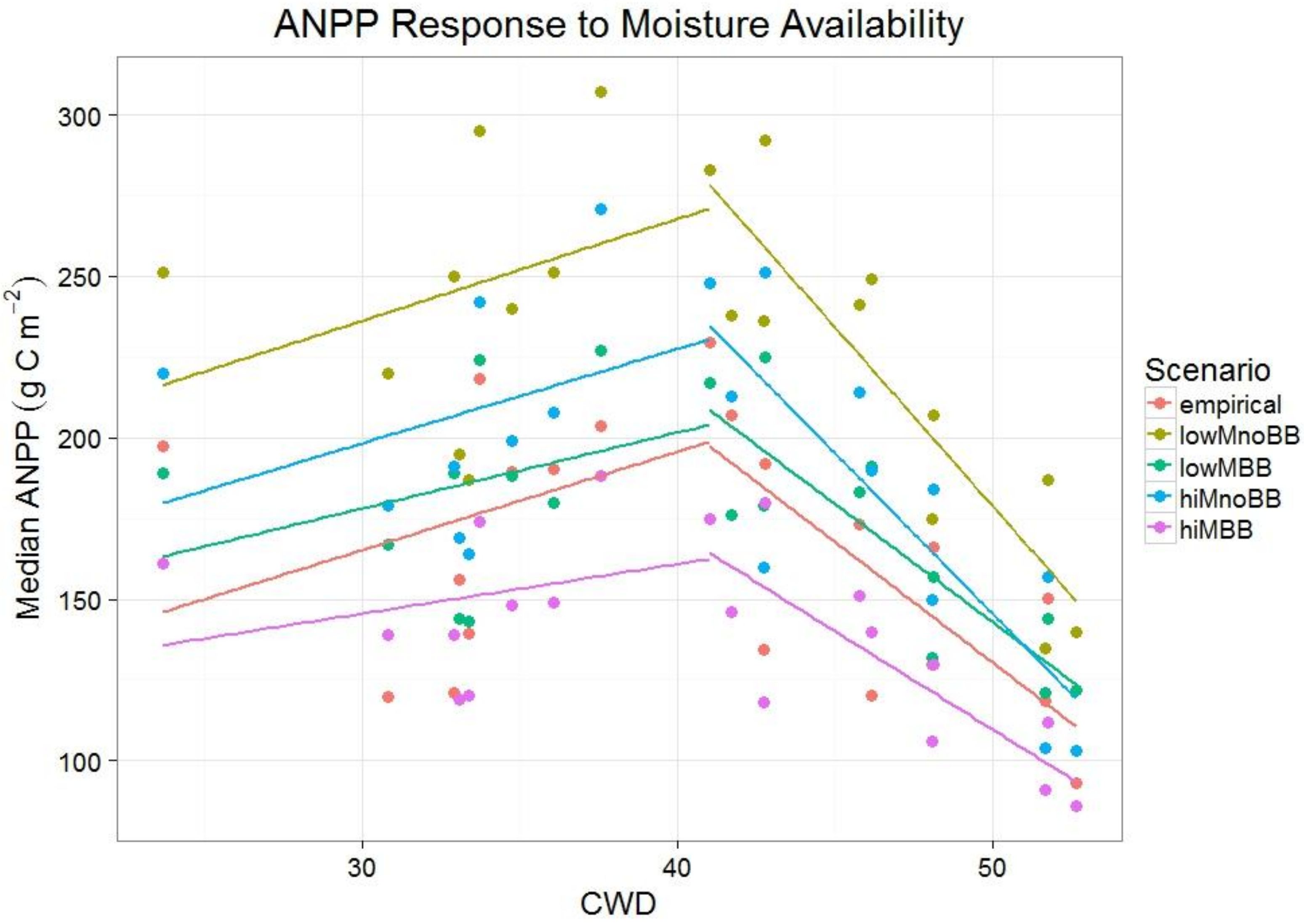

ANPP Response to Moisture Availability
Median ANPP (g C m−2)
300
250
200
150
100
30
40
50
CWD
Scenario
empirical
lowMnoBB
lowMBB
hiMnoBB
hiMBB

Fig 5

Table S1: Plot metadata including plot location, topography and forest type for 21 sampled drainage creeks across the Lake Tahoe Baisn.

Site	Plot	Northing	Easting	Elevation	Aspect	Slope	Slope Position	Forest Type
BLC	01	0246750	4336077	2139	123	5	MID	PIJE
BLC	02	0247413	4335993	2123	268	15%	MID	PIJE/ABCO
RC	01	0746096	4341919	2104	123	11%	MID	ABCO/PILA
RC	02	0746544	4342203	2082	127	12%	MID	ABMA/ABCO
RC	03	0746513	4341825	2105	0	4%	MID	ABCO
BC	01	0746180	4340577	2031	173	13%	MID	ABCO/PILA
BC	02	0746066	4340555	2044	128	17%	MID	ABCO/PILA
MC	01	0247858	4340544	2022	156	17%	MID	CADE/PIJE
MC	02	0247518	4339834	1985	235	11%	MID	PIKE/CADE
DC	01	0750087	4342862	2168	45	14%	MID	PIJE /ABCO
DC	02	0749667	4342870	2016	37	6%	MID	PIJE/PILA
SP	01	0248347	4333188	2149	142	25%	UPPER	PIJE
SP	02	0248224	4333525	2179	227	23%	UPPER	PIJE
BUI	01	0247558	4318627	2096	270	22%	MID	PIJE/ABCO
BUI	02	0247333	4318581	2067	225	28%	MID	PIJE/ABCO
MF	01	0246052	4321109	2085	55	23%	UPPER	PIJE/ABCO
MF	02	0245879	4321011	2047	247	25%	UPPER	PIJE/ABCO
HT	01	0245523	4322237	1968	283	16%	MID	PIJE/ABCO
HT	02	0245269	4322050	1942	233	10%	MID	PIJE
ZC	01	0245917	4322556	2182	73	32%	UPPER	PIJE/ABCO
ZC	02	0245481	4322781	1986	57	2%	MID	PIJE
ZC	03	0245662	4323812	2036	252	42%	MID	PIJE/ABCO
LC	01	0245528	4324365	2035	290	12%	UPPER	PIJE/ABCO
LC	02	0245845	4324272	2076	291	31%	UPPER	PIJE/ABCO
MEEKS	01	0747999	4324555	1922	100	27%	MID	CADE/ABCO
MEEKS	02	0748288	4324831	1937	155	25%	MID	PIJE/ABCO

MEEKS	03	0748424	4324954	1940	170	12%	MID	PIJE/ABCO
MCK	01	0746135	4326206	2016	265	21%	MID	PIJE/ABMA
MCK	02	0746198	4326484	2016	313	17%	MID	PIJE/ABCO
CASCADE CREEK	01	0752767	4315039	1982	319	1%	MID	PIJE/PILA
CASCADE CREEK	02	0752707	4314854	1989	2	1%	MID	PIJE/ABCO
CASCADE CREEK	03	0753035	4315473	1942	25	6%	MID	ABCO/PIJE
GENERAL CREEK	01	0749107	4326415	1934	51	37%	MID	ABCO/PIJE
GENERAL CREEK	02	0748649	4326370	1953	312	11%	MID	PIJE/ABCO
GENERAL CREEK	03	0746889	4325668	1980	142	14%	MID	ABCO/PIJE
GENERAL CREEK	04	0747485	4326302	1971	67	10%	MID	ABCO/PIJE
RUBICON	01	0750533	4319495	1967	309	28.5	MID	ABMA/PIJE
RUBICON	02	0750522	4318732	2084	24	40%	MID	ABCO/ABMA
RUBICON	03	0750199	4319573	1984	62	20.5%	MID	ABCO/PIJE
TAYLOR	01	0755142	4312849	1926	46	4%	MID	PIJE/ABCO
TAYLOR	02	0755141	4313154	1922	15	6%	MID	PIJE/ABCO
BLK	01	0743168	4333077	1957	173	15%	MID	PIJE/ABCO
BLK	02	0744281	4333081	1949	210	16%	MID	ABCO/PIJE
BLK	03	0744044	4333078	1954	228	16%	MID	ABCO/PIJE
TALLAC	01	0753174	4313074	1960	294	17.5	MID	ABCO/PIJE
TALLAC	02	0752635	4312357	1974	13	10%	MID	PIJE/ABCO
WARD	01	0739981	4336335	2107	132	15%	MID	PIJE/ABCO
WARD	02	0741841	4336516	2022	216	27%	MID	PIJE/ABCO
WARD	03	0742564	4332564	2060	177	42%	UPPER	PIJE/ABCO
GRAN	01	0745575	4338029	1972	128	20%	MID	PIJE/ABCO
GRAN	02	0745634	4338284	2025	122	30%	MID	ABCO/PILA
GRAN	03	0745544	4338274	2028	97	16%	MID	ABCO/PIJE

Table S2: Tree ring summary statistics

ABCO												
	series	first	last	year	mean	median	stdev	skew	sens1	sens2	gini	ar1
1	BC01A1	162	271	110	3.081	2.987	0.884	0.095	0.188	0.175	0.156	0.615
2	BC01A3	196	271	76	1.531	1.442	0.785	1.621	0.295	0.332	0.259	0.311
3	BC01A6	171	271	101	3.702	3.46	1.774	1.564	0.162	0.155	0.251	0.734
4	BC02A7	181	271	91	1.825	1.883	0.8	-0.198	0.233	0.202	0.251	0.79
5	BC02A10	99	271	173	2.096	2.062	0.636	0.426	0.187	0.174	0.168	0.724
6	BLC02A2	204	271	68	1.792	1.611	0.82	1.671	0.211	0.207	0.226	0.712
7	BLK01A1	200	271	72	4.098	4.192	1.058	0.201	0.136	0.132	0.146	0.764
8	BLK02A5	216	271	56	4.328	4.044	1.711	0.282	0.156	0.154	0.224	0.836
9	BLK02A4	167	271	105	2.302	2.424	0.734	-0.21	0.167	0.157	0.181	0.738
10	BLK02A2	207	271	65	3.161	3.25	0.586	-0.218	0.159	0.153	0.104	0.498
11	BLK02A1	230	271	42	2.335	2.307	0.349	0.276	0.135	0.136	0.084	0.315
12	BLK02A3	184	271	88	1.857	1.886	0.871	0.006	0.182	0.159	0.268	0.855
13	BLK03A2	191	271	81	3.505	3.088	1.854	2.122	0.153	0.162	0.246	0.889
14	BLK03A8	160	271	112	2.641	2.74	1.196	0.643	0.141	0.138	0.25	0.809
15	BLK03A7	199	271	73	2.677	2.216	1.425	1.578	0.18	0.174	0.275	0.74
16	BUI01A5	173	271	99	2.008	1.868	1.069	1.453	0.207	0.182	0.273	0.773
17	BUI02A2	200	271	72	2.195	2.243	0.775	0.158	0.211	0.189	0.2	0.717
18	DC01A1	203	271	69	2.645	2.769	0.805	-0.005	0.231	0.219	0.171	0.553
19	DC01A7	131	271	141	2.728	2.759	1.514	0.131	0.186	0.144	0.318	0.938
20	DC02A3	176	271	96	1.368	1.385	0.396	0.179	0.195	0.188	0.163	0.547
21	DC02A4	198	271	74	1.786	1.869	0.423	-0.687	0.187	0.167	0.128	0.523
22	GC01A1	119	271	153	0.721	0.422	0.66	1.273	0.209	0.185	0.479	0.941
23	GC01A3	205	271	67	1.512	1.395	0.69	0.446	0.226	0.211	0.257	0.814
24	GC03A2	205	271	67	2.809	2.744	0.943	0.042	0.206	0.19	0.19	0.725
25	GC03A4	144	271	128	2.712	2.794	1.079	-0.215	0.153	0.141	0.225	0.87

26	GC04A5	169	271	103	1.981	2.033	0.857	0.202	0.152	0.143	0.246	0.881
27	GC04A1	194	271	78	1.741	1.714	0.458	0.14	0.206	0.205	0.149	0.56
28	GC04A2	181	271	91	1.552	1.475	0.654	1.269	0.186	0.174	0.217	0.79
29	GC04A3	177	271	95	1.692	1.678	0.459	0.361	0.197	0.184	0.152	0.638
30	GRAN1A1	211	271	61	1.815	1.675	0.725	2.746	0.166	0.174	0.182	0.559
31	GRAN1A6	182	271	90	2.69	2.68	1.054	0.711	0.175	0.164	0.216	0.819
32	GRAN2A7	203	271	69	2.629	2.412	1.261	0.786	0.266	0.216	0.262	0.738
33	GRAN2A5	183	271	89	2.159	2.221	0.553	-0.96	0.227	0.192	0.138	0.526
34	GRAN2A3	193	271	79	1.58	1.264	0.793	1.133	0.247	0.228	0.266	0.71
35	GRAN2A2	192	271	80	1.437	1.517	0.547	-0.192	0.282	0.236	0.215	0.659
36	GRAN2A9	178	271	94	2.571	2.632	0.833	-0.29	0.212	0.176	0.181	0.746
37	GRAN2A4	177	271	95	2.85	3.042	1.254	-0.149	0.245	0.206	0.251	0.776
38	GRAN3A8	187	271	85	2.426	2.463	0.646	-0.398	0.193	0.17	0.149	0.637
39	GRAN3A9	174	271	98	1.77	1.772	0.645	-0.02	0.213	0.183	0.208	0.772
40	GRAN3A7	182	271	90	2.624	2.495	1.156	0.469	0.221	0.18	0.247	0.839
41	LC02A1	210	271	62	1.516	1.466	0.536	0.148	0.322	0.298	0.199	0.425
42	MC01A1	182	271	90	1.56	1.312	1.051	0.762	0.26	0.224	0.372	0.861
43	MC01A8	168	271	104	2.353	2.13	1.097	0.996	0.234	0.215	0.251	0.763
44	MEEKS1A1	204	271	68	1.684	1.653	0.491	0.169	0.205	0.198	0.163	0.561
45	MEEKS1A2	195	271	77	0.883	0.787	0.373	1.157	0.243	0.228	0.224	0.686
46	MEEKS2A1	236	271	36	1.796	1.719	0.647	1.111	0.223	0.217	0.189	0.518
47	MEEKS2A3	206	271	66	2.014	1.874	0.745	0.482	0.229	0.21	0.206	0.724
48	MF01A4	181	271	91	1.306	1.23	0.581	0.716	0.265	0.237	0.245	0.764
49	RC01A2	205	271	67	1.458	1.348	0.512	0.346	0.203	0.193	0.199	0.751
50	RC01A3	188	271	84	2.306	1.773	1.444	1.297	0.227	0.171	0.326	0.88
51	RC01A4	141	271	131	2.445	2.334	2.637	4.343	0.929	0.743	0.48	0.068
52	RC01A5	127	271	145	2.411	1.963	1.619	0.771	0.201	0.163	0.37	0.938
53	RC01A6	182	271	90	2.169	2.352	0.822	-0.387	0.213	0.186	0.215	0.776
54	RC01A7	126	271	146	2.48	2.602	0.988	-0.067	0.152	0.14	0.228	0.877
55	RC02A4	103	271	169	1.507	1.414	0.61	0.595	0.166	0.152	0.227	0.877
56	RC02A7	171	271	101	2.395	2.214	0.784	1.069	0.184	0.174	0.176	0.731

57	RC03A6	188	271	84	2.522	2.582	0.652	-0.028	0.172	0.163	0.144	0.594
58	RC03A8	183	271	89	2.753	2.485	1.334	2.677	0.178	0.174	0.229	0.664
59	RC03A1	201	271	71	2.43	2.5	0.748	1.613	0.17	0.157	0.152	0.542
60	RC03A2	205	271	67	1.76	1.763	0.572	-0.13	0.18	0.164	0.184	0.751
61	RC03A3	188	271	84	1.807	1.828	0.464	0.261	0.207	0.201	0.142	0.473
62	RC03A4	184	271	88	2.517	2.548	0.805	0.158	0.174	0.156	0.18	0.747
63	RC03A7	191	271	81	2.943	2.729	0.904	0.332	0.206	0.193	0.173	0.607
64	RUB2A5	196	271	76	2.279	2.248	1.105	0.039	0.299	0.222	0.277	0.797
65	RUB3A1	208	271	64	1.351	1.349	0.499	0.31	0.197	0.19	0.206	0.765
66	RUB3A2	185	271	87	1.169	1.152	0.427	0.192	0.19	0.177	0.208	0.803
67	RUB3A3	164	271	108	1.104	0.986	0.654	0.829	0.235	0.221	0.327	0.787
68	TALL1A1	199	271	73	1.463	1.656	0.619	-0.386	0.243	0.19	0.234	0.782
69	TALL1A6	144	271	128	2.629	2.094	1.464	1.362	0.194	0.187	0.288	0.845
70	TALL1A2	203	271	69	1.369	1.308	0.432	0.476	0.179	0.165	0.174	0.759
71	TALL1A5	184	271	88	1.195	1.139	0.423	1.209	0.219	0.218	0.186	0.601
72	TALL2A2	186	271	86	2.194	2.125	0.975	0.244	0.349	0.3	0.252	0.636
73	WARD1A3	185	271	87	1.082	0.941	0.485	1.615	0.207	0.208	0.227	0.697
74	WARD1A7	183	271	89	3.136	3.042	1.588	0.09	0.168	0.144	0.29	0.897
75	ZC03A2	206	271	66	1.04	1.049	0.437	0.364	0.254	0.248	0.236	0.673
ABMA												
	series	first	last	year	mean	median	stdev	skew	sens1	sens2	gini	ar1
1	GC01AB4	285	352	68	0.915	0.754	0.698	1.3	0.245	0.227	0.392	0.861
2	GC01AB5	208	352	145	0.868	0.772	0.344	0.83	0.16	0.153	0.217	0.817
3	GC01AB6	207	352	146	1.828	1.539	0.917	1.265	0.16	0.158	0.26	0.871
4	MCK01AB2	212	352	141	1.496	1.463	0.452	0.847	0.194	0.19	0.163	0.613
5	RC01AB1	274	352	79	2.879	2.986	1.067	-0.311	0.262	0.213	0.21	0.712
6	RC02AB1	323	352	30	2.437	2.239	1.065	1.822	0.164	0.16	0.21	0.67
7	RC02AB2	262	352	91	1.669	1.538	0.629	0.592	0.177	0.164	0.21	0.849
8	RC02AB3	291	352	62	1.204	1.211	0.342	0.606	0.206	0.209	0.154	0.42
9	RC02AB5	327	352	26	2.552	2.555	0.559	-0.333	0.171	0.157	0.122	0.571
10	RC02AB6	233	352	120	2.036	1.757	1.166	0.711	0.205	0.19	0.318	0.869

