

How we sample trees influences our assessment of climate change impacts on forests

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Behind the paper

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It seems as though dire predictions of U.S. forest decline continue to roll off the presses. Even the Nation's forest census, the USDA Forest Service Forest Inventory and Analysis (FIA) program, has measured elevated levels of tree mortality in many forest types - mostly as a result of fires, drought, and insect outbreaks. However, in contrast to these indicators of decline, the FIA program also shows substantial regeneration and regrowth. In our recent paper ([Klesse et al., 2018](#)), we use a new network of tree-ring data collected in FIA plots to compare two predictions of forest decline, the first based on the forest inventory sample and the second based on a public tree-ring archive, the International Tree-Ring Data Bank (ITRDB). The result: how we sample trees makes a big difference in projected forest decline.

The ITRDB is the product of decades of hard work and is a testament to how tree-ring scientists have openly shared data. Studies based on this dataset predict severe forest decline. But how well does the ITRDB represent regional forest growth? The ITRDB and FIA datasets differ in one key aspect: sampling design. Trees in the ITRDB were typically selected to describe past climate variability. Trees in the FIA were selected following a strict protocol representing the overall forest population, regardless of tree size or species. We compared these two extensive tree-ring databases to test for differences that might influence predictions of future growth decline.

Our findings confirm what many of our colleagues have known for years – the variability of tree growth is higher in ITRDB trees compared to FIA trees – because of a stronger influence of climate variability at ITRDB locations. Our analysis suggests three reasons for this. First, in the case of Douglas-fir, we found that ITRDB locations were at the low-elevation edge of the species distribution, where growing conditions are warmer and drier (Figure 1a and

Figure 2). Second, ITRDB trees are older, by almost 200 years on average (Figure 1b); older (larger) trees are more sensitive to climate variation. Third, ITRDB trees tend to be chosen from steep or rocky slopes where there is little soil water capacity (Figure 1c and Figure 2), with the goal of maximizing variability in the width of annual growth rings. The ITRDB sample represents a small and very special subset of the overall forest population – one that shows a stronger response to climate than do the FIA samples (Figure 3).