11	RUB1AB1	252	352	101	0.959	0.88	0.456	2.852	0.309	0.33	0.223	0.42
12	RUB1AB2	241	352	112	1.759	1.766	0.51	0.03	0.183	0.177	0.165	0.646
13	RUB1AB3	1	352	352	0.824	0.787	0.226	0.525	0.183	0.181	0.153	0.617
14	RUB1AB4	221	352	132	1.919	1.937	0.701	0.692	0.167	0.161	0.198	0.805
CADE												
	series	first	last	year	mean	median	stdev	skew	sens1	sens2	gini	ar1
1	BC01C2	246	314	69	1.411	1.512	0.516	-0.319	0.216	0.201	0.206	0.709
2	BC01C5	44	314	271	0.948	0.918	0.418	0.342	0.215	0.197	0.25	0.814
3	GRAN1C3	240	314	75	1.236	1.288	0.374	0.033	0.159	0.156	0.171	0.743
4	MC1C2	284	314	31	3.135	2.776	1.797	0.768	0.268	0.253	0.311	0.833
5	MC1C3	204	314	111	1.683	1.471	0.761	1.182	0.218	0.215	0.24	0.776
6	MC1C4	221	314	94	4.239	4.037	1.245	0.43	0.191	0.179	0.163	0.656
7	MC1C5	223	314	92	2.585	2.444	1.168	0.716	0.195	0.174	0.25	0.844
8	MC1C6	205	314	110	2.771	2.547	0.926	0.796	0.17	0.167	0.181	0.788
9	MC1C7	229	314	86	1.936	1.761	1.263	1.608	0.261	0.231	0.333	0.84
10	MC2C2	230	314	85	1.517	1.518	0.577	0.229	0.195	0.181	0.216	0.744
11	MEEKS1C4	1	314	314	0.897	0.699	0.728	2.97	0.25	0.233	0.355	0.853
12	MEEKS1C2	17	314	298	1.325	1.232	0.722	0.531	0.204	0.198	0.308	0.875
13	MEEKS2C5	112	314	203	1.873	1.723	0.703	1.076	0.18	0.175	0.202	0.784
PILA												
	series	first	last	year	mean	median	stdev	skew	sens1	sens2	gini	ar1
1	BC01PILA4	106	212	107	3.275	3.139	1.022	0.613	0.189	0.178	0.172	0.748
2	DC02PILA1	112	212	101	1.877	1.767	0.586	0.148	0.217	0.192	0.177	0.656
3	DC02PILA5	64	212	149	1.711	1.586	0.805	2.88	0.168	0.152	0.223	0.745
4	GRAN2PILA1	123	212	90	2.848	3.007	1.12	0.022	0.213	0.178	0.224	0.812
5	GRAN2PILA10	96	212	117	3.046	2.983	1.077	0.098	0.199	0.169	0.201	0.801
6	GRAN2PILA8	116	212	97	2.828	2.697	1.045	0.564	0.198	0.199	0.207	0.754
7	GRAN2PILA6	98	212	115	2.566	2.22	1.242	0.475	0.23	0.207	0.273	0.826
8	GRAN3PILA10	75	212	138	2.692	2.527	1.001	1.349	0.175	0.166	0.194	0.844
9	MC02PILA10	109	212	104	3.401	2.801	1.974	0.816	0.182	0.161	0.319	0.896
10	MCK01PILA4	1	212	212	0.763	0.556	0.477	1.463	0.196	0.2	0.319	0.842

11	RC02PILA8	115	212	98	2.71	2.453	1.012	0.802	0.175	0.16	0.205	0.837
12	RUB2PILA6	89	212	124	1.954	2.042	0.589	0.235	0.163	0.157	0.169	0.763
13	RUB2PILA4	104	212	109	1.158	1.121	0.38	1.103	0.178	0.169	0.169	0.702
14	RUB2PILA2	110	212	103	2.63	2.623	0.609	0.128	0.164	0.161	0.128	0.535
15	RUB3PILA7	99	212	114	3.168	2.909	0.797	0.728	0.118	0.118	0.139	0.793
16	UK01PILA4	133	212	80	2.95	2.852	1.027	0.049	0.241	0.207	0.195	0.697
17	ZC01PILA2	155	212	58	1.349	1.358	0.507	0.202	0.355	0.339	0.208	0.38
PIJE												
	series	first	last	year	mean	median	stdev	skew	sens1	sens2	gini	ar1
1	BLC01P1	241	352	112	1.407	1.141	1.057	1.172	0.181	0.162	0.395	0.902
2	BLC01P2	248	352	105	1.553	1.422	0.727	1.586	0.233	0.247	0.239	0.712
3	BLC01P3	239	352	114	1.724	1.189	1.346	0.982	0.162	0.138	0.415	0.933
4	BLC01P4	246	352	107	1.806	1.418	1.157	0.838	0.176	0.167	0.352	0.907
5	BLC01P5	257	352	96	2.133	1.998	1.106	1.573	0.193	0.193	0.267	0.805
6	BLC01P6	239	352	114	1.765	1.556	0.995	0.553	0.162	0.156	0.317	0.902
7	BLC01P7	244	352	109	2.5	2.479	1.381	0.475	0.152	0.151	0.31	0.887
8	BLC02P1	281	352	72	1.59	1.454	0.687	0.253	0.227	0.199	0.245	0.792
9	BLC02P3	272	352	81	1.633	1.315	1.005	0.968	0.192	0.161	0.333	0.923
10	BLC02P9	236	352	117	3.383	3.281	1.774	0.178	0.171	0.155	0.299	0.906
11	BLC02P4	278	352	75	2.226	2.084	0.989	0.506	0.129	0.13	0.249	0.913
12	BLC02P6	263	352	90	2.039	1.796	1.176	1.734	0.171	0.178	0.29	0.862
13	BLC02P5	251	352	102	3.016	2.48	1.886	0.727	0.228	0.204	0.346	0.857
14	BLC02P7	267	352	86	2.033	2.129	0.824	0.152	0.238	0.215	0.228	0.747
15	BLC02P8	267	352	86	2.235	2.107	0.915	1.31	0.189	0.173	0.213	0.67
16	BLK1P2	257	352	96	2.937	3.024	1.152	0.098	0.138	0.13	0.224	0.896
17	BLK1P3	277	352	76	4.577	3.864	2.643	0.764	0.163	0.173	0.318	0.895
18	BLK2P8	249	352	104	3.062	2.877	1.124	0.294	0.155	0.15	0.208	0.796
19	BLK2P7	253	352	100	1.906	1.898	0.944	0.284	0.231	0.217	0.277	0.792
20	BLK2P6	264	352	89	3.08	3.003	0.946	0.891	0.162	0.157	0.165	0.765
21	BLK3P9	236	352	117	2.999	2.881	1.133	0.745	0.202	0.203	0.207	0.704
22	BUI1P6	1	352	352	0.799	0.774	0.311	0.314	0.233	0.227	0.22	0.721

23	BUI1P1	254	352	99	1.51	1.287	0.707	1.494	0.221	0.208	0.24	0.781
24	BUI1P2	245	352	108	1.234	0.644	1.209	1.521	0.274	0.216	0.47	0.944
25	BUI1P3	245	352	108	1.616	1.204	1.296	2.214	0.241	0.207	0.37	0.847
26	BUI1P4	251	352	102	1.32	1.057	0.711	1.702	0.24	0.227	0.263	0.802
27	BUI2P1	278	352	75	2.244	2.071	1.065	0.547	0.177	0.161	0.265	0.864
28	BUI2P3	249	352	104	2.573	2.462	1.306	0.483	0.169	0.15	0.286	0.903
29	BUI2P5	266	352	87	2.391	2.494	1.052	0.444	0.202	0.181	0.245	0.791
30	BUI2P6	266	352	87	2.509	2.5	1.047	0.023	0.22	0.182	0.237	0.823
31	BUI2P8	250	352	103	1.897	1.835	1.076	1.24	0.2	0.176	0.299	0.877
32	BUI2P9	266	352	87	2.973	2.809	1.19	0.69	0.201	0.188	0.221	0.808
33	CASC1P5	273	352	80	3.4	3.156	0.844	0.503	0.182	0.177	0.138	0.605
34	CASC1P	267	352	86	2.658	2.449	1.193	0.676	0.26	0.264	0.25	0.642
35	CASC1P11	248	352	105	2.946	1.821	2.396	1.416	0.217	0.181	0.409	0.937
36	CASC1P8	250	352	103	2.674	2.325	1.371	1.892	0.284	0.282	0.25	0.627
37	CASC1P1	257	352	96	3.396	3.248	1.719	0.862	0.298	0.259	0.275	0.747
38	CASC1P4	279	352	74	3.072	2.894	0.94	0.595	0.243	0.236	0.17	0.492
39	CASC1P7	247	352	106	2.905	2.027	2.484	1.712	0.243	0.218	0.42	0.907
40	CASC2P1	258	352	95	1.964	1.755	0.784	0.952	0.22	0.209	0.215	0.714
41	CASC2P2	297	352	56	2.958	3.053	0.938	-0.123	0.268	0.255	0.177	0.498
42	CASC2P7	182	352	171	1.33	1.167	0.658	0.875	0.294	0.285	0.272	0.705
43	CASC2P3	190	352	163	2.304	2.251	0.905	0.313	0.215	0.214	0.223	0.727
44	CASC2P5	207	352	146	2.567	2.47	1.04	0.344	0.246	0.234	0.23	0.719
45	DC1P4	124	352	229	0.609	0.497	0.385	0.81	0.247	0.219	0.349	0.883
46	DC1P6	237	352	116	1.02	0.971	0.381	0.924	0.247	0.243	0.202	0.594
47	DC1P2	225	352	128	2.578	2.251	1.295	0.671	0.218	0.205	0.28	0.858
48	DC2P2	231	352	122	1.729	1.712	0.429	0.239	0.182	0.181	0.14	0.557
49	DC2P5	204	352	149	1.711	1.586	0.805	2.88	0.168	0.152	0.223	0.745
50	DC2P8	185	352	168	2.028	1.826	0.947	0.816	0.186	0.165	0.258	0.899
51	DC2P7	222	352	131	1.995	1.963	0.486	0.868	0.182	0.181	0.132	0.522
52	GC1P8	194	352	159	1.678	1.495	0.651	1.07	0.153	0.142	0.208	0.871
53	GC1P9	195	352	158	2.348	1.756	1.185	0.512	0.136	0.125	0.28	0.94

54	GC3P3	150	352	203	1.247	1.143	0.745	3.061	0.235	0.214	0.279	0.739
55	GC4P4	140	352	213	1.749	1.857	1.046	0.42	0.224	0.216	0.336	0.846
56	GRAN1P4	257	352	96	1.449	1.095	0.937	0.892	0.163	0.156	0.35	0.893
57	GRAN1P10	268	352	85	2.34	2.158	0.816	1.088	0.219	0.221	0.187	0.638
58	GRAN1P2	264	352	89	2.3	1.821	1.23	1.581	0.182	0.174	0.266	0.841
59	GRAN1P7	259	352	94	1.973	1.761	0.957	1.157	0.183	0.173	0.256	0.79
60	GRAN1P5	228	352	125	1.822	1.682	0.798	1.478	0.164	0.16	0.226	0.878
61	GRAN1P9	247	352	106	2.586	2.399	0.813	0.989	0.163	0.16	0.17	0.748
62	GRAN1P8	238	352	115	2.119	1.629	1.231	0.854	0.175	0.155	0.317	0.927
63	GRAN1P11	196	352	157	1.843	1.55	1.147	0.274	0.2	0.175	0.35	0.92
64	HT1P4	264	352	89	1.835	1.812	0.731	1.096	0.239	0.227	0.21	0.703
65	HT1P3	249	352	104	1.108	1.066	0.415	0.626	0.256	0.239	0.207	0.582
66	HT1P2	248	352	105	1.457	1.376	0.671	1.342	0.239	0.204	0.24	0.742
67	HT1P1	135	352	218	1.02	0.943	0.505	0.792	0.243	0.217	0.273	0.824
68	HT1P5	236	352	117	2.497	2.658	0.916	-0.194	0.24	0.212	0.206	0.69
69	HT1P6	278	352	75	2.392	2.412	0.972	0.015	0.262	0.225	0.232	0.761
70	HT1P7	161	352	192	1.629	1.559	0.715	1.134	0.275	0.256	0.233	0.716
71	HT2P1	284	352	69	1.53	1.519	0.469	-0.146	0.273	0.252	0.173	0.445
72	HT2P2	237	352	116	2.015	1.564	1.308	1.238	0.218	0.196	0.342	0.897
73	HT2P3	253	352	100	1.402	1.226	0.759	1.207	0.266	0.243	0.286	0.769
74	HT2P4	251	352	102	2.424	1.922	1.548	1.728	0.28	0.255	0.317	0.797
75	HT2P5	213	352	140	2.479	2.001	1.544	0.872	0.261	0.226	0.341	0.848
76	LC1P1	241	352	112	1.299	0.814	1.195	1.92	0.237	0.196	0.423	0.907
77	LC1P2	243	352	110	1.195	0.72	1.176	2.019	0.251	0.209	0.447	0.906
78	LC1P3	235	352	118	1.652	1.096	1.586	1.268	0.217	0.167	0.495	0.961
79	LC1P4	239	352	114	1.126	0.728	1.051	1.807	0.262	0.207	0.456	0.939
80	LC1P6	262	352	91	0.85	0.803	0.374	0.191	0.275	0.254	0.251	0.644
81	LC1P7	239	352	114	1.965	1.254	1.729	1.228	0.281	0.213	0.453	0.918
82	LC1P8	244	352	109	1.635	1.357	1.019	1.723	0.244	0.197	0.306	0.851
83	LC1P9	240	352	113	1.667	0.907	1.567	1.389	0.287	0.194	0.461	0.929
84	LC1P10	238	352	115	1.733	1.447	0.93	1.028	0.278	0.227	0.289	0.824

85	LC1P11	232	352	121	1.41	0.92	1.337	1.983	0.285	0.198	0.44	0.906
86	LC2P2	208	352	145	0.505	0.483	0.269	0.631	0.298	0.276	0.298	0.774
87	LC2P3	213	352	140	0.511	0.429	0.321	0.931	0.339	0.324	0.344	0.706
88	LC2P4	236	352	117	0.88	0.78	0.534	1.563	0.327	0.287	0.307	0.811
89	LC2P5	138	352	215	0.856	0.617	0.702	1.708	0.249	0.228	0.402	0.902
90	LC2P8	155	352	198	1.531	1.263	0.977	0.82	0.257	0.211	0.351	0.892
91	LC2P6	153	352	200	1.988	1.55	1.321	1.289	0.276	0.235	0.349	0.858
92	LC2P9	199	352	154	0.86	0.643	0.627	1.032	0.266	0.224	0.391	0.91
93	MC1P9	247	352	106	3.341	3.228	1.014	0.558	0.233	0.223	0.165	0.553
94	MC2P7	246	352	107	2.34	1.917	1.455	0.891	0.243	0.197	0.338	0.884
95	MC2P8	240	352	113	1.895	1.499	1.191	1.209	0.222	0.184	0.331	0.908
96	MC2P9	245	352	108	1.895	1.28	1.493	1.92	0.25	0.233	0.382	0.749
97	MC2P10	248	352	105	1.476	1.243	0.898	0.982	0.247	0.241	0.33	0.772
98	MC2P1	246	352	107	1.324	1.185	0.934	1.365	0.222	0.21	0.371	0.806
99	MC2P3	245	352	108	1.526	1.114	1.119	1.411	0.195	0.157	0.373	0.895
100	MC2P4	240	352	113	1.36	1.126	0.929	1.231	0.224	0.187	0.362	0.926
101	MC2P5	242	352	111	0.956	0.84	0.573	1.341	0.23	0.221	0.316	0.827
102	MC2P6	247	352	106	1.592	1.365	0.893	1.684	0.223	0.202	0.278	0.873
103	MCK1P6	191	352	162	1.062	0.911	0.762	0.391	0.216	0.192	0.406	0.915
104	MCK1P2	200	352	153	1.155	1.047	0.493	0.892	0.152	0.15	0.233	0.87
105	MCK1P8	157	352	196	1.093	0.98	0.463	0.703	0.165	0.162	0.236	0.861
106	MCK1P1	253	352	100	0.744	0.737	0.185	0.109	0.183	0.176	0.141	0.586
107	MCK1P5	174	352	179	1.048	0.768	0.71	0.937	0.199	0.178	0.365	0.928
108	MCK1P3	177	352	176	1.288	0.976	0.757	1.388	0.203	0.204	0.301	0.861
109	MEEKS2P4	242	352	111	2.364	2.061	1.241	0.335	0.176	0.154	0.298	0.909
110	MF1P1	270	352	83	1.15	0.926	0.674	1.452	0.211	0.207	0.292	0.843
111	MF1P2	278	352	75	1.775	1.71	0.834	0.625	0.219	0.195	0.262	0.81
112	MF1P3	288	352	65	1.321	1.382	0.405	-0.355	0.206	0.177	0.173	0.711
113	MF1P5	228	352	125	1.118	1.053	0.527	1.049	0.225	0.201	0.251	0.807
114	MF2P1	274	352	79	1.902	1.586	1.109	1.398	0.244	0.207	0.3	0.832
115	MF2P2	249	352	104	2.436	2.061	1.354	0.495	0.232	0.196	0.312	0.869

116	MF2P3	264	352	89	1.463	1.101	0.964	0.981	0.224	0.176	0.355	0.915
117	MF2P4	261	352	92	1.573	1.312	1.016	1.592	0.232	0.212	0.323	0.819
118	MF2P5	258	352	95	1.132	1.018	0.633	1.739	0.275	0.258	0.279	0.716
119	MF2P6	267	352	86	1.598	1.407	0.863	0.888	0.261	0.247	0.295	0.796
120	MF2P7	265	352	88	2.309	1.824	1.365	1.468	0.197	0.17	0.306	0.827
121	MF2P8	263	352	90	2.929	2.688	1.683	0.765	0.214	0.184	0.318	0.88
122	MF2P9	273	352	80	2.118	2.09	0.682	0.208	0.201	0.184	0.182	0.685
123	MF2P10	240	352	113	2.146	1.182	2.111	1.253	0.213	0.193	0.504	0.939
124	MF2P11	180	352	173	1.909	1.451	1.469	1.713	0.221	0.211	0.38	0.918
125	RC3P5	257	352	96	2.161	1.695	1.559	1.49	0.253	0.237	0.372	0.741
126	RUB3P4	248	352	105	1.961	1.87	0.88	0.466	0.174	0.17	0.25	0.822
127	SP2P7	231	352	122	2.557	2.402	1.082	0.587	0.151	0.149	0.237	0.877
128	SP2P9	249	352	104	2.378	1.844	1.748	0.916	0.176	0.18	0.394	0.899
129	SP2P10	242	352	111	3.134	2.496	1.906	0.651	0.159	0.151	0.336	0.892
130	SP2P8	236	352	117	1.759	1.121	1.502	0.9	0.231	0.196	0.458	0.897
131	SP2P11	245	352	108	3.065	2.449	1.541	0.91	0.189	0.176	0.271	0.87
132	SP2P1	236	352	117	2.12	1.572	1.385	0.817	0.165	0.142	0.355	0.924
133	SP2P2	247	352	106	1.871	1.53	1.211	0.779	0.185	0.176	0.356	0.883
134	SP2P3	185	352	168	1.951	1.831	1.338	1.602	0.214	0.202	0.356	0.899
135	SP2P5	245	352	108	1.937	1.596	1.386	0.853	0.161	0.156	0.392	0.905
136	TALL1P3	282	352	71	1.398	1.393	0.452	0.229	0.185	0.177	0.182	0.728
137	TALL1P4	287	352	66	0.931	0.725	0.496	1.046	0.215	0.185	0.283	0.857
138	TALL2P4	210	352	143	2.761	2.718	0.846	0.059	0.256	0.234	0.17	0.479
139	TALL2P6	87	352	266	1.5	1.508	0.821	0.723	0.196	0.191	0.305	0.864
140	TALL2P1	236	352	117	1.815	1.682	0.869	0.824	0.296	0.265	0.263	0.734
141	TALL2P3	252	352	101	2.187	1.526	1.684	1.273	0.316	0.278	0.399	0.83
142	UK1P1	287	352	66	1.753	1.439	0.91	1.473	0.262	0.237	0.266	0.74
143	UK1P2	285	352	68	2.594	2.422	0.812	0.53	0.194	0.177	0.175	0.715
144	WARD1P1	269	352	84	3.685	3.516	1.755	0.461	0.143	0.139	0.268	0.901
145	WARD1P2	259	352	94	2.778	2.11	2.076	0.901	0.189	0.169	0.406	0.93
146	WARD1P5	275	352	78	2.701	2.575	1.169	0.794	0.152	0.145	0.238	0.845

147	WARD1P4	267	352	86	2.871	2.593	1.244	0.876	0.164	0.158	0.237	0.841
148	WARD1P6	273	352	80	2.836	2.725	0.909	1.144	0.151	0.152	0.171	0.727
149	WARD1P8	253	352	100	2.637	2.205	1.178	0.856	0.189	0.172	0.244	0.853
150	WARD1P9	277	352	76	2.705	2.601	1.038	0.358	0.183	0.162	0.217	0.844
151	ZC1P1	254	352	99	1.406	1.322	0.529	0.352	0.23	0.206	0.211	0.745
152	ZC1P3	218	352	135	0.701	0.632	0.391	1.021	0.302	0.288	0.302	0.755
153	ZC2P1	124	352	229	1.036	0.91	0.595	1.244	0.264	0.254	0.306	0.749
154	ZC2P3	139	352	214	0.98	0.842	0.526	1.091	0.273	0.24	0.288	0.809
155	ZC2P5	158	352	195	1.118	1.069	0.458	0.942	0.283	0.257	0.221	0.622
156	ZC2P2	136	352	217	0.886	0.684	0.669	1.875	0.27	0.25	0.37	0.846
157	ZC2P8	155	352	198	0.993	0.857	0.52	1.107	0.288	0.279	0.281	0.701
158	ZC3P1	284	352	69	1.422	1.519	0.575	-0.144	0.234	0.228	0.23	0.733
159	ZC3P3	265	352	88	1.379	1.396	0.326	-0.008	0.204	0.198	0.132	0.466
160	ZC3P4	175	352	178	1.335	1.275	0.455	0.523	0.245	0.228	0.19	0.666
161	ZC3P5	129	352	224	0.791	0.626	0.496	0.803	0.253	0.219	0.345	0.891
162	ZC3P6	180	352	173	0.961	0.929	0.361	0.735	0.216	0.208	0.208	0.746
163	ZC3P7	1	352	352	1.098	0.874	0.765	1.538	0.274	0.234	0.355	0.893

Table S3: Sample size of cored trees by species, segregated by East and West side of the Lake Tahoe Basin.

Species	**Sample Size West**	**Sample Size East**
Abies concolor	64	8
Abies magnifica	14	0
Calocedrus decurrens	5	7
Pinus jeffreyi	59	100
Pinus lambertiana	16	2

Table S4: Pearson correlation coefficients used for annual increment core data

See attached supplemental file TableS4_CorrCoeff.xlsx

Table S5: Mean live tree basal area (m^2 ha^{-1}) by species by site for inventory plots. Orientation, East (E) and West (W) side of the Lake Tahoe Basin, is denoted for each site. Species codes are as follows: *Abies concolor* (ABCO), *A. magnifica* (ABMA), *Calocedrus decurrens* (CADE), *Pinus jeffreyi* (PIJE), *Pinus lambertiana* (PILA).

Site	Orientation	ABCO	ABMA	CADE	PIJE	PILA	TOTAL
BC	W	31.7	1.5	9.1	0	3.1	45.4
BLC	E	2.8	0	0	36.4	0	39.2
BLK	W	26.2	0	0	10.8	0	37.0
BUI	E	4.7	0	0	37.6	0	42.3
CASC	W	11.4	0	9.7	31	0	52.0
DC	W	12.7	0	3.2	9.7	9.1	34.6
GC	W	32.5	7.9	0	6.7	0	47.1
GRAN	W	44.0	1.0	1.7	17.6	8.4	66.9
HT	E	0	0	0	25.8	0	25.8
LC	E	4.6	0	0	39.6	0	44.2
MC	E	12.0	0	18.6	21.6	1.8	48.0
MCK	W	6.8	1.9	0	26	1.1	35.8
MEEKS	W	7.1	0	6.8	8.3	1.0	23.2
MF	E	4.2	0	0	48.4	0	52.6
RC	W	34.9	15.8	0	3.2	2.7	54.5
RUB	W	16.3	4.6	10.1	18.2	12.5	49.6
SP	E	0	0	0	60.8	0	60.8
TALL	W	33.6	0	0	32	0	65.6
TAY	W	5.1	0	0	15.1	0	17.6
WARD	W	20.0	0	0	27.6	0	47.7
ZC	E	3.1	0	0	31.0	5.3	38.3

Table S6: Mean dead tree basal area (m^2 ha^{-1}) by species by site for inventory plots. Orientation, East (E) and West (W) side of the Lake Tahoe Basin, is denoted for each site. Species codes are as follows: *Abies concolor* (ABCO), *A. magnifica* (ABMA), *Calocedrus decurrens* (CADE), *Pinus jeffreyi* (PIJE), *Pinus lambertiana* (PILA).

Site	Orientation	ABCO	ABMA	CADE	PIJE	PILA	TOTAL
BC	W	8.6	0	0	0	0	8.6
BLC	E	0	0	0	0	0	0
BLK	W	4.8	0	0	0	0	4.8

BUI	E	13.	0	0	0	0	1.3
CASC	W	2.3	0	0	0	0	2.3
DC	W	2.0	0	6.3	1.6	0	6.8
GC	W	9.4	0.7	1.3	1.1	0	12.5
GRAN	W	15.0	0	0	1.5	0	16.6
HT	E	1.1	0	0	0	0	1.1
LC	E	0.8	0	0	4.9	0	5.7
MC	E	7.8	0	4.8	0	0	12.7
MCK	W	4.7	5.6	0	0	0	10.3
MEEKS	W	0	0	2.2	0	1.0	3.2
MF	E	6.1	0	0	2.0	0	8.0
RC	W	4.0	7.9	0	0	1.5	13.5
RUB	W	12.7	1.2	0	0.9	0	14.7
SP	E	0	0	0	3.5	0	3.5
TALL	W	33.6	0	0	2.8	0	36.5
TAY	W	3.9	0	0	0	0	3.9
WARD	W	9.5	0	0	2.1	0	11.6
ZC	E	4.2	0	0	3.2	0	7.4

Table S7: Host species susceptibilities for each of the 3 beetle species modeled using the Biological Disturbance Agent (BDA) extension for LANDIS-II. Species codes are consistent with previous supplemental tables, with the following additional codes: *P. albicaulis* (PIAL), *P. contorta* (PICO), *P. monticola* (PIMO), *C. decurrens* (CADE),

Beetle species	**Dispersal rate**	**Host tree species**	**Minor host age**	**Moderate host age**	**Major host age**
Mountain pine beetle	400 m/yr	PILA	20	60	80
		PILA	20	60	80
		PICO	20	60	80
		PIMO	20	60	80
		CADE	20	60	80
Jeffrey pine beetle	600 m/yr	PIJE	15	25	40
Fir engraver	1000m/yr	ABCO	15	30	60

beetle				
	ABMA	15	30	60

Table S8: Linear regression models of ANPP ~ CWD for both high CWD and low CWD levels for tree ring-estaimted ANPP and all LANDIS-II model scenarios. Low CWD indicates all CWD values below 41mm, the determined break point in the linear regression.

CWD Level	Scenario	Slope	Intercept
Low CWD	Tree ring	1.06	135.72
Low CWD	LowM-noBB	2.37	165.97
Low CWD	LowMBB	1.51	133.85
Low CWD	HiMnoBB	1.79	145.92
Low CWD	HiMBB	0.73	124.86
High CWD	Tree ring	-7.45	503.17
High CWD	LowMnoBB	-11.06	732.11
High CWD	LowMBB	-7.3	508.11
High CWD	HiMnoBB	-9.92	641.78
High CWD	HiMBB	-6.08	413.8

Model Parameterization

Century Succession extension

Carbon dynamics were modeled using the Century Succession extension ('*Century*') for LANDIS-II, which is based on the CENTURY soil model (Parton et al. 1983). *Century* was calibrated and validated with available data to satisfy five model output targets: aboveground net primary productivity (ANPP), Net Ecosystem Production (NEP), aboveground live biomass, soil organic C (SOC), and soil inorganic nitrogen (mineral N) (Loudermilk et al. 2013). Further details on model development, parameterization, and calibration are in Loudermilk et al. (2013). Our simulations contained three functional groups (conifers, hardwoods, and shrubs) of which the conifers were most abundant. The 'conifer' group contained Jeffrey pine, sugar pine, whitebark pine, western white pine, lodgepole pine, white fir, red fir, incense cedar, and mountain hemlock. The 'hardwood' group consisted of quaking aspen (*Populus tremuloides*). The 'shrub' group consisted of four generic shrub types, Non N-fixing obligate seeding shrubs, Non N-fixing resprouting shrubs, N-fixing obligate seeding shrubs, and N-fixing resprouting shrubs.

Century utilizes monthly climate data, which influences tree establishment, growth, and regeneration (Scheller et al. 2011). Individual species' growth response to available soil moisture is dictated by two parameters; these parameters are assigned to broader functional groups to which each species belongs. These two parameters dictate moisture sensitivity by determining the ratio of available water content (AWC) to potential evapotranspiration (PET). The first parameter ('DroughtIntercept', in CENTURY: 'pprpts2') determines the effect of AWC on the intercept of this relationship, therefore if this value is increased, the intercept is raised and higher AWC is required to achieve the same PET. The second parameter ('DroughtRatio', in CENTURY: 'pprpts3') is the minimum ratio of AWC/PET at which there is no restriction on production, effectively determining the minimum AWC necessary for any growth to occur. The LANDIS-II *Century* extension requires calibration of these moisture-related parameters to accommodate unique species and soils combinations.

We simulated two levels of tree moisture sensitivity and two levels of bark beetle occurrence (with and without bark beetles, extension discussed below). We developed two levels of moisture sensitivity (low and high) by leaving DroughtIntercept constant and iteratively increasing the DroughtRatio parameter by the minimum amount (0.1) demonstrated to have a significant effect on the response variable (ANPP) because this parameter is not empirically derived. ‘Significant effect’ in this context is defined as 50% increase or reduction in ANPP, well above the tolerance of the calibration targets in Loudermilk et al (2013). We simulated both levels of DroughtRatio with both levels of bark beetle occurrence and the scenarios were named as follows: low moisture sensitivity with no beetles (LowM-noBB), low moisture sensitivity with beetles (LowM-BB), high moisture sensitivity with no beetles (HiM-noBB), and high moisture sensitivity with beetles (HiM-BB).

Using LANDIS-II, we ran five replicate 20-year simulations of each scenario for the 31,000 ha study area using a 100m x 100m grid and climate data from 1987-2006. Monthly temperature and precipitation values for 1987-2006 were from the PRISM dataset for the LTB, at a 4km resolution (18 PRISM tiles total across the study area). Although forest thinning operations and wildfires occurred in the LTB during 1987-2006 timeframe, there were no records or physical evidence of any recent fire (wildfire or prescribed burning) or thinning at the field locations where tree-cores were collected. We excluded these disturbances from out simulations to be congruent with field site disturbance history over the study period.

BDA parametrization extension

Three bark beetle species were modeled: the Jeffrey Pine Beetle (‘JPB’), the Mountain Pine Beetle (*Dendroctonus ponderosae,* ‘MPB’), and the Fir Engraver Beetle (*Scolytus ventralis,* ‘FEB’). Although there are other beetles active in the area (e.g. Red turpentine beetle (*Dendrocotnus valens*), these three beetles are responsible for the majority of the recorded damage in the LTB and there is very little overlap in host species. Empirical data from the literature and expert opinion were used to determine host species and ages most preferred by each of the three modeled beetle species (Table S7). JPB and FEB are limited in their primary host selection (Jeffrey pine and red/white fir respectively), whereas MPB is more of a generalist, impacting a variety of pine species across the basin (Cole and Amman 1980; Ferrell 1994; Bradley and Tueller 2001; Walker et al. 2007; Egan et al. 2010). Beetle dispersal is modeled within BDA, defined at an annual rate (m year^{-1}).

A widespread outbreak of bark beetles occurred in the region, concurrent with a severe drought that began in 1988. USFS Aerial Detection Survey (ADS) maps of the basin indicated >15,000 ha of damaged area during the peak year of the outbreak (1993). ADS maps include attribution of damage to specific beetle species on an annual basis, allowing us to use these survey data to calibrate each of the three beetle species modeled in this study. Total forest area impacted over the study period for each beetle species was 15,785 ha: mountain pine beetle (933 ha), Jeffrey pine beetle (3126 ha), and Fir engraver beetle (11726 ha).

Outbreaks are probabilistic at the site level, where the probability of a site being disturbed is based on the available hosts within site as well as neighboring resources (hosts). Individual host tree species are ranked (primary, secondary, minor, and non-host) and described by both species and age. In the LTB, the Jeffrey pine beetle (*Dendroctonus jeffreyi*) is an obligate of Jeffrey pine, though it prefers older cohorts (>60 years, primary host) much more than younger cohorts (<20 years old, minor host) (Egan et al., 2010). These host categorizations help determine 'site vulnerability' (Sturtevant et al., 2004). The severity of a simulated outbreak is a function of site vulnerability, classified as light, moderate, and severe. A 'light' outbreak kills all vulnerable cohorts; a 'moderate' outbreak kills all tolerant and vulnerable cohorts; and a 'severe' outbreak kills resistant, tolerant, and vulnerable cohorts. Outbreaks are synchronous across a landscape, and severity can be bounded by defining a minimum and maximum possible outbreak severity. The BDA extension reduces site and landscape ANPP through mortality of affected cohorts rather than direct reductions in cohort growth rates. Total forest area impacted over the study period for each beetle species was: mountain pine beetle (933 ha), Jeffrey pine beetle (3126 ha), and Fir engraver beetle (11726 ha). From the ADS flyover maps and expert opinion, total area affected by FEB required modest correction for two reasons; firstly, fir engravers are typically less aggressive (i.e., lower mortality percentage amongst affected stands) than species of genus *Dendroctonus*, killing fewer trees per hectare.

Because mortality within the BDA extension removes entire species/age cohorts on a given site rather than individual trees, this might lead to an overestimation of mortality of FEB hosts on affected sites. Secondly, FEB are generally restricted to areas dominated by their host species. Thus, areas defined as impacted by FEB on ADS maps may have overstated the total area affected by FEB because the full extent of all mapped FEB areas was not entirely fir-dominated. To correct for this overestimation, stand dominance by tree species was determined using biomass estimates within a 5 ha moving window across modeled sites. Stands that contained >75% red and white fir and were within an identified outbreak zone were determined to have likely been impacted, which could then be totaled to calculate total area affected by Fir Engraver. This correction factor was not applied to area affected by the two species of *Dendroctonus* beetles, as the flyover maps were reasonable estimates of damage. Therefore, area affected by each beetle species was calibrated to reproduce the following: mountain pine beetle (933 ha), Jeffrey pine beetle (3126 ha), and fir engraver (8795 ha). Total area affected in the peak outbreak year of 1993 within the model was 10,418 ha, compared to remotely sensed estimates of 15,783 ha. Mortality from beetle outbreaks within our simulations began 3 years after the severe drought event in 1988 and lasted for 7 years; a period which matches flyover maps and local opinion (USDA Forest Service Pacific Southwest Region 2013).

Supplemental References

USDA Forest Service Pacific Southwest Region. 2013. Region 5 Aerial Detection Monitoring. http://www.fs.usda.gov/detail/r5/forest-grasslandhealth/?cid=fsbdev3_046696. Accessed October 2012.

	Abies concolor_DBH	67.9	23.4	33.2	72.5	59	48.3	41	19.6	32.6	56.7	59.1
west	67.9	1.000										
west	23.4	0.993	1.000									
west	33.2	0.985	0.997	1.000								
west	72.5	0.998	0.985	0.978	1.000							
west	59	0.994	0.998	0.999	0.985	1.000						
west	48.3	0.998	0.986	0.975	0.998	0.986	1.000					
west	41	0.998	0.996	0.998	0.994	0.999	0.995	1.000				
west	19.6	0.999	0.999	0.999	0.998	1.000	0.998	0.999	1.000			
west	32.6	0.991	0.982	0.987	0.991	0.984	0.988	0.988	0.991	1.000		
west	56.7	0.985	0.992	0.997	0.979	0.996	0.976	0.996	0.983	0.987	1.000	
west	59.1	0.987	0.995	0.997	0.981	0.999	0.987	0.999	0.999	0.992	0.994	1.000
west	39	0.978	0.993	0.994	0.963	0.993	0.966	0.988	0.995	0.959	0.984	0.990
west	36.5	0.998	0.994	0.995	0.995	0.997	0.995	0.999	0.999	0.992	0.994	0.998
west	76.9	0.991	0.993	0.995	0.973	0.996	0.991	0.998	0.993	0.996	0.995	0.998
west	26.2	0.998	0.993	0.981	0.998	0.993	0.998	0.999	0.998	0.989	0.987	0.987
west	26.4	0.998	0.996	0.996	0.993	0.998	0.994	0.999	0.998	0.993	0.994	0.999
west	22	0.943	0.977	0.985	0.915	0.983	0.937	0.976	0.984	0.949	0.973	0.979
west	20.2	0.989	0.973	0.976	0.995	0.979	0.992	0.987	0.970	0.995	0.986	0.982
west	37.6	0.994	0.991	0.993	0.992	0.995	0.992	0.997	0.991	0.994	0.996	0.994
west	69.4	0.996	0.992	0.990	0.989	0.994	0.996	0.998	0.995	0.996	0.993	0.995
west	40.8	0.988	0.996	0.999	0.979	0.999	0.982	0.998	0.998	0.989	0.995	0.999
west	27.1	0.999	0.991	0.985	0.998	0.991	0.999	0.998	0.998	0.993	0.982	0.992
west	28.2	0.995	0.998	0.993	0.990	0.997	0.990	0.995	0.996	0.984	0.991	0.996
west	32.1	0.998	0.995	0.989	0.997	0.995	0.996	0.999	0.994	0.993	0.993	0.993
west	22.1	0.996	0.996	0.998	0.994	0.998	0.995	0.998	0.996	0.982	0.992	0.999
west	48.4	0.990	0.994	0.998	0.985	0.998	0.983	0.999	0.997	0.993	0.997	0.999
west	36.2	0.990	0.994	0.994	0.981	0.994	0.984	0.992	0.991	0.970	0.985	0.995
west	54.1	0.990	0.997	0.998	0.984	0.999	0.983	0.997	1.000	0.987	0.995	0.999
west	38.4	0.998	0.996	0.990	0.996	0.998	0.995	0.999	0.998	0.991	0.993	0.995
west	24.9	0.991	0.987	0.973	0.987	0.986	0.991	0.992	0.986	0.972	0.963	0.981
west	22.9	0.997	0.996	0.992	0.990	0.997	0.992	0.996	0.993	0.986	0.984	0.996
west	48.3	0.994	0.996	0.997	0.989	0.999	0.987	0.998	0.999	0.988	0.994	0.998
west	41.2	0.998	0.996	0.992	0.994	0.998	0.994	0.999	0.998	0.991	0.992	0.997
west	34.6	0.989	0.996	0.999	0.981	0.999	0.981	0.997	1.000	0.984	0.996	0.997
west	47.2	0.986	0.994	0.997	0.979	0.997	0.978	0.993	0.994	0.982	0.990	0.998
west	22.8	0.996	0.997	0.998	0.989	0.999	0.991	0.999	0.998	0.988	0.996	0.998
west	13.6	0.995	0.990	0.981	0.995	0.988	0.996	0.996	0.998	0.982	0.975	0.988
west	13	0.996	0.995	0.998	0.996	0.997	0.998	0.998	0.998	0.991	0.974	0.998
west	26.5	0.990	0.998	0.998	0.980	0.997	0.983	0.995	0.998	0.969	0.989	0.996
west	19.5	0.992	0.997	0.997	0.982	0.997	0.985	0.995	0.996	0.973	0.987	0.997
west	38.7	0.969	0.985	0.991	0.956	0.988	0.956	0.982	0.987	0.960	0.980	0.987
west	64	0.996	0.984	0.970	0.996	0.985	0.996	0.992	0.996	0.987	0.975	0.977
west	69.9	0.989	0.950	0.949	0.981	0.945	0.994	0.958	0.961	0.980	0.948	0.974
west	38.3	0.984	0.994	0.999	0.977	1.000	0.974	0.999	0.999	0.989	0.997	0.998
west	72.4	0.997	0.991	0.988	0.987	0.992	0.997	0.997	0.999	0.995	0.988	0.995
west	42.3	0.997	0.995	0.995	0.992	0.998	0.991	0.998	0.998	0.992	0.992	0.999
west	49	0.990	0.997	0.997	0.984	0.998	0.983	0.995	0.998	0.983	0.993	0.997
west	34.5	0.997	0.997	0.998	0.991	0.999	0.992	1.000	0.999	0.989	0.996	0.999
west	23.5	0.992	0.998	0.999	0.985	0.999	0.986	0.998	0.997	0.982	0.997	0.996
west	30.3	0.999	0.991	0.985	0.998	0.993	0.998	0.997	0.998	0.994	0.985	0.992
west	44.2	0.992	0.996	0.998	0.985	0.999	0.984	0.998	0.999	0.989	0.994	0.999
west	47.6	0.998	0.991	0.991	0.994	0.993	0.995	0.996	0.995	0.996	0.988	0.997
west	34.8	0.984	0.994	0.998	0.973	0.998	0.973	0.994	0.998	0.976	0.993	0.995

west	17.2	0.988	0.966	0.971	0.996	0.976	0.995	0.984	0.988	0.996	0.980	0.981
west	20.3	0.991	0.995	0.991	0.984	0.996	0.985	0.991	0.994	0.977	0.987	0.994
west	23.8	0.978	0.985	0.993	0.971	0.989	0.966	0.984	0.991	0.963	0.982	0.979
west	21.3	0.989	0.997	0.999	0.978	0.999	0.979	0.998	1.000	0.980	0.995	0.997
west	67.3	0.981	0.993	0.997	0.974	0.994	0.976	0.989	0.994	0.974	0.987	0.996
west	18.8	0.996	0.986	0.986	0.996	0.989	0.996	0.995	0.999	0.985	0.982	0.994
west	21	0.993	0.997	0.995	0.986	0.999	0.986	0.996	0.998	0.983	0.992	0.997
west	42	0.945	0.968	0.955	0.949	0.953	0.983	0.963	0.957	0.957	0.967	0.956
west	37.7	0.997	0.995	0.986	0.995	0.997	0.995	0.998	0.993	0.989	0.990	0.991
west	18.8	0.995	0.994	0.995	0.989	0.996	0.989	0.995	0.990	0.990	0.989	0.999
west	55.8	0.976	0.992	0.997	0.967	0.997	0.964	0.993	0.998	0.976	0.991	0.994
east	24.3	0.994	0.991	0.992	0.986	0.994	0.991	0.993	0.984	0.978	0.984	0.997
east	39.9	0.989	0.995	0.997	0.981	0.997	0.983	0.994	0.991	0.984	0.990	0.998
east	31.6	0.994	0.997	0.998	0.984	0.998	0.988	0.997	0.996	0.982	0.991	0.999
east	18.7	0.998	0.990	0.993	0.999	0.995	0.998	0.998	0.997	0.994	0.994	0.996
east	48.9	0.990	0.996	0.996	0.988	0.997	0.984	0.993	0.996	0.981	0.990	0.985
east	28	0.973	0.977	0.941	0.970	0.970	0.976	0.962	0.956	0.941	0.952	0.954
east	23.7	0.992	0.981	0.963	0.994	0.980	0.995	0.987	0.975	0.983	0.977	0.974
east	13.7	0.988	0.963	0.968	0.995	0.972	0.994	0.982	0.983	0.994	0.975	0.979

39	36.5	76.9	26.2	26.4	22	20.2	37.6	69.4	40.8	27.1	28.2	32.1	22.1	48.4	36.2
1.000															
0.983	1.000														
0.979	0.998	1.000													
0.977	0.999	0.991	1.000												
0.985	0.999	0.999	0.998	1.000											
0.997	0.969	0.901	0.940	0.971	1.000										
0.951	0.990	0.992	0.992	0.988	0.931	1.000									
0.976	0.997	0.999	0.996	0.997	0.961	0.991	1.000								
0.976	0.999	0.998	0.996	0.998	0.955	0.995	0.998	1.000							
0.994	0.995	0.996	0.982	0.997	0.983	0.976	0.993	0.992	1.000						
0.973	0.998	0.994	0.999	0.997	0.951	0.991	0.995	0.996	0.987	1.000					
0.994	0.994	0.994	0.994	0.995	0.973	0.972	0.987	0.995	0.995	0.990	1.000				
0.981	0.999	0.996	0.998	0.999	0.953	0.992	0.997	0.999	0.990	0.996	0.997	1.000			
0.991	0.997	0.993	0.997	0.998	0.983	0.982	0.993	0.994	1.000	0.996	0.997	0.997	1.000		
0.988	0.998	0.998	0.988	0.999	0.978	0.986	0.997	0.995	0.999	0.989	0.995	0.994	0.999	1.000	
0.995	0.991	0.985	0.990	0.992	0.990	0.967	0.982	0.985	0.995	0.988	0.998	0.990	0.994	0.993	1.000
0.994	0.996	0.996	0.985	0.997	0.981	0.976	0.990	0.993	0.999	0.988	0.997	0.992	0.997	0.998	0.997
0.984	0.999	0.997	0.998	0.999	0.958	0.989	0.997	0.999	0.992	0.996	0.996	0.999	0.997	0.994	0.990
0.979	0.991	0.977	0.989	0.988	0.949	0.968	0.981	0.981	0.977	0.992	0.986	0.984	0.995	0.975	0.997
0.990	0.994	0.993	0.995	0.997	0.971	0.973	0.990	0.993	0.994	0.995	0.996	0.995	0.997	0.992	0.995
0.994	0.996	0.996	0.992	0.997	0.975	0.977	0.992	0.996	0.997	0.989	0.998	0.996	0.998	0.998	0.997
0.986	0.999	0.997	0.998	0.999	0.964	0.985	0.996	0.998	0.994	0.995	0.996	0.998	0.997	0.995	0.992
0.996	0.994	0.995	0.984	0.995	0.981	0.974	0.992	0.993	0.998	0.982	0.996	0.991	0.998	0.998	0.995
0.997	0.991	0.991	0.983	0.993	0.989	0.965	0.984	0.989	0.998	0.983	0.996	0.989	0.996	0.996	0.998
0.988	0.998	0.997	0.997	0.999	0.978	0.985	0.997	0.996	0.999	0.995	0.996	0.998	0.999	1.000	0.993
0.976	0.995	0.986	0.995	0.992	0.953	0.982	0.986	0.989	0.983	0.996	0.990	0.991	0.998	0.983	0.994
0.997	0.996	0.990	0.998	0.998	0.990	0.964	0.989	0.992	0.998	0.998	0.998	0.994	0.998	0.998	0.995
0.998	0.992	0.987	0.990	0.993	0.992	0.967	0.986	0.986	0.998	0.988	0.998	0.990	0.996	0.994	0.998
0.997	0.993	0.988	0.991	0.994	0.991	0.969	0.987	0.987	0.998	0.990	0.998	0.991	0.997	0.995	0.998
0.999	0.976	0.975	0.968	0.978	0.998	0.941	0.968	0.971	0.991	0.962	0.988	0.974	0.988	0.986	0.993
0.963	0.994	0.984	0.998	0.993	0.933	0.992	0.992	0.992	0.971	0.998	0.986	0.994	0.992	0.979	0.979
0.906	0.965	0.988	0.988	0.964	0.870	0.987	0.966	0.991	0.962	0.982	0.966	0.983	0.950	0.961	0.932
0.991	0.997	0.995	0.980	0.998	0.984	0.982	0.996	0.990	0.999	0.985	0.991	0.988	0.999	0.999	0.994
0.975	0.998	0.997	0.996	0.998	0.899	0.993	0.995	1.000	0.992	0.998	0.995	0.998	0.996	0.994	0.988
0.989	0.998	0.997	0.996	0.998	0.973	0.982	0.994	0.997	0.998	0.994	0.997	0.997	0.999	0.997	0.995
0.997	0.993	0.993	0.989	0.994	0.983	0.969	0.987	0.992	0.998	0.985	0.999	0.993	0.997	0.997	0.998
0.989	0.999	0.997	0.997	0.999	0.977	0.986	0.996	0.997	0.998	0.996	0.997	0.999	0.999	0.999	0.994
0.990	0.996	0.996	0.994	0.997	0.979	0.981	0.996	0.994	0.998	0.992	0.996	0.996	0.997	0.998	0.992
0.974	0.998	0.995	0.999	0.998	0.948	0.993	0.997	0.998	0.988	0.999	0.991	0.998	0.995	0.990	0.985
0.994	0.996	0.996	0.990	0.997	0.982	0.977	0.992	0.994	0.999	0.988	0.997	0.994	0.999	0.999	0.996
0.978	0.996	0.997	0.997	0.998	0.963	0.988	0.995	0.998	0.994	0.996	0.993	0.998	0.995	0.996	0.988
0.996	0.991	0.990	0.983	0.991	0.988	0.966	0.988	0.986	0.997	0.979	0.993	0.987	0.994	0.994	0.992

0.947	0.986	0.989	0.991	0.985	0.930	0.996	0.988	0.993	0.975	0.991	0.967	0.989	0.982	0.984	0.963
0.998	0.988	0.989	0.990	0.991	0.976	0.959	0.981	0.989	0.993	0.983	0.997	0.991	0.993	0.990	0.996
0.999	0.977	0.977	0.966	0.980	0.969	0.943	0.972	0.977	0.989	0.961	0.984	0.974	0.991	0.988	0.992
0.994	0.995	0.993	0.988	0.995	0.985	0.977	0.994	0.990	0.998	0.985	0.995	0.992	0.997	0.997	0.994
1.000	0.985	0.992	0.976	0.988	0.982	0.954	0.978	0.990	0.997	0.975	0.993	0.984	0.992	0.993	0.997
0.977	0.995	0.989	0.996	0.992	0.965	0.985	0.986	0.992	0.987	0.996	0.990	0.993	0.996	0.990	0.991
0.997	0.993	0.993	0.992	0.995	0.978	0.969	0.988	0.993	0.997	0.987	0.999	0.995	0.997	0.995	0.997
0.954	0.951	0.898	0.966	0.966	0.971	0.962	0.966	0.962	0.976	0.967	0.976	0.972	0.977	0.975	0.963
0.981	0.998	0.995	0.998	0.998	0.951	0.989	0.997	0.997	0.989	0.996	0.993	0.997	0.993	0.989	0.987
0.990	0.994	0.995	0.993	0.997	0.977	0.975	0.989	0.995	0.998	0.991	0.997	0.995	0.998	0.997	0.996
0.999	0.990	0.986	0.973	0.991	0.993	0.963	0.984	0.982	0.996	0.976	0.989	0.981	0.995	0.994	0.997
0.990	0.993	0.987	0.993	0.994	0.985	0.973	0.985	0.989	0.995	0.993	0.996	0.992	0.997	0.995	0.997
0.996	0.992	0.994	0.984	0.994	0.984	0.968	0.985	0.992	0.999	0.985	0.997	0.991	0.997	0.997	0.999
0.994	0.995	0.993	0.993	0.997	0.986	0.974	0.990	0.992	0.999	0.991	0.997	0.994	0.999	0.998	0.997
0.977	0.997	0.999	0.998	0.999	0.964	0.992	0.998	0.999	0.995	0.999	0.987	0.998	0.996	0.998	0.982
0.998	0.990	0.986	0.989	0.993	0.958	0.963	0.984	0.989	0.986	0.983	0.998	0.993	0.996	0.996	0.998
0.978	0.964	0.951	0.977	0.971	0.916	0.927	0.944	0.960	0.949	0.976	0.971	0.968	0.965	0.947	0.987
0.953	0.990	0.983	0.995	0.991	0.912	0.998	0.993	0.989	0.968	0.995	0.980	0.991	0.980	0.974	0.967
0.945	0.984	0.986	0.990	0.983	0.928	0.995	0.984	0.990	0.972	0.990	0.966	0.987	0.981	0.982	0.964

54.1	38.4	24.9	22.9	48.3	41.2	34.6	47.2	22.8	13.6	13	26.5	19.5	38.7	64	69.9

1.000															
0.994	1.000														
0.979	0.984	1.000													
0.993	0.996	0.992	1.000												
0.998	0.996	0.979	0.994	1.000											
0.995	1.000	0.985	0.997	0.996	1.000										
0.999	0.992	0.971	0.991	0.998	0.992	1.000									
0.998	0.990	0.976	0.992	0.998	0.991	0.998	1.000								
0.997	0.998	0.991	0.997	0.998	0.998	0.998	0.994	1.000							
0.987	0.991	0.997	0.992	0.986	0.990	0.979	0.982	0.991	1.000						
0.999	0.994	0.989	0.994	0.998	0.994	0.998	0.997	0.999	0.998	1.000					
0.999	0.992	0.996	0.997	0.998	0.994	0.999	0.999	0.995	0.993	0.998	1.000				
0.998	0.993	0.997	0.998	0.999	0.994	0.998	0.999	0.995	0.994	0.996	0.999	1.000			
0.990	0.976	0.960	0.980	0.990	0.978	0.993	0.996	0.983	0.963	0.991	0.996	0.994	1.000		
0.975	0.994	0.989	0.991	0.983	0.993	0.975	0.972	0.989	0.993	0.997	0.978	0.981	0.953	1.000	
0.960	0.978	0.967	0.963	0.965	0.973	0.958	0.947	0.953	0.973	0.956	0.926	0.932	0.907	0.992	1.000
0.997	0.989	0.969	0.990	0.996	0.991	0.998	0.997	1.000	0.979	0.998	0.996	0.996	0.989	0.969	0.950
0.993	0.998	0.986	0.995	0.995	0.998	0.991	0.989	0.995	0.993	0.999	0.987	0.989	0.970	0.993	0.993
0.997	0.998	0.984	0.997	0.998	0.999	0.995	0.996	0.998	0.989	0.998	0.995	0.997	0.984	0.990	0.966
0.999	0.994	0.979	0.994	0.999	0.994	0.999	0.999	0.996	0.984	0.999	0.999	0.999	0.993	0.979	0.953
0.998	0.999	0.990	0.997	0.999	0.999	0.997	0.995	0.999	0.993	0.998	0.996	0.996	0.983	0.991	0.957
0.997	0.996	0.989	0.995	0.997	0.996	0.999	0.993	0.999	0.990	0.996	0.995	0.995	0.984	0.985	0.944
0.988	0.998	0.987	0.995	0.989	0.997	0.983	0.982	0.996	0.992	0.998	0.985	0.987	0.964	0.998	0.985
0.999	0.995	0.978	0.995	0.999	0.996	0.999	0.999	0.998	0.984	0.999	0.998	0.999	0.991	0.981	0.957
0.992	0.997	0.984	0.996	0.994	0.997	0.989	0.990	0.996	0.989	0.996	0.987	0.990	0.974	0.994	0.974
0.996	0.992	0.970	0.990	0.997	0.993	0.999	0.996	0.994	0.974	0.993	0.997	0.996	0.992	0.971	0.928

0.971	0.986	0.965	0.972	0.974	0.983	0.969	0.963	0.982	0.978	0.991	0.963	0.966	0.940	0.992	0.992
0.995	0.994	0.981	0.995	0.996	0.995	0.993	0.995	0.991	0.983	0.996	0.999	0.998	0.990	0.982	0.953
0.991	0.973	0.957	0.980	0.989	0.976	0.994	0.995	0.986	0.960	0.993	0.996	0.995	0.999	0.966	0.941
0.997	0.995	0.978	0.993	0.997	0.996	0.999	0.996	0.998	0.981	0.997	0.997	0.997	0.989	0.978	0.935
0.997	0.985	0.972	0.989	0.995	0.987	0.997	0.999	0.990	0.976	0.996	0.999	0.998	0.998	0.975	0.966
0.992	0.994	0.993	0.990	0.992	0.993	0.985	0.988	0.990	0.998	0.998	0.990	0.991	0.971	0.992	0.967
0.998	0.996	0.981	0.996	0.998	0.997	0.997	0.997	0.996	0.985	0.998	1.000	0.999	0.991	0.984	0.958
0.964	0.955	0.960	0.962	0.943	0.946	0.970	0.970	0.972	0.972	0.960	0.963	0.959	0.979	0.952	0.955
0.990	0.999	0.984	0.995	0.991	0.999	0.987	0.984	0.996	0.990	0.982	0.989	0.990	0.969	0.994	0.979
0.997	0.996	0.984	0.997	0.998	0.996	0.995	0.997	0.996	0.988	0.990	0.995	0.997	0.987	0.987	0.963
0.996	0.981	0.967	0.987	0.994	0.986	0.997	0.998	0.993	0.975	0.998	0.999	0.999	0.997	0.959	0.930
0.995	0.992	0.998	0.997	0.995	0.993	0.992	0.997	0.994	0.995	0.989	0.995	0.996	0.989	0.987	0.945
0.998	0.991	0.979	0.994	0.998	0.992	0.998	0.999	0.995	0.984	0.993	0.999	0.999	0.995	0.975	0.960
0.998	0.996	0.991	0.998	0.998	0.997	0.997	0.998	0.997	0.990	0.996	0.998	0.999	0.991	0.985	0.944
0.990	0.998	0.985	0.992	0.993	0.997	0.992	0.986	0.997	0.992	0.996	0.987	0.988	0.971	0.997	0.972
0.996	0.992	0.979	0.994	0.998	0.993	0.995	0.999	0.994	0.982	0.996	0.999	0.999	0.994	0.985	0.965
0.955	0.972	0.990	0.985	0.962	0.974	0.950	0.954	0.964	0.985	0.968	0.980	0.982	0.958	0.976	0.953
0.970	0.991	0.979	0.985	0.977	0.989	0.967	0.963	0.986	0.985	0.977	0.966	0.969	0.942	0.997	0.992
0.969	0.984	0.967	0.970	0.972	0.980	0.965	0.962	0.979	0.979	0.991	0.961	0.965	0.937	0.993	0.992

38.3	72.4	42.3	49	34.5	23.5	30.3	44.2	47.6	34.8	17.2	20.3	23.8	21.3	67.3	18.8

1.000									
0.988	1.000								
0.995	0.997	1.000							
0.996	0.991	0.997	1.000						
0.999	0.996	0.999	0.997	1.000					
0.999	0.992	0.995	0.996	0.998	1.000				
0.984	0.998	0.995	0.986	0.996	0.992	1.000			
0.998	0.994	0.999	0.999	0.999	0.997	0.989	1.000		
0.993	0.999	0.998	0.991	0.996	0.991	0.998	0.995	1.000	
0.997	0.983	0.993	0.997	0.994	0.996	0.982	0.997	0.985	1.000

0.980	0.993	0.982	0.964	0.982	0.975	0.993	0.976	0.990	0.962	1.000					
0.988	0.989	0.996	0.997	0.993	0.991	0.987	0.995	0.988	0.996	0.958	1.000				
0.992	0.975	0.983	0.991	0.984	0.987	0.962	0.990	0.974	0.993	0.941	0.985	1.000			
0.999	0.987	0.996	0.997	0.997	0.999	0.988	0.998	0.989	0.998	0.973	0.995	0.992	1.000		
0.995	0.990	0.992	0.998	0.991	0.991	0.976	0.996	0.984	0.996	0.950	0.993	0.987	0.995	1.000	
0.989	0.996	0.994	0.988	0.993	0.987	0.993	0.991	0.992	0.981	0.984	0.985	0.969	0.986	0.980	1.000
0.993	0.993	0.998	0.999	0.997	0.996	0.989	0.998	0.992	0.997	0.966	0.999	0.988	0.998	0.995	0.988
0.965	0.961	0.969	0.971	0.968	0.962	0.973	0.969	0.960	0.927	0.977	0.969	0.964	0.941	0.972	0.955
0.984	0.996	0.996	0.989	0.998	0.995	0.998	0.990	0.994	0.989	0.985	0.992	0.966	0.994	0.979	0.991
0.995	0.996	0.999	0.997	0.997	0.992	0.992	0.999	0.997	0.992	0.976	0.995	0.986	0.994	0.994	0.991
0.997	0.980	0.991	0.995	0.994	0.994	0.974	0.996	0.984	0.998	0.960	0.989	0.997	0.997	0.998	0.985
0.994	0.992	0.997	0.995	0.995	0.991	0.991	0.997	0.993	0.989	0.973	0.994	0.987	0.992	0.992	0.993
0.996	0.992	0.997	0.999	0.996	0.994	0.985	0.999	0.992	0.995	0.966	0.995	0.993	0.996	0.999	0.988
0.998	0.993	0.999	0.998	0.998	0.996	0.992	0.999	0.994	0.995	0.973	0.997	0.991	0.997	0.996	0.990
0.997	0.999	0.996	0.988	0.997	0.994	0.999	0.994	0.997	0.989	0.992	0.983	0.975	0.993	0.979	0.993
0.994	0.988	0.996	1.000	0.995	0.994	0.985	0.998	0.990	0.997	0.958	0.997	0.993	0.997	0.987	0.985
0.936	0.965	0.974	0.964	0.971	0.960	0.974	0.961	0.973	0.967	0.923	0.980	0.933	0.965	0.950	0.976
0.962	0.990	0.985	0.972	0.987	0.981	0.997	0.974	0.992	0.968	0.996	0.976	0.937	0.975	0.955	0.983
0.977	0.992	0.981	0.963	0.980	0.972	0.992	0.973	0.989	0.957	0.999	0.955	0.938	0.969	0.948	0.984

21	42	37.7	18.8	55.8	24.3	39.9	31.6	18.7	48.9	28	23.7	13.7

1.000												
0.966	1.000											
0.993	0.949	1.000										
0.997	0.975	0.991	1.000									
0.992	0.961	0.977	0.991	1.000								
0.995	0.978	0.988	0.998	0.993	1.000							
0.997	0.978	0.985	0.998	0.996	0.998	1.000						
0.999	0.969	0.993	0.999	0.997	0.997	0.999	1.000					
0.989	0.962	0.997	0.992	0.985	0.988	0.987	0.992	1.000				
0.999	0.967	0.988	0.997	0.995	0.995	0.992	0.998	0.985	1.000			
0.973	0.980	0.973	0.970	0.938	0.984	0.957	0.979	0.945	0.963	1.000		
0.978	0.976	0.993	0.979	0.948	0.975	0.967	0.978	0.993	0.970	0.972	1.000	
0.963	0.968	0.981	0.976	0.957	0.974	0.966	0.972	0.990	0.957	0.931	0.995	1.000

	Abies magnifica_DBH	12.4	25.1	53.3	42.1	45.4	14.6	30.3	14.9	48.8	13.2	19.3
west	12.4	1.000										
west	25.1	0.953	1.000									
west	53.3	0.989	0.975	1.000								
west	42.1	0.984	0.992	0.988	1.000							
west	45.4	0.960	0.999	0.973	0.985	1.000						
west	14.6	0.961	0.999	0.997	0.993	0.994	1.000					
west	30.3	0.977	0.956	0.988	0.987	0.957	0.994	1.000				
west	14.9	0.981	0.985	0.994	0.998	0.991	0.987	0.998	1.000			
west	48.8	0.983	0.945	0.983	0.980	0.956	0.986	0.996	0.996	1.000		
west	13.2	0.995	0.995	0.993	0.990	0.999	0.991	0.989	0.996	0.998	1.000	
west	19.3	0.981	0.996	0.992	0.993	0.995	0.997	0.973	0.996	0.951	0.992	1.000
west	39.3	0.983	0.995	0.990	0.992	0.993	0.986	0.969	0.999	0.947	0.999	0.998
west	64.1	0.988	0.992	0.986	0.999	0.977	0.997	0.989	0.996	0.980	0.991	0.992
west	50.6	0.992	0.991	0.961	0.988	0.987	0.986	0.977	0.997	0.947	0.999	0.998

39.3	64.1	50.6

1.000		
0.992	1.000	
0.999	0.988	1.000

	Calocedrus decurrens_DBH	19.5	51.4	56.3	78.9	76.3	19.4	37.3	54.7	47.5	60.9
west	19.5	1.000									
west	51.4	0.993	1.000								
west	56.3	0.970	0.991	1.000							
west	78.9	0.997	0.981	0.994	1.000						
west	76.3	0.999	0.993	0.994	0.991	1.000					
east	19.4	0.984	0.979	0.935	0.975	0.980	1.000				
east	37.3	0.995	0.993	0.989	0.996	0.997	0.995	1.000			
east	54.7	0.990	0.999	0.987	0.998	0.995	0.977	0.995	1.000		
east	47.5	0.986	0.992	0.964	0.987	0.988	0.938	0.977	0.989	1.000	
east	60.9	0.996	0.998	0.983	0.999	0.997	0.987	0.996	0.998	0.990	1.000
east	33.2	0.990	0.993	0.966	0.987	0.987	0.971	0.980	0.992	0.989	0.990
east	25.7	0.998	0.993	0.979	0.998	0.998	0.978	0.998	0.993	0.980	0.997

33.2	25.7

1.000	
0.981	1.000

Pinus Jeffreyi_DBH	56.3	57.5	63.6	38.1	54.8	70.1	54.3	45.7	61.8	62.6	55	65.1	45.4
56.3	1.000												
57.5	0.992	1.000											
63.6	0.993	0.992	1.000										
38.1	0.953	0.987	0.965	1.000									
54.8	0.983	0.996	0.995	0.991	1.000								
70.1	0.982	0.993	0.989	0.988	0.996	1.000							
54.3	0.995	0.991	0.998	0.977	0.994	0.994	1.000						
45.7	0.995	0.994	0.988	0.978	0.988	0.991	0.987	1.000					
61.8	0.977	0.978	0.959	0.910	0.947	0.946	0.952	0.984	1.000				
62.6	0.868	0.929	0.882	0.935	0.918	0.880	0.853	0.916	0.944	1.000			
55	0.991	0.997	0.993	0.974	0.993	0.992	0.988	0.998	0.975	0.940	1.000		
65.1	0.998	0.998	0.995	0.965	0.990	0.987	0.994	0.997	0.979	0.915	0.997	1.000	
45.4	0.995	0.997	0.997	0.990	0.999	0.996	0.996	0.991	0.964	0.907	0.995	0.998	1.000
61.5	0.978	0.980	0.958	0.907	0.948	0.943	0.955	0.985	1.000	0.942	0.974	0.979	0.967
37.3	0.952	0.984	0.974	0.992	0.991	0.989	0.992	0.968	0.898	0.853	0.969	0.960	0.993
33.1	0.998	0.992	0.992	0.981	0.992	0.999	0.991	0.996	0.982	0.889	0.991	0.997	0.997
75.7	0.964	0.973	0.985	0.986	0.991	0.994	0.986	0.963	0.911	0.831	0.978	0.970	0.986
45.4	0.982	0.986	0.996	0.977	0.997	0.996	0.996	0.980	0.941	0.859	0.989	0.987	0.994
74.9	0.994	0.994	0.997	0.974	0.995	0.996	0.998	0.995	0.963	0.875	0.996	0.996	0.997
27.8	0.988	0.973	0.971	0.931	0.958	0.968	0.966	0.989	0.993	0.898	0.982	0.986	0.968
48.3	0.996	0.995	0.996	0.972	0.994	0.995	0.996	0.996	0.968	0.890	0.997	0.998	0.998
65.9	1.000	0.991	0.994	0.949	0.985	0.981	0.995	0.995	0.977	0.858	0.991	0.997	0.995
68.1	0.998	0.996	0.995	0.960	0.988	0.990	0.993	0.999	0.980	0.900	0.997	0.999	0.996
52.2	0.995	0.992	0.995	0.973	0.991	0.996	0.998	0.994	0.963	0.863	0.995	0.996	0.995
42.1	0.997	0.993	0.998	0.968	0.993	0.994	0.999	0.993	0.964	0.865	0.995	0.997	0.997
53.3	0.997	0.998	0.997	0.965	0.992	0.991	0.995	0.997	0.975	0.910	0.998	0.999	0.999
73.3	1.000	0.994	0.995	0.949	0.985	0.982	0.996	0.995	0.978	0.875	0.993	0.998	0.996
50.6	0.990	0.997	0.993	0.980	0.995	0.997	0.990	0.997	0.967	0.930	0.999	0.996	0.996
73.2	0.990	0.994	0.994	0.982	0.997	0.996	0.999	0.991	0.947	0.872	0.993	0.993	0.998
27.8	0.988	0.985	0.966	0.924	0.954	0.956	0.968	0.988	0.997	0.911	0.979	0.985	0.976
39.7	0.987	0.995	0.995	0.993	0.999	0.998	0.995	0.989	0.952	0.903	0.993	0.993	0.998
40.9	0.992	0.993	0.982	0.968	0.981	0.982	0.980	0.998	0.991	0.935	0.996	0.996	0.987
37	0.995	0.994	0.986	0.962	0.981	0.983	0.984	0.998	0.989	0.919	0.996	0.997	0.989
45.5	0.998	0.989	0.994	0.960	0.986	0.990	0.993	0.995	0.975	0.862	0.994	0.997	0.992
54.8	0.996	0.997	0.998	0.969	0.994	0.993	0.997	0.996	0.970	0.898	0.998	0.999	0.998
48.7	0.996	0.989	0.980	0.926	0.968	0.966	0.984	0.994	0.990	0.877	0.984	0.992	0.986
57.8	0.998	0.992	0.998	0.958	0.990	0.985	0.998	0.991	0.969	0.868	0.993	0.997	0.998
34.4	0.999	0.996	0.996	0.953	0.989	0.983	0.997	0.996	0.977	0.885	0.994	0.999	0.997
35.4	0.998	0.996	0.994	0.961	0.986	0.991	0.992	0.998	0.980	0.899	0.997	0.999	0.995
42.8	0.995	0.992	0.999	0.968	0.994	0.994	0.999	0.991	0.961	0.872	0.995	0.996	0.998
14.8	0.988	0.989	0.996	0.980	0.997	0.996	0.999	0.986	0.944	0.859	0.991	0.991	0.996
37.5	0.999	0.996	0.991	0.941	0.982	0.976	0.993	0.996	0.985	0.892	0.991	0.998	0.995
45.3	0.997	0.992	0.987	0.944	0.977	0.979	0.985	0.997	0.990	0.903	0.992	0.997	0.990
52.6	0.999	0.992	0.989	0.939	0.978	0.974	0.991	0.996	0.986	0.879	0.989	0.996	0.992
41.4	0.990	0.988	0.972	0.932	0.963	0.963	0.973	0.993	0.997	0.919	0.985	0.990	0.980
41.1	0.984	0.988	0.977	0.978	0.981	0.990	0.979	0.997	0.961	0.917	0.991	0.989	0.980
19.8	0.995	0.995	0.989	0.994	0.993	0.997	0.989	0.996	0.979	0.910	0.997	0.998	0.996
12.2	0.984	0.991	0.971	0.992	0.984	0.990	0.972	0.997	0.995	0.938	0.998	0.993	0.987
80.2	0.999	0.991	0.995	0.956	0.986	0.989	0.996	0.995	0.975	0.861	0.993	0.997	0.993
79.9	0.990	0.996	0.996	0.981	0.998	0.998	0.995	0.993	0.959	0.908	0.997	0.995	0.999
42.4	0.997	0.997	0.996	0.959	0.990	0.989	0.993	0.996	0.978	0.915	0.997	0.999	0.999
44.1	0.984	0.990	0.976	0.949	0.963	0.972	0.969	0.988	0.984	0.943	0.989	0.987	0.976
61.9	0.995	0.995	0.982	0.963	0.978	0.980	0.985	0.997	0.990	0.909	0.993	0.995	0.990

52.2	0.980	0.981	0.954	0.911	0.943	0.944	0.961	0.984	0.996	0.908	0.971	0.977	0.972
42.1	0.995	0.995	0.983	0.974	0.985	0.989	0.986	0.999	0.989	0.915	0.996	0.997	0.991
49.3	0.996	0.995	0.986	0.970	0.983	0.985	0.987	0.999	0.989	0.914	0.996	0.998	0.992
45.3	0.998	0.996	0.992	0.983	0.992	0.996	0.994	0.998	0.978	0.899	0.997	0.999	0.996
52.7	0.998	0.988	0.987	0.945	0.976	0.979	0.988	0.995	0.984	0.869	0.991	0.996	0.989
41.1	0.996	0.996	0.985	0.977	0.986	0.992	0.988	0.999	0.988	0.910	0.996	0.997	0.992

61.5	37.3	33.1	75.7	45.4	74.9	27.8	48.3	65.9	68.1	52.2	42.1	53.3	73.3	50.6	73.2

1.000															
0.896	1.000														
0.982	0.991	1.000													
0.909	0.995	0.984	1.000												
0.939	0.987	0.990	0.996	1.000											
0.962	0.978	0.998	0.989	0.997	1.000										
0.992	0.923	0.989	0.954	0.950	0.971	1.000									
0.966	0.973	0.998	0.989	0.985	0.980	0.977	1.000								
0.977	0.956	0.997	0.968	0.987	0.994	0.992	0.982	1.000							
0.979	0.960	0.999	0.985	0.995	0.998	0.952	0.978	0.997	1.000						
0.960	0.976	0.997	0.992	0.994	0.993	0.978	0.998	0.985	0.992	1.000					
0.962	0.972	0.996	0.989	0.996	0.998	0.978	0.999	0.991	0.997	0.999	1.000				
0.974	0.965	0.998	0.989	0.996	0.998	0.970	0.988	0.996	0.998	0.994	0.998	1.000			
0.978	0.956	0.998	0.974	0.989	0.995	0.952	0.965	1.000	0.998	0.984	0.992	0.993	1.000		
0.965	0.975	0.994	0.994	0.997	0.997	0.961	0.990	0.988	0.997	0.996	0.997	0.998	0.990	1.000	
0.944	0.984	0.996	0.996	0.996	0.991	0.925	0.972	0.976	0.990	0.998	0.996	0.993	0.979	0.991	1.000
0.996	0.910	0.995	0.920	0.947	0.973	0.996	0.978	0.986	0.987	0.975	0.975	0.982	0.986	0.975	0.963
0.953	0.993	0.999	0.990	0.997	0.996	0.965	0.995	0.988	0.991	0.994	0.994	0.993	0.989	0.996	0.997
0.991	0.953	0.992	0.951	0.971	0.989	0.992	0.992	0.992	0.997	0.990	0.988	0.995	0.993	0.994	0.985
0.988	0.951	0.997	0.956	0.975	0.992	0.993	0.994	0.995	0.998	0.993	0.992	0.996	0.995	0.994	0.987
0.974	0.963	0.995	0.979	0.992	0.998	0.991	0.992	0.997	0.999	0.994	0.996	0.998	0.997	0.995	0.986
0.968	0.971	0.998	0.983	0.994	0.999	0.981	0.999	0.995	0.998	0.999	0.999	0.999	0.996	0.998	0.995
0.990	0.928	0.999	0.943	0.969	0.983	0.996	0.981	0.996	0.992	0.979	0.982	0.989	0.995	0.977	0.964
0.969	0.964	0.997	0.970	0.986	0.994	0.932	0.952	0.999	0.994	0.983	0.993	0.987	0.998	0.985	0.973
0.977	0.960	0.999	0.959	0.979	0.991	0.914	0.940	0.999	0.990	0.979	0.990	0.981	0.996	0.978	0.965
0.978	0.959	0.999	0.987	0.994	0.997	0.968	0.985	0.994	0.999	0.996	0.998	0.999	0.994	0.998	0.994
0.960	0.974	0.994	0.992	0.998	0.999	0.948	0.988	0.995	0.998	0.994	0.998	0.999	0.995	0.997	0.994
0.943	0.985	0.991	0.993	0.998	0.997	0.961	0.996	0.987	0.989	0.996	0.997	0.993	0.988	0.994	0.999
0.985	0.947	0.999	0.965	0.984	0.992	0.920	0.958	0.999	0.995	0.978	0.988	0.989	0.999	0.982	0.976
0.989	0.941	0.996	0.978	0.990	0.994	0.954	0.979	0.997	0.999	0.986	0.990	0.996	0.997	0.994	0.986
0.985	0.944	0.999	0.954	0.978	0.989	0.994	0.987	0.999	0.996	0.985	0.989	0.994	0.998	0.983	0.973
0.997	0.918	0.994	0.929	0.955	0.977	0.996	0.982	0.989	0.991	0.979	0.979	0.986	0.989	0.980	0.969
0.957	0.966	0.995	0.972	0.977	0.988	0.973	0.989	0.976	0.986	0.991	0.986	0.985	0.977	0.992	0.991
0.981	0.985	0.997	0.975	0.986	0.996	0.982	0.998	0.995	0.998	0.995	0.993	0.998	0.995	0.999	0.993
0.996	0.964	0.988	0.949	0.966	0.985	0.988	0.989	0.983	0.994	0.982	0.979	0.992	0.984	0.997	0.978
0.974	0.961	0.997	0.981	0.993	0.998	0.988	0.984	0.998	0.999	0.992	0.997	0.998	0.997	0.995	0.987
0.957	0.981	0.998	0.995	0.993	0.992	0.965	0.928	0.986	0.988	0.998	0.998	0.996	0.979	0.997	0.990
0.977	0.960	0.996	0.979	0.991	0.996	0.985	0.997	0.994	0.999	0.995	0.997	0.999	0.996	0.996	0.990
0.983	0.934	0.985	0.945	0.964	0.981	0.984	0.984	0.982	0.988	0.983	0.982	0.987	0.985	0.985	0.978
0.991	0.954	0.998	0.947	0.968	0.989	0.991	0.992	0.994	0.997	0.991	0.989	0.994	0.995	0.990	0.985

0.997	0.891	0.991	0.901	0.932	0.961	0.992	0.968	0.978	0.980	0.965	0.964	0.974	0.978	0.965	0.951
0.990	0.968	0.998	0.954	0.973	0.993	0.990	0.994	0.994	0.998	0.992	0.991	0.995	0.995	0.994	0.989
0.989	0.960	0.997	0.955	0.974	0.992	0.992	0.995	0.996	0.999	0.993	0.992	0.997	0.996	0.994	0.988
0.979	0.982	0.999	0.972	0.986	0.998	0.986	0.999	0.998	1.000	0.998	0.997	0.999	0.998	0.998	0.996
0.984	0.945	0.997	0.957	0.977	0.991	0.994	0.994	0.998	0.998	0.992	0.993	0.995	0.998	0.989	0.984
0.989	0.973	0.999	0.959	0.976	0.994	0.989	0.995	0.995	0.999	0.994	0.992	0.996	0.996	0.995	0.990

27.8	39.7	40.9	37	45.5	54.8	48.7	57.8	34.4	35.4	42.8	14.8	37.5	45.3	52.6	41.4

1.000															
0.959	1.000														
0.993	0.981	1.000													
0.993	0.982	0.999	1.000												
0.984	0.990	0.992	0.995	1.000											
0.978	0.995	0.993	0.995	0.997	1.000										
0.997	0.975	0.994	0.995	0.992	0.985	1.000									
0.977	0.993	0.988	0.991	0.997	0.997	0.990	1.000								
0.984	0.992	0.993	0.995	0.996	0.997	0.994	0.999	1.000							
0.989	0.988	0.997	0.999	0.998	0.998	0.990	0.989	0.985	1.000						
0.970	0.995	0.986	0.989	0.997	0.999	0.983	0.991	0.984	0.998	1.000					
0.957	0.997	0.979	0.983	0.989	0.996	0.969	0.993	0.990	0.990	0.997	1.000				
0.991	0.985	0.995	0.997	0.995	0.993	0.998	0.997	0.997	0.991	0.989	0.982	1.000			
0.995	0.982	0.998	0.998	0.997	0.992	0.998	0.991	0.988	0.997	0.995	0.978	0.994	1.000		
0.993	0.982	0.995	0.997	0.995	0.992	0.999	0.995	0.998	0.994	0.989	0.980	0.999	0.998	1.000	
0.999	0.968	0.996	0.996	0.987	0.983	0.997	0.981	0.988	0.992	0.975	0.964	0.993	0.997	0.994	1.000
0.979	0.982	0.997	0.995	0.984	0.988	0.967	0.976	0.978	0.989	0.983	0.985	0.974	0.978	0.974	0.982
0.989	0.997	0.994	0.995	0.995	0.997	0.993	0.994	0.996	0.997	0.992	0.988	0.995	0.997	0.995	0.991
0.996	0.988	0.999	0.997	0.985	0.988	0.991	0.978	0.986	0.993	0.976	0.969	0.989	0.996	0.989	0.998
0.984	0.989	0.992	0.995	0.999	0.998	0.992	0.995	0.994	0.998	0.998	0.991	0.995	0.997	0.996	0.987
0.967	0.999	0.988	0.989	0.994	0.998	0.976	0.970	0.958	0.993	0.994	0.997	0.969	0.986	0.983	0.973
0.984	0.992	0.995	0.996	0.997	0.998	0.989	0.996	0.995	0.999	0.997	0.990	0.994	0.995	0.993	0.988
0.989	0.963	0.994	0.994	0.983	0.986	0.983	0.980	0.984	0.991	0.979	0.973	0.987	0.988	0.986	0.991
0.996	0.979	0.998	0.999	0.993	0.992	0.998	0.989	0.994	0.998	0.986	0.978	0.998	0.998	0.998	0.998

0.998	0.952	0.988	0.986	0.976	0.968	0.993	0.968	0.976	0.981	0.959	0.944	0.984	0.990	0.987	0.997
0.995	0.985	0.999	1.000	0.993	0.994	0.997	0.989	0.995	0.998	0.987	0.981	0.998	0.998	0.998	0.997
0.994	0.984	0.999	0.999	0.995	0.995	0.997	0.992	0.996	0.999	0.990	0.983	0.998	0.999	0.998	0.996
0.987	0.994	0.995	0.996	0.998	0.999	0.995	0.996	0.999	0.999	0.995	0.991	0.998	0.997	0.997	0.991
0.993	0.981	0.995	0.997	0.997	0.993	0.998	0.994	0.997	0.998	0.991	0.981	0.998	0.999	0.999	0.994
0.995	0.988	0.998	0.999	0.995	0.996	0.998	0.991	0.996	0.999	0.989	0.983	0.999	0.999	0.998	0.997

41.1	19.8	12.2	80.2	79.9	42.4	44.1	61.9	52.2	42.1	49.3	45.3	52.7	41.1

1.000							
0.989	1.000						
0.995	0.995	1.000					
0.984	0.993	0.982	1.000				
0.988	0.998	0.990	0.991	1.000			
0.981	0.998	0.992	0.997	0.996	1.000		
0.991	0.983	0.992	0.985	0.979	0.986	1.000	
0.995	0.996	0.996	0.994	0.985	0.994	0.993	1.000

0.971	0.986	0.996	0.975	0.956	0.976	0.984	0.993	1.000					
0.997	0.995	0.997	0.994	0.989	0.995	0.993	1.000	0.993	1.000				
0.996	0.997	0.997	0.995	0.990	0.997	0.991	0.999	0.990	1.000	1.000			
0.993	0.998	0.993	0.997	0.997	0.998	0.984	0.996	0.983	0.997	0.998	1.000		
0.984	0.994	0.989	0.998	0.987	0.995	0.986	0.997	0.987	0.996	0.998	0.997	1.000	
0.997	0.996	0.996	0.995	0.991	0.996	0.992	1.000	0.992	1.000	1.000	0.998	0.997	1.000

PIJE_DBH	31.5	39.3	38.6	41	40.2	54.4	22.8	26.4	79.1	33.3	36.6	61.5	34.9	38.4
31.5	1.000													
39.3	0.996	1.000												
38.6	0.997	0.998	1.000											
41	0.995	0.986	0.993	1.000										
40.2	0.997	0.993	0.998	0.997	1.000									
54.4	0.996	0.989	0.995	0.999	0.998	1.000								
22.8	0.997	0.996	0.998	0.992	0.996	0.997	1.000							
26.4	0.997	0.999	0.997	0.988	0.992	0.990	0.996	1.000						
79.1	0.994	0.987	0.994	0.999	0.998	0.998	0.990	0.983	1.000					
33.3	0.997	0.998	0.999	0.993	0.998	0.995	0.997	0.997	0.992	1.000				
36.6	0.999	0.994	0.996	0.997	0.997	0.998	0.997	0.996	0.994	0.998	1.000			
61.5	0.998	0.996	0.999	0.996	0.999	0.996	0.995	0.994	0.996	0.998	0.998	1.000		
34.9	0.991	0.985	0.992	0.998	0.997	0.998	0.990	0.982	1.000	0.991	0.993	0.995	1.000	
38.4	0.992	0.984	0.991	0.999	0.996	0.999	0.993	0.984	0.999	0.992	0.994	0.995	0.999	1.000
56.8	0.974	0.957	0.978	0.996	0.980	0.988	0.996	0.986	0.976	0.994	0.994	0.986	0.998	0.999
29.8	0.967	0.948	0.959	0.981	0.970	0.978	0.992	0.980	0.973	0.987	0.983	0.962	0.985	0.992
26.6	0.990	0.992	0.987	0.972	0.979	0.977	0.980	0.993	0.969	0.981	0.984	0.982	0.958	0.961
34.9	0.998	0.993	0.995	0.994	0.995	0.995	0.994	0.997	0.991	0.996	0.999	0.995	0.987	0.989
26.9	0.987	0.975	0.982	0.993	0.987	0.991	0.996	0.994	0.986	0.995	0.997	0.983	0.989	0.993
33.6	0.996	0.998	1.000	0.993	0.999	0.995	0.997	0.996	0.992	0.999	0.997	0.999	0.992	0.993
53.1	0.997	0.990	0.995	0.999	0.999	0.999	0.997	0.992	0.998	0.998	0.998	0.997	0.997	0.998
41.6	0.994	0.989	0.995	0.999	0.998	0.998	0.992	0.987	0.999	0.994	0.996	0.998	0.999	0.998
43.6	0.995	0.991	0.996	0.998	0.999	0.998	0.995	0.991	0.998	0.998	0.997	0.998	0.998	0.998
39	0.996	0.988	0.994	1.000	0.998	0.999	0.993	0.989	0.998	0.994	0.998	0.997	0.997	0.998
51.7	0.994	0.989	0.995	0.998	0.998	0.999	0.997	0.990	0.998	0.996	0.996	0.996	0.998	0.998
32.6	0.991	0.980	0.988	0.999	0.994	0.998	0.991	0.982	0.998	0.989	0.994	0.992	0.998	1.000
23	0.950	0.925	0.941	0.974	0.957	0.967	0.976	0.951	0.964	0.968	0.967	0.949	0.976	0.983
30.5	0.986	0.971	0.981	0.997	0.990	0.995	0.988	0.976	0.993	0.986	0.990	0.986	0.994	0.997
44.6	0.973	0.955	0.977	0.994	0.980	0.989	0.990	0.975	0.978	0.987	0.988	0.985	0.997	0.998
58.4	0.982	0.969	0.981	0.995	0.990	0.993	0.989	0.976	0.993	0.987	0.989	0.985	0.997	0.999
35.8	0.996	0.993	0.997	0.998	0.998	0.998	0.995	0.992	0.997	0.997	0.997	0.999	0.997	0.998
62.5	0.924	0.899	0.921	0.961	0.938	0.947	0.967	0.945	0.943	0.967	0.954	0.932	0.975	0.981
21.1	0.983	0.974	0.984	0.996	0.991	0.993	0.982	0.971	0.998	0.982	0.986	0.990	0.997	0.997
46.7	0.998	0.995	0.998	0.996	0.999	0.997	0.996	0.996	0.996	0.999	0.998	0.999	0.994	0.993
28	0.997	0.989	0.994	0.999	0.997	0.999	0.996	0.993	0.997	0.997	0.999	0.996	0.996	0.997
49.4	0.998	0.993	0.996	0.995	0.996	0.997	0.997	0.998	0.993	0.998	0.998	0.996	0.990	0.992
69.4	0.988	0.980	0.989	0.996	0.996	0.996	0.983	0.973	0.999	0.984	0.988	0.991	0.998	0.997
29.1	0.993	0.993	0.990	0.977	0.985	0.983	0.984	0.995	0.976	0.985	0.987	0.986	0.964	0.967
26.2	0.992	0.993	0.988	0.975	0.983	0.981	0.982	0.993	0.974	0.983	0.986	0.985	0.962	0.964
38.9	0.991	0.997	0.991	0.977	0.982	0.979	0.992	0.998	0.975	0.993	0.989	0.989	0.973	0.974
25.6	0.996	0.997	0.993	0.983	0.988	0.986	0.990	0.997	0.982	0.992	0.993	0.992	0.976	0.978
15.4	0.929	0.901	0.920	0.954	0.937	0.953	0.956	0.923	0.951	0.945	0.940	0.928	0.958	0.967
44.8	0.994	0.998	0.994	0.978	0.987	0.982	0.991	0.998	0.979	0.993	0.989	0.990	0.973	0.973
35.6	0.992	0.983	0.988	0.996	0.992	0.993	0.996	0.996	0.989	0.996	0.999	0.992	0.989	0.992
37.6	0.987	0.993	0.986	0.964	0.978	0.972	0.981	0.992	0.967	0.983	0.979	0.980	0.955	0.955

39.8	0.996	0.989	0.995	0.998	0.998	0.999	0.998	0.995	0.996	0.998	0.999	0.997	0.996	0.997
34.1	0.995	0.996	0.992	0.981	0.988	0.986	0.988	0.996	0.982	0.990	0.991	0.990	0.971	0.973
14.6	0.969	0.951	0.965	0.985	0.977	0.985	0.980	0.955	0.982	0.970	0.974	0.969	0.983	0.988
36.8	0.998	0.997	0.999	0.993	0.998	0.995	0.998	0.997	0.994	0.999	0.997	0.998	0.991	0.991
60.6	0.985	0.973	0.983	0.997	0.991	0.993	0.996	0.988	0.991	0.996	0.995	0.988	0.996	0.998
79.5	0.991	0.982	0.990	0.997	0.994	0.996	0.999	0.994	0.993	0.999	0.998	0.993	0.995	0.996
26.4	0.983	0.976	0.985	0.990	0.992	0.990	0.969	0.963	0.996	0.974	0.980	0.989	0.994	0.990
70.8	0.971	0.954	0.967	0.992	0.979	0.985	0.984	0.971	0.984	0.982	0.985	0.975	0.993	0.996
50	0.999	0.997	0.999	0.995	0.998	0.996	0.997	0.998	0.994	0.999	0.999	0.999	0.992	0.992
42.8	0.999	0.994	0.997	0.997	0.998	0.998	0.997	0.997	0.995	0.998	1.000	0.998	0.992	0.993
40.9	0.999	0.995	0.997	0.994	0.996	0.996	0.996	0.998	0.992	0.996	0.998	0.997	0.987	0.989
31	0.997	0.995	0.999	0.996	0.999	0.997	0.996	0.993	0.997	0.998	0.997	1.000	0.996	0.995
28.3	0.998	0.993	0.997	0.998	0.997	0.998	0.994	0.992	0.997	0.995	0.998	0.999	0.996	0.997
32.9	0.999	0.997	0.998	0.991	0.995	0.994	0.996	0.999	0.990	0.997	0.997	0.997	0.987	0.988
30.7	1.000	0.995	0.997	0.997	0.998	0.998	0.997	0.996	0.996	0.997	1.000	0.998	0.993	0.994
21.2	0.995	0.987	0.994	1.000	0.998	0.999	0.993	0.987	0.999	0.993	0.997	0.997	0.999	0.999
33.7	0.988	0.973	0.982	0.997	0.989	0.994	0.988	0.981	0.991	0.986	0.993	0.986	0.991	0.995
19	0.999	0.994	0.995	0.996	0.995	0.996	0.996	0.996	0.992	0.997	0.999	0.997	0.991	0.993
17.1	0.994	0.990	0.994	0.997	0.996	0.999	0.994	0.988	0.995	0.992	0.994	0.995	0.996	0.998
26.6	0.999	0.997	0.998	0.996	0.997	0.998	0.999	0.996	0.993	0.999	0.999	0.998	0.992	0.994
27.9	0.981	0.964	0.975	0.994	0.985	0.991	0.989	0.976	0.987	0.985	0.988	0.980	0.990	0.995
30	0.999	0.995	0.996	0.996	0.996	0.997	0.997	0.996	0.992	0.997	0.999	0.997	0.991	0.993
50.6	0.995	0.993	0.998	0.996	0.999	0.997	0.994	0.989	0.998	0.996	0.996	0.999	0.998	0.996
26	0.998	0.999	0.998	0.989	0.994	0.990	0.996	0.999	0.986	0.998	0.996	0.996	0.985	0.985
28.9	0.999	0.992	0.995	0.997	0.996	0.998	0.996	0.995	0.994	0.996	1.000	0.996	0.992	0.994
21.5	0.995	0.988	0.993	0.998	0.997	0.998	0.997	0.993	0.996	0.997	0.999	0.995	0.996	0.997
27.4	0.999	0.997	0.998	0.996	0.998	0.997	0.998	0.997	0.993	0.999	0.999	0.998	0.993	0.993
40.6	0.998	0.996	0.998	0.996	0.999	0.996	0.995	0.995	0.995	0.999	0.999	0.999	0.995	0.994
52.7	0.999	0.996	0.998	0.996	0.998	0.997	0.997	0.996	0.995	0.998	0.999	0.999	0.994	0.994
33.8	0.994	0.987	0.992	0.999	0.997	0.999	0.994	0.987	0.999	0.994	0.996	0.996	0.998	0.999
48.5	0.986	0.994	0.987	0.968	0.976	0.971	0.988	0.996	0.966	0.990	0.983	0.983	0.965	0.964
66	0.905	0.877	0.892	0.924	0.919	0.928	0.934	0.877	0.929	0.908	0.905	0.894	0.918	0.929
62.3	0.988	0.978	0.987	0.998	0.995	0.996	0.984	0.976	0.998	0.986	0.991	0.992	0.999	0.998
61.2	0.997	0.999	0.999	0.990	0.997	0.993	0.997	0.997	0.992	0.999	0.996	0.998	0.991	0.989
69.5	0.998	0.997	1.000	0.993	0.999	0.996	0.997	0.996	0.995	0.999	0.996	0.999	0.993	0.991
41.1	0.994	0.998	0.997	0.985	0.992	0.986	0.994	0.996	0.986	0.998	0.992	0.996	0.986	0.984
79.4	0.996	0.992	0.997	0.997	1.000	0.998	0.995	0.991	0.999	0.998	0.997	0.998	0.998	0.997
57.4	0.998	0.995	0.998	0.995	0.998	0.997	0.998	0.998	0.994	0.999	0.998	0.998	0.992	0.992
49.6	0.999	0.997	0.999	0.994	0.999	0.996	0.997	0.997	0.996	0.999	0.998	0.999	0.993	0.992
39.6	0.998	0.997	0.999	0.995	0.998	0.996	0.996	0.997	0.995	0.999	0.998	0.999	0.992	0.992
65.5	0.966	0.949	0.963	0.984	0.978	0.982	0.958	0.942	0.986	0.959	0.968	0.969	0.985	0.986
41.8	0.998	0.998	0.999	0.993	0.997	0.995	0.999	0.997	0.993	0.999	0.997	0.999	0.993	0.992
27.8	0.982	0.970	0.982	0.995	0.991	0.993	0.976	0.966	0.997	0.978	0.985	0.987	0.997	0.996
18.9	0.903	0.873	0.897	0.938	0.916	0.929	0.968	0.913	0.920	0.946	0.926	0.905	0.941	0.952
47.4	0.991	0.983	0.992	0.998	0.996	0.996	0.993	0.990	0.994	0.996	0.997	0.996	0.998	0.997
41.9	0.966	0.945	0.976	0.996	0.966	0.980	0.998	0.997	0.955	0.999	0.998	0.991	0.993	0.994
43.6	0.942	0.919	0.941	0.979	0.951	0.960	0.990	0.980	0.951	0.989	0.982	0.954	0.992	0.997

38.4	0.998	0.992	0.997	0.998	0.999	0.998	0.995	0.994	0.997	0.998	0.999	0.999	0.996	0.996
39.3	0.992	0.983	0.991	0.997	0.993	0.994	0.996	0.996	0.990	0.997	0.999	0.995	0.992	0.993
19.6	0.943	0.930	0.947	0.970	0.961	0.966	0.944	0.924	0.979	0.943	0.948	0.959	0.980	0.977
24.2	0.978	0.965	0.977	0.991	0.986	0.991	0.987	0.971	0.992	0.986	0.983	0.981	0.993	0.996
47.5	0.934	0.908	0.927	0.960	0.947	0.956	0.951	0.920	0.955	0.944	0.944	0.934	0.962	0.969
35.4	0.986	0.974	0.987	0.998	0.992	0.996	0.992	0.983	0.991	0.992	0.993	0.991	0.999	0.999
33.2	0.913	0.882	0.916	0.968	0.923	0.940	0.980	0.953	0.921	0.973	0.965	0.936	0.980	0.986
77.2	0.994	0.986	0.994	0.998	0.998	0.999	0.996	0.990	0.998	0.996	0.996	0.996	0.999	0.999

56.8	29.8	26.6	34.9	26.9	33.6	53.1	41.6	43.6	39	51.7	32.6	23	30.5	44.6	58.4

1.000															
0.990	1.000														
0.955	0.941	1.000													
0.985	0.973	0.990	1.000												
0.996	0.993	0.972	0.992	1.000											
0.994	0.986	0.979	0.995	0.994	1.000										
0.994	0.979	0.978	0.997	0.993	0.998	1.000									
0.997	0.983	0.966	0.991	0.991	0.995	0.998	1.000								
0.998	0.987	0.972	0.994	0.995	0.998	0.999	0.999	1.000							
0.993	0.977	0.976	0.996	0.991	0.994	0.999	0.998	0.998	1.000						
0.999	0.989	0.970	0.992	0.994	0.996	0.999	0.998	0.999	0.997	1.000					
0.998	0.991	0.960	0.989	0.993	0.990	0.997	0.997	0.997	0.997	0.997	1.000				
0.986	0.996	0.916	0.958	0.983	0.966	0.967	0.971	0.973	0.968	0.977	0.985	1.000			
0.996	0.989	0.958	0.988	0.993	0.985	0.994	0.993	0.993	0.995	0.994	0.999	0.986	1.000		
0.985	0.987	0.950	0.982	0.991	0.988	0.994	0.994	0.994	0.993	0.996	0.997	0.985	0.997	1.000	
0.992	0.990	0.954	0.985	0.992	0.988	0.994	0.995	0.995	0.993	0.996	0.999	0.987	0.999	0.992	1.000
0.997	0.991	0.971	0.993	0.994	0.997	0.998	0.999	0.999	0.998	0.998	0.997	0.979	0.994	0.993	0.995
0.983	0.989	0.888	0.939	0.971	0.968	0.952	0.969	0.970	0.953	0.971	0.979	0.994	0.974	0.995	0.975
0.994	0.988	0.939	0.976	0.980	0.984	0.991	0.996	0.992	0.995	0.992	0.998	0.993	0.997	0.996	0.999
0.976	0.966	0.985	0.997	0.987	0.999	0.998	0.996	0.997	0.997	0.995	0.991	0.950	0.986	0.975	0.986
0.995	0.980	0.979	0.997	0.995	0.996	0.999	0.997	0.999	0.999	0.998	0.997	0.971	0.995	0.993	0.993
0.991	0.976	0.987	0.999	0.994	0.996	0.998	0.993	0.996	0.996	0.996	0.991	0.963	0.990	0.988	0.988
0.953	0.974	0.958	0.986	0.984	0.985	0.995	0.997	0.994	0.995	0.995	0.997	0.970	0.994	0.961	0.995
0.965	0.950	0.999	0.994	0.978	0.983	0.984	0.971	0.977	0.981	0.975	0.966	0.927	0.966	0.960	0.966
0.963	0.947	0.999	0.993	0.977	0.982	0.982	0.969	0.975	0.980	0.972	0.964	0.924	0.964	0.957	0.962
0.930	0.934	0.996	0.987	0.965	0.992	0.980	0.979	0.982	0.979	0.980	0.970	0.905	0.956	0.927	0.950
0.955	0.947	0.997	0.994	0.975	0.991	0.986	0.982	0.985	0.985	0.982	0.976	0.922	0.967	0.952	0.964
0.965	0.983	0.880	0.932	0.956	0.944	0.949	0.950	0.952	0.947	0.956	0.967	0.994	0.974	0.971	0.973
0.952	0.939	0.997	0.991	0.970	0.993	0.983	0.979	0.982	0.982	0.979	0.969	0.913	0.961	0.948	0.960
0.993	0.982	0.981	0.997	0.997	0.994	0.996	0.992	0.995	0.996	0.994	0.992	0.971	0.992	0.990	0.991
0.947	0.926	0.998	0.985	0.962	0.981	0.973	0.962	0.968	0.970	0.965	0.952	0.898	0.947	0.941	0.949

0.988	0.979	0.981	0.998	0.994	0.998	1.000	0.997	0.999	0.999	0.998	0.996	0.967	0.994	0.987	0.994
0.956	0.952	0.998	0.995	0.980	0.988	0.987	0.977	0.982	0.985	0.979	0.972	0.929	0.969	0.953	0.969
0.972	0.989	0.938	0.974	0.985	0.968	0.984	0.979	0.979	0.983	0.984	0.990	0.993	0.995	0.980	0.996
0.937	0.961	0.988	0.996	0.984	0.999	0.996	0.994	0.996	0.994	0.995	0.988	0.945	0.982	0.968	0.983
0.936	0.991	0.964	0.991	0.997	0.995	0.996	0.996	0.998	0.995	0.998	0.998	0.985	0.998	0.969	0.999
0.942	0.985	0.975	0.995	0.997	0.998	0.998	0.996	0.999	0.996	0.999	0.995	0.976	0.995	0.973	0.996
0.937	0.956	0.949	0.978	0.971	0.977	0.988	0.993	0.987	0.991	0.986	0.988	0.954	0.985	0.952	0.989
0.997	0.994	0.941	0.977	0.992	0.982	0.986	0.991	0.991	0.987	0.992	0.997	0.994	0.997	0.996	0.997
0.984	0.965	0.988	0.998	0.988	0.999	0.997	0.995	0.997	0.997	0.995	0.990	0.951	0.986	0.983	0.985
0.982	0.973	0.988	0.999	0.991	0.997	0.998	0.995	0.997	0.998	0.996	0.993	0.959	0.990	0.980	0.988
0.982	0.967	0.992	0.999	0.988	0.995	0.996	0.991	0.994	0.995	0.992	0.989	0.951	0.985	0.979	0.983
0.986	0.963	0.981	0.995	0.984	0.999	0.997	0.998	0.998	0.997	0.996	0.993	0.949	0.986	0.986	0.986
0.983	0.968	0.982	0.996	0.986	0.995	0.997	0.998	0.998	0.998	0.996	0.996	0.955	0.990	0.984	0.987
0.978	0.961	0.993	0.998	0.985	0.997	0.994	0.991	0.993	0.994	0.991	0.986	0.943	0.981	0.976	0.979
0.977	0.970	0.987	0.998	0.989	0.996	0.998	0.995	0.997	0.998	0.996	0.994	0.955	0.989	0.976	0.986
0.987	0.977	0.974	0.995	0.990	0.994	0.999	0.999	0.999	0.999	0.997	0.999	0.967	0.995	0.988	0.994
0.994	0.990	0.966	0.991	0.995	0.984	0.994	0.991	0.992	0.995	0.993	0.997	0.984	0.999	0.994	0.996
0.993	0.992	0.985	0.999	0.999	0.996	0.997	0.994	0.997	0.997	0.995	0.993	0.971	0.990	0.986	0.989
0.998	0.995	0.964	0.988	0.991	0.994	0.997	0.995	0.996	0.997	0.997	0.997	0.993	0.996	0.996	0.997
0.996	0.993	0.982	0.997	0.998	0.998	0.999	0.995	0.998	0.996	0.997	0.993	0.976	0.990	0.990	0.990
0.991	0.994	0.956	0.986	0.995	0.984	0.991	0.989	0.990	0.991	0.993	0.997	0.991	0.999	0.991	0.998
0.994	0.993	0.984	0.999	0.999	0.997	0.998	0.993	0.997	0.997	0.995	0.993	0.974	0.990	0.987	0.989
0.988	0.965	0.975	0.993	0.984	0.997	0.997	0.999	0.998	0.997	0.997	0.994	0.953	0.988	0.989	0.989
0.985	0.970	0.992	0.998	0.991	0.997	0.993	0.989	0.992	0.992	0.990	0.983	0.946	0.976	0.976	0.976
0.994	0.984	0.984	0.999	0.997	0.995	0.998	0.995	0.997	0.998	0.996	0.994	0.970	0.992	0.989	0.990
0.997	0.986	0.975	0.996	0.997	0.997	0.999	0.998	0.999	0.998	0.998	0.997	0.975	0.994	0.994	0.995
0.993	0.985	0.985	0.999	0.997	0.998	0.998	0.995	0.997	0.997	0.996	0.992	0.964	0.987	0.987	0.988
0.993	0.980	0.980	0.997	0.994	0.999	0.998	0.997	0.998	0.998	0.996	0.992	0.962	0.987	0.988	0.988
0.992	0.977	0.983	0.997	0.993	0.998	0.997	0.997	0.997	0.998	0.995	0.993	0.960	0.987	0.986	0.987
0.999	0.995	0.965	0.991	0.994	0.994	0.998	0.998	0.998	0.999	0.999	0.999	0.985	0.998	0.997	0.998
0.930	0.921	0.994	0.981	0.956	0.989	0.972	0.971	0.975	0.971	0.972	0.959	0.890	0.945	0.926	0.940
0.940	0.972	0.863	0.915	0.947	0.903	0.926	0.909	0.913	0.922	0.922	0.934	0.987	0.956	0.963	0.965
0.982	0.979	0.960	0.988	0.988	0.987	0.996	0.998	0.996	0.997	0.996	0.998	0.975	0.997	0.984	0.998
0.970	0.953	0.987	0.993	0.978	1.000	0.993	0.993	0.994	0.992	0.993	0.986	0.933	0.976	0.970	0.976
0.978	0.960	0.985	0.995	0.983	0.999	0.996	0.995	0.996	0.995	0.995	0.988	0.945	0.983	0.977	0.983
0.944	0.941	0.987	0.989	0.970	0.999	0.988	0.990	0.991	0.987	0.989	0.979	0.918	0.967	0.943	0.963
0.975	0.972	0.977	0.995	0.988	0.998	0.999	0.999	0.999	0.998	0.998	0.995	0.961	0.991	0.975	0.991
0.989	0.971	0.987	0.998	0.991	0.999	0.998	0.995	0.997	0.996	0.996	0.990	0.956	0.988	0.987	0.987
0.971	0.963	0.987	0.997	0.985	1.000	0.997	0.995	0.997	0.996	0.995	0.990	0.947	0.984	0.970	0.984
0.982	0.963	0.987	0.997	0.985	0.999	0.996	0.996	0.997	0.996	0.994	0.989	0.946	0.984	0.981	0.983
0.931	0.982	0.925	0.968	0.978	0.959	0.981	0.981	0.978	0.982	0.980	0.988	0.987	0.993	0.956	0.996
0.975	0.958	0.987	0.995	0.981	0.999	0.995	0.995	0.996	0.994	0.995	0.989	0.940	0.980	0.975	0.979
0.994	0.978	0.945	0.980	0.984	0.979	0.992	0.995	0.992	0.993	0.992	0.996	0.979	0.996	0.997	0.997
0.984	0.981	0.868	0.920	0.957	0.944	0.933	0.933	0.938	0.930	0.944	0.953	0.992	0.960	0.982	0.960
0.971	0.978	0.972	0.994	0.992	0.997	0.997	0.999	0.999	0.998	0.997	0.996	0.969	0.994	0.992	0.995
0.992	0.984	0.963	0.986	0.998	0.999	0.994	0.995	0.998	0.994	0.997	0.993	0.976	0.990	0.995	0.974
0.987	0.997	0.917	0.958	0.987	0.989	0.968	0.990	0.991	0.969	0.992	0.994	0.995	0.982	0.997	0.980

0.955	0.973	0.982	0.998	0.990	0.998	0.999	0.998	0.999	0.999	0.997	0.995	0.959	0.991	0.982	0.991
0.995	0.978	0.980	0.997	0.995	0.996	0.997	0.995	0.996	0.998	0.995	0.993	0.968	0.992	0.984	0.992
0.970	0.955	0.875	0.930	0.937	0.948	0.959	0.974	0.963	0.968	0.964	0.978	0.979	0.978	0.980	0.983
0.996	0.993	0.939	0.976	0.986	0.986	0.990	0.990	0.991	0.988	0.992	0.996	0.992	0.997	0.998	0.999
0.982	0.986	0.892	0.943	0.968	0.943	0.955	0.955	0.956	0.956	0.959	0.972	0.997	0.980	0.993	0.983
0.991	0.985	0.962	0.990	0.993	0.993	0.997	0.998	0.998	0.996	0.998	0.999	0.980	0.998	0.961	0.998
0.992	0.994	0.888	0.936	0.976	0.973	0.954	0.974	0.976	0.955	0.979	0.985	0.996	0.973	0.993	0.959
0.965	0.978	0.973	0.994	0.992	0.997	0.999	0.999	0.999	0.998	1.000	0.997	0.970	0.995	0.972	0.996

35.8	62.5	21.1	46.7	28	49.4	69.4	29.1	26.2	38.9	25.6	15.4	44.8	35.6	37.6	39.8

1.000														
0.982	1.000													
0.993	0.995	1.000												
0.997	0.933	0.987	1.000											
0.999	0.956	0.991	0.997	1.000										
0.995	0.945	0.979	0.997	0.998	1.000									
0.992	0.948	0.997	0.992	0.993	0.988	1.000								
0.975	0.908	0.946	0.990	0.984	0.991	0.968	1.000							
0.973	0.904	0.944	0.989	0.982	0.989	0.964	1.000	1.000						
0.986	0.868	0.963	0.987	0.981	0.986	0.964	0.993	0.993	1.000					
0.986	0.895	0.964	0.993	0.987	0.991	0.972	0.997	0.997	0.998	1.000				
0.962	0.995	0.988	0.926	0.950	0.936	0.959	0.890	0.886	0.883	0.898	1.000			
0.985	0.889	0.963	0.992	0.983	0.989	0.970	0.996	0.997	0.998	0.999	0.883	1.000		
0.994	0.959	0.978	0.993	0.998	0.998	0.986	0.988	0.987	0.973	0.984	0.943	0.981	1.000	
0.970	0.880	0.939	0.985	0.972	0.981	0.956	0.997	0.997	0.996	0.996	0.859	0.998	0.975	1.000

0.998	0.953	0.989	0.997	1.000	0.999	0.994	0.988	0.986	0.977	0.987	0.946	0.985	0.997	0.977	1.000
0.981	0.911	0.956	0.993	0.987	0.992	0.974	0.999	0.999	0.994	0.999	0.897	0.998	0.987	0.997	0.989
0.979	0.980	0.994	0.972	0.983	0.977	0.988	0.951	0.946	0.929	0.947	0.986	0.941	0.983	0.929	0.985
0.994	0.956	0.979	0.999	0.995	0.996	0.992	0.992	0.990	0.988	0.994	0.924	0.993	0.991	0.987	0.996
0.998	0.974	0.994	0.989	0.997	0.993	0.993	0.974	0.971	0.955	0.970	0.966	0.966	0.996	0.958	0.996
0.998	0.974	0.987	0.993	0.998	0.998	0.992	0.983	0.981	0.966	0.979	0.951	0.977	0.998	0.971	0.998
0.985	0.946	0.993	0.989	0.986	0.979	0.997	0.959	0.956	0.959	0.967	0.936	0.966	0.978	0.950	0.988
0.992	0.988	0.999	0.974	0.989	0.982	0.988	0.951	0.949	0.935	0.949	0.982	0.943	0.987	0.929	0.985
0.998	0.933	0.984	0.999	0.997	0.998	0.989	0.992	0.991	0.990	0.994	0.924	0.993	0.995	0.986	0.998
0.997	0.939	0.984	0.999	0.999	0.999	0.991	0.992	0.991	0.986	0.993	0.936	0.991	0.996	0.984	0.999
0.995	0.932	0.978	0.997	0.997	0.998	0.986	0.995	0.994	0.990	0.995	0.926	0.993	0.995	0.988	0.997
0.999	0.934	0.991	0.999	0.996	0.995	0.993	0.985	0.984	0.987	0.990	0.928	0.989	0.992	0.979	0.997
0.999	0.935	0.993	0.998	0.998	0.996	0.993	0.985	0.985	0.985	0.991	0.940	0.988	0.992	0.977	0.997
0.994	0.923	0.978	0.998	0.995	0.997	0.984	0.996	0.995	0.993	0.997	0.916	0.996	0.993	0.991	0.996
0.997	0.931	0.986	0.999	0.998	0.998	0.991	0.991	0.990	0.988	0.994	0.936	0.992	0.993	0.984	0.997
0.998	0.950	0.996	0.997	0.999	0.995	0.997	0.980	0.979	0.975	0.984	0.953	0.980	0.993	0.969	0.998
0.993	0.970	0.991	0.987	0.996	0.992	0.991	0.973	0.971	0.961	0.973	0.969	0.966	0.995	0.955	0.995
0.996	0.965	0.984	0.997	0.999	0.999	0.985	0.988	0.986	0.991	0.994	0.948	0.990	0.999	0.980	0.999
0.996	0.980	0.994	0.994	0.997	0.992	0.991	0.970	0.969	0.983	0.982	0.981	0.983	0.990	0.967	0.997
0.997	0.971	0.985	0.998	0.999	0.998	0.985	0.985	0.984	0.993	0.993	0.955	0.992	0.998	0.981	0.999
0.992	0.981	0.993	0.982	0.993	0.988	0.987	0.967	0.964	0.945	0.963	0.978	0.957	0.993	0.948	0.992
0.996	0.969	0.983	0.998	0.999	0.998	0.984	0.987	0.986	0.992	0.994	0.952	0.991	0.999	0.980	0.999
0.998	0.939	0.992	0.998	0.996	0.994	0.995	0.980	0.979	0.982	0.986	0.935	0.985	0.991	0.973	0.997
0.993	0.932	0.974	0.998	0.993	0.997	0.977	0.995	0.994	0.998	0.998	0.912	0.998	0.995	0.991	0.995
0.996	0.955	0.985	0.997	0.999	0.998	0.988	0.987	0.986	0.988	0.992	0.943	0.988	0.999	0.977	0.999
0.998	0.964	0.990	0.996	0.999	0.996	0.993	0.980	0.979	0.979	0.985	0.951	0.981	0.997	0.969	0.999
0.997	0.956	0.984	0.999	0.998	0.999	0.986	0.989	0.988	0.993	0.995	0.938	0.992	0.998	0.982	0.999
0.998	0.955	0.987	1.000	0.998	0.997	0.989	0.985	0.984	0.989	0.992	0.935	0.990	0.996	0.978	0.998
0.999	0.949	0.988	0.999	0.998	0.997	0.989	0.987	0.986	0.991	0.993	0.931	0.991	0.997	0.980	0.998
0.998	0.986	0.996	0.994	0.998	0.994	0.996	0.970	0.967	0.978	0.981	0.970	0.977	0.993	0.960	0.998
0.980	0.855	0.954	0.982	0.973	0.980	0.954	0.990	0.992	0.999	0.995	0.864	0.997	0.966	0.996	0.971
0.920	0.980	0.969	0.913	0.924	0.916	0.952	0.886	0.877	0.850	0.874	0.990	0.864	0.937	0.853	0.937
0.994	0.962	0.999	0.992	0.995	0.990	0.998	0.970	0.967	0.961	0.973	0.961	0.969	0.990	0.956	0.996
0.996	0.911	0.982	0.998	0.992	0.994	0.986	0.990	0.989	0.993	0.994	0.912	0.995	0.985	0.988	0.992
0.998	0.927	0.986	0.999	0.995	0.996	0.990	0.990	0.988	0.989	0.992	0.920	0.993	0.990	0.985	0.996
0.993	0.887	0.978	0.993	0.987	0.989	0.978	0.987	0.987	0.995	0.994	0.897	0.996	0.977	0.989	0.984
0.999	0.940	0.991	0.998	0.998	0.996	0.997	0.983	0.981	0.980	0.986	0.942	0.985	0.992	0.975	0.997
0.997	0.940	0.981	0.999	0.998	0.999	0.990	0.991	0.990	0.988	0.992	0.930	0.991	0.996	0.984	0.999
0.997	0.927	0.985	1.000	0.996	0.997	0.991	0.991	0.990	0.989	0.994	0.923	0.994	0.992	0.986	0.996
0.998	0.930	0.984	0.999	0.996	0.997	0.989	0.990	0.989	0.990	0.994	0.923	0.993	0.992	0.985	0.997
0.974	0.965	0.992	0.973	0.980	0.970	0.993	0.940	0.936	0.927	0.942	0.982	0.936	0.976	0.920	0.982
0.997	0.917	0.984	0.998	0.994	0.995	0.988	0.990	0.989	0.993	0.994	0.922	0.994	0.987	0.986	0.994
0.989	0.971	0.998	0.985	0.991	0.984	0.999	0.952	0.950	0.953	0.961	0.965	0.956	0.983	0.936	0.990
0.957	0.992	0.990	0.909	0.935	0.927	0.916	0.889	0.883	0.840	0.871	0.995	0.863	0.943	0.856	0.935
0.999	0.987	0.994	0.995	0.998	0.995	0.988	0.980	0.979	0.966	0.979	0.944	0.978	0.995	0.969	0.998
0.997	0.987	0.984	0.962	0.998	0.997	0.919	0.966	0.968	0.913	0.948	0.945	0.947	0.993	0.948	0.977
0.997	0.999	0.998	0.948	0.975	0.967	0.949	0.933	0.930	0.890	0.918	0.984	0.913	0.975	0.908	0.965

0.999	0.973	0.990	0.999	0.999	0.997	0.994	0.988	0.986	0.982	0.990	0.939	0.988	0.994	0.980	0.999
0.997	0.976	0.987	0.994	0.998	0.998	0.979	0.987	0.986	0.969	0.983	0.935	0.981	0.999	0.976	0.998
0.965	0.996	0.987	0.951	0.958	0.937	0.987	0.884	0.882	0.910	0.912	0.990	0.909	0.934	0.875	0.954
0.993	0.992	0.998	0.979	0.989	0.981	0.994	0.947	0.944	0.950	0.957	0.982	0.950	0.982	0.930	0.987
0.963	0.998	0.989	0.941	0.956	0.946	0.960	0.912	0.906	0.880	0.905	0.998	0.896	0.960	0.883	0.960
0.997	0.942	0.997	0.989	0.997	0.992	0.920	0.972	0.969	0.951	0.970	0.962	0.967	0.993	0.957	0.996
0.984	0.992	0.998	0.916	0.962	0.951	0.909	0.903	0.900	0.844	0.882	0.995	0.876	0.957	0.872	0.940
0.999	0.967	0.993	0.996	0.998	0.996	0.997	0.981	0.978	0.971	0.981	0.951	0.980	0.995	0.970	0.999

34.1	14.6	36.8	60.6	79.5	26.4	70.8	50	42.8	40.9	31	28.3	32.9	30.7	21.2	33.7

1.000															
0.956	1.000														
0.995	0.977	1.000													
0.976	0.996	0.992	1.000												
0.984	0.993	0.995	0.999	1.000											
0.968	0.982	0.990	0.989	0.989	1.000										
0.953	0.996	0.969	0.996	0.991	0.979	1.000									
0.994	0.971	0.999	0.989	0.994	0.985	0.974	1.000								
0.994	0.977	0.998	0.991	0.996	0.985	0.979	0.999	1.000							
0.996	0.970	0.997	0.988	0.993	0.979	0.973	0.999	0.999	1.000						
0.989	0.971	0.998	0.988	0.993	0.991	0.975	0.999	0.997	0.996	1.000					
0.989	0.975	0.996	0.989	0.992	0.989	0.977	0.998	0.998	0.997	0.998	1.000				
0.997	0.965	0.998	0.984	0.991	0.979	0.968	0.999	0.998	0.999	0.997	0.997	1.000			
0.994	0.974	0.998	0.988	0.992	0.985	0.976	0.999	0.999	0.999	0.998	0.999	0.998	1.000		
0.984	0.985	0.994	0.994	0.996	0.993	0.986	0.996	0.997	0.994	0.997	0.998	0.993	0.997	1.000	
0.975	0.993	0.983	0.997	0.995	0.981	0.995	0.988	0.992	0.989	0.986	0.991	0.985	0.991	0.995	1.000
0.991	0.973	0.996	0.996	0.998	0.974	0.986	0.998	1.000	0.998	0.995	0.998	0.997	0.999	0.996	0.994
0.977	0.996	0.991	0.997	0.995	0.979	0.993	0.994	0.994	0.990	0.996	0.996	0.991	0.996	0.997	0.993
0.990	0.977	0.998	0.997	0.999	0.974	0.986	0.999	0.999	0.997	0.997	0.997	0.998	0.999	0.995	0.991
0.969	0.997	0.979	0.997	0.995	0.980	0.997	0.982	0.987	0.982	0.981	0.985	0.978	0.984	0.991	0.998
0.992	0.974	0.997	0.996	0.998	0.973	0.986	0.998	1.000	0.998	0.996	0.997	0.998	0.999	0.996	0.993
0.985	0.975	0.997	0.990	0.994	0.993	0.978	0.997	0.996	0.994	0.999	0.997	0.994	0.996	0.997	0.986
0.997	0.955	0.998	0.986	0.993	0.970	0.968	0.999	0.997	0.998	0.995	0.993	0.999	0.997	0.989	0.980
0.991	0.977	0.996	0.995	0.997	0.978	0.986	0.998	0.999	0.998	0.996	0.998	0.997	0.999	0.997	0.995
0.985	0.983	0.994	0.998	0.999	0.985	0.991	0.995	0.997	0.994	0.995	0.996	0.992	0.997	0.998	0.995
0.993	0.970	0.999	0.994	0.998	0.978	0.982	0.999	1.000	0.998	0.998	0.998	0.998	0.999	0.995	0.990
0.989	0.969	0.998	0.994	0.997	0.984	0.982	0.999	0.999	0.996	0.999	0.997	0.997	0.998	0.997	0.988
0.991	0.969	0.998	0.993	0.996	0.984	0.981	0.999	0.999	0.998	0.999	0.999	0.998	0.999	0.997	0.989
0.976	0.987	0.992	0.999	0.997	0.987	0.996	0.994	0.995	0.991	0.996	0.998	0.990	0.996	0.999	0.996
0.993	0.917	0.985	0.947	0.960	0.950	0.922	0.985	0.980	0.985	0.981	0.978	0.989	0.982	0.967	0.950
0.896	0.987	0.952	0.981	0.975	0.948	0.970	0.903	0.921	0.905	0.900	0.908	0.895	0.913	0.930	0.952
0.976	0.991	0.989	0.996	0.995	0.996	0.992	0.990	0.992	0.987	0.993	0.994	0.985	0.991	0.998	0.994
0.993	0.959	0.998	0.978	0.986	0.983	0.961	0.998	0.995	0.995	0.998	0.995	0.997	0.996	0.991	0.977
0.992	0.968	0.998	0.985	0.992	0.988	0.971	0.999	0.997	0.997	0.999	0.997	0.998	0.998	0.995	0.984
0.991	0.942	0.994	0.966	0.975	0.976	0.949	0.994	0.990	0.991	0.995	0.991	0.994	0.992	0.985	0.968
0.987	0.978	0.997	0.991	0.994	0.993	0.982	0.997	0.997	0.995	0.999	0.997	0.994	0.997	0.998	0.990
0.993	0.974	0.998	0.991	0.997	0.983	0.978	0.999	0.999	0.998	0.998	0.997	0.998	0.998	0.996	0.989
0.994	0.970	0.999	0.986	0.992	0.987	0.971	0.999	0.998	0.997	0.999	0.997	0.998	0.998	0.996	0.985
0.993	0.967	0.999	0.987	0.993	0.986	0.971	0.999	0.998	0.998	0.999	0.998	0.998	0.998	0.995	0.985
0.950	0.996	0.981	0.994	0.991	0.991	0.995	0.968	0.974	0.965	0.971	0.974	0.959	0.971	0.985	0.988
0.993	0.964	0.999	0.981	0.988	0.984	0.965	0.998	0.997	0.996	0.998	0.997	0.998	0.998	0.993	0.981
0.959	0.990	0.980	0.994	0.990	0.995	0.994	0.983	0.985	0.979	0.988	0.989	0.976	0.985	0.995	0.991
0.889	0.962	0.902	0.949	0.942	0.910	0.976	0.910	0.919	0.910	0.908	0.912	0.900	0.909	0.930	0.956
0.982	0.989	0.990	0.991	0.993	0.985	0.989	0.995	0.995	0.993	0.996	0.995	0.992	0.993	0.997	0.993
0.940	0.949	0.947	0.945	0.951	0.915	0.989	0.986	0.973	0.983	0.987	0.981	0.980	0.966	0.977	0.991
0.930	0.977	0.958	0.972	0.973	0.944	0.993	0.953	0.954	0.951	0.952	0.951	0.945	0.946	0.961	0.980

0.991	0.985	0.997	0.994	0.996	0.991	0.980	0.999	0.999	0.997	0.999	0.999	0.997	0.999	0.999	0.991
0.986	0.982	0.948	0.941	0.948	0.965	0.986	0.996	0.996	0.996	0.994	0.994	0.994	0.993	0.994	0.994
0.899	0.983	0.939	0.965	0.952	0.992	0.985	0.946	0.944	0.935	0.962	0.963	0.934	0.949	0.972	0.963
0.954	0.995	0.978	0.996	0.990	0.983	0.998	0.978	0.982	0.975	0.982	0.985	0.970	0.982	0.992	0.992
0.919	0.988	0.956	0.978	0.976	0.954	0.990	0.936	0.947	0.936	0.937	0.943	0.927	0.941	0.959	0.976
0.968	0.927	0.892	0.874	0.883	0.876	0.994	0.990	0.991	0.988	0.992	0.992	0.985	0.989	0.996	0.996
0.890	0.951	0.917	0.944	0.944	0.907	0.987	0.931	0.927	0.928	0.933	0.931	0.920	0.917	0.940	0.968
0.984	0.991	0.997	0.998	0.999	0.995	0.988	0.996	0.997	0.994	0.997	0.996	0.992	0.995	0.999	0.994

19	17.1	26.6	27.9	30	50.6	26	28.9	21.5	27.4	40.6	52.7	33.8	48.5	66	62.3

1.000															
0.993	1.000														
0.998	0.995	1.000													
0.990	0.997	0.991	1.000												
0.999	0.994	0.999	0.991	1.000											
0.993	0.994	0.995	0.982	0.994	1.000										
0.996	0.989	0.997	0.974	0.997	0.992	1.000									
0.999	0.994	0.999	0.991	1.000	0.994	0.995	1.000								
0.998	0.996	0.999	0.993	0.999	0.996	0.993	0.998	1.000							
0.999	0.995	0.999	0.986	0.999	0.996	0.998	0.999	0.998	1.000						
0.997	0.994	0.998	0.984	0.998	0.998	0.997	0.998	0.998	0.999	1.000					
0.998	0.996	0.999	0.984	0.998	0.997	0.997	0.998	0.998	0.999	0.999	1.000				
0.995	0.998	0.996	0.996	0.996	0.996	0.987	0.996	0.998	0.995	0.995	0.995	1.000			
0.985	0.978	0.988	0.936	0.986	0.976	0.994	0.980	0.971	0.987	0.984	0.985	0.970	1.000		
0.906	0.986	0.921	0.976	0.911	0.905	0.872	0.911	0.924	0.898	0.895	0.891	0.931	0.829	1.000	
0.988	0.992	0.988	0.993	0.987	0.995	0.979	0.991	0.995	0.989	0.991	0.990	0.997	0.952	0.951	1.000
0.994	0.993	0.997	0.970	0.995	0.997	0.998	0.994	0.992	0.998	0.998	0.998	0.991	0.990	0.884	0.984
0.995	0.995	0.998	0.978	0.995	0.998	0.997	0.995	0.994	0.998	0.998	0.999	0.993	0.985	0.899	0.990
0.992	0.990	0.995	0.955	0.993	0.993	0.997	0.990	0.986	0.995	0.996	0.995	0.987	0.993	0.866	0.974
0.995	0.995	0.997	0.985	0.995	0.999	0.992	0.996	0.997	0.997	0.998	0.997	0.997	0.973	0.925	0.995
0.998	0.993	0.999	0.984	0.998	0.997	0.998	0.998	0.996	0.999	0.998	0.999	0.993	0.982	0.910	0.990
0.997	0.994	0.999	0.979	0.998	0.998	0.998	0.997	0.995	0.999	0.999	0.999	0.994	0.985	0.909	0.990
0.997	0.993	0.998	0.979	0.997	0.998	0.998	0.996	0.995	0.999	0.999	0.999	0.993	0.986	0.896	0.989
0.964	0.973	0.962	0.993	0.962	0.975	0.946	0.970	0.979	0.963	0.967	0.965	0.983	0.912	0.982	0.994
0.996	0.995	0.999	0.974	0.997	0.997	0.998	0.996	0.994	0.999	0.998	0.999	0.993	0.988	0.890	0.986
0.981	0.986	0.980	0.992	0.979	0.991	0.970	0.985	0.991	0.982	0.985	0.984	0.994	0.942	0.938	0.999
0.935	0.995	0.956	0.969	0.945	0.914	0.899	0.931	0.941	0.923	0.920	0.915	0.960	0.827	0.978	0.942
0.995	0.996	0.996	0.993	0.995	0.997	0.992	0.996	0.998	0.996	0.998	0.998	0.997	0.962	0.969	0.996
0.999	0.995	0.999	0.970	0.999	0.988	0.995	0.998	0.999	0.999	0.998	0.997	0.995	0.926	0.937	0.956
0.991	0.997	0.993	0.985	0.992	0.956	0.969	0.981	0.985	0.985	0.983	0.978	0.999	0.883	0.973	0.967

0.998	0.996	0.998	0.987	0.998	0.998	0.995	0.998	0.998	0.999	0.999	0.999	0.997	0.977	0.962	0.995
0.999	0.995	0.998	0.993	0.999	0.993	0.996	0.999	0.997	0.999	0.998	0.999	0.995	0.965	0.946	0.993
0.944	0.966	0.947	0.969	0.944	0.966	0.928	0.946	0.958	0.945	0.952	0.954	0.971	0.897	0.966	0.986
0.984	0.994	0.988	0.995	0.985	0.986	0.968	0.984	0.989	0.982	0.982	0.980	0.996	0.938	0.956	0.995
0.947	0.974	0.953	0.988	0.949	0.942	0.916	0.948	0.958	0.939	0.940	0.937	0.970	0.864	0.985	0.972
0.992	0.996	0.993	0.990	0.992	0.994	0.984	0.993	0.997	0.992	0.994	0.993	0.999	0.948	0.869	0.990
0.972	0.994	0.979	0.962	0.975	0.940	0.944	0.966	0.972	0.965	0.963	0.959	0.989	0.842	0.954	0.937
0.995	0.997	0.997	0.992	0.995	0.998	0.990	0.996	0.998	0.996	0.997	0.996	0.999	0.965	0.970	0.998

61.2	69.5	41.1	79.4	57.4	49.6	39.6	65.5	41.8	27.8	18.9	47.4	41.9	43.6	38.4	39.3

1.000													
0.999	1.000												
0.998	0.996	1.000											
0.995	0.998	0.990	1.000										
0.997	0.999	0.993	0.998	1.000									
0.999	0.999	0.995	0.998	0.999	1.000								
0.998	0.999	0.996	0.998	0.999	1.000	1.000							
0.957	0.967	0.945	0.981	0.969	0.969	0.966	1.000						
1.000	0.999	0.997	0.996	0.997	0.999	0.999	0.961	1.000					
0.978	0.983	0.970	0.992	0.984	0.983	0.983	0.995	0.981	1.000				
0.886	0.902	0.857	0.917	0.919	0.903	0.904	0.946	0.893	0.949	1.000			
0.988	0.994	0.977	0.995	0.996	0.993	0.995	0.983	0.990	0.993	0.950	1.000		
0.966	0.972	0.926	0.954	0.992	0.955	0.985	0.920	0.973	0.987	0.980	0.980	1.000	
0.931	0.944	0.905	0.951	0.960	0.942	0.949	0.958	0.936	0.980	0.990	0.988	0.992	1.000

0.995	0.998	0.989	0.998	0.998	0.998	0.999	0.984	0.997	0.989	0.924	0.997	0.964	0.975	1.000	
0.987	0.992	0.975	0.991	0.997	0.992	0.994	0.953	0.989	0.986	0.953	0.976	0.985	0.981	0.964	1.000
0.944	0.952	0.938	0.963	0.941	0.948	0.947	0.997	0.947	0.992	0.981	0.969	0.945	0.977	0.958	0.951
0.973	0.976	0.965	0.988	0.980	0.978	0.978	0.994	0.977	0.995	0.973	0.987	0.986	0.997	0.985	0.980
0.918	0.932	0.898	0.950	0.941	0.936	0.932	0.973	0.924	0.973	0.988	0.986	0.980	0.996	0.974	0.980
0.982	0.989	0.965	0.989	0.992	0.986	0.989	0.856	0.985	0.997	0.975	0.941	0.975	0.951	0.916	0.982
0.902	0.917	0.864	0.917	0.941	0.908	0.927	0.927	0.912	0.974	0.995	0.966	0.995	0.994	0.943	0.979
0.991	0.995	0.982	0.998	0.997	0.995	0.995	0.992	0.993	0.995	0.930	0.992	0.948	0.966	0.997	0.944

19.6	24.2	47.5	35.4	33.2	77.2

1.000					
0.985	1.000				
0.996	0.985	1.000			
0.977	0.996	0.938	1.000		
0.989	0.995	0.987	0.965	1.000	
0.968	0.992	0.970	0.892	0.933	1.000

	Pinus lambertiana_DBH	70.1	39	37.9	50.9	71.2	54.8	59	51.2	74.3	32.3
west	70.1	1.000									
west	39	0.993	1.000								
west	37.9	0.997	0.999	1.000							
west	50.9	0.991	0.999	0.999	1.000						
west	71.2	0.982	0.999	0.994	0.998	1.000					
west	54.8	0.989	0.999	0.997	0.999	0.999	1.000				
west	59	0.983	0.988	0.988	0.991	0.992	0.984	1.000			
west	51.2	0.987	0.998	0.996	0.998	0.999	0.999	0.980	1.000		
west	74.3	0.992	0.986	0.990	0.993	0.989	0.981	0.996	0.976	1.000	
west	32.3	0.972	0.998	0.990	0.992	0.996	0.998	0.988	0.998	0.979	1.000
west	53.1	0.990	0.978	0.982	0.976	0.964	0.968	0.972	0.972	0.979	0.953
west	48.4	0.996	0.978	0.986	0.979	0.971	0.972	0.977	0.968	0.988	0.949
west	25.2	0.997	0.995	0.998	0.997	0.991	0.995	0.987	0.992	0.991	0.984
west	54.1	0.996	0.997	0.998	0.998	0.995	0.994	0.995	0.992	0.996	0.990
west	74.5	0.990	0.997	0.996	0.998	0.997	0.995	0.997	0.993	0.995	0.992
west	72.2	0.993	0.999	0.999	0.999	0.997	0.999	0.990	0.998	0.992	0.990
east	70.7	0.965	0.991	0.982	0.988	0.992	0.993	0.968	0.996	0.961	0.995
east	15.6	0.991	0.996	0.992	0.993	0.996	0.989	0.992	0.991	0.989	0.994

53.1	48.4	25.2	54.1	74.5	72.2	70.7	15.6

1.000							
0.994	1.000						
0.984	0.990	1.000					
0.982	0.989	0.998	1.000				
0.978	0.980	0.996	0.999	1.000			
0.975	0.983	0.998	0.998	0.997	1.000		
0.935	0.940	0.979	0.978	0.981	0.988	1.000	
0.994	0.997	0.985	0.998	0.998	0.993	0.983	1.000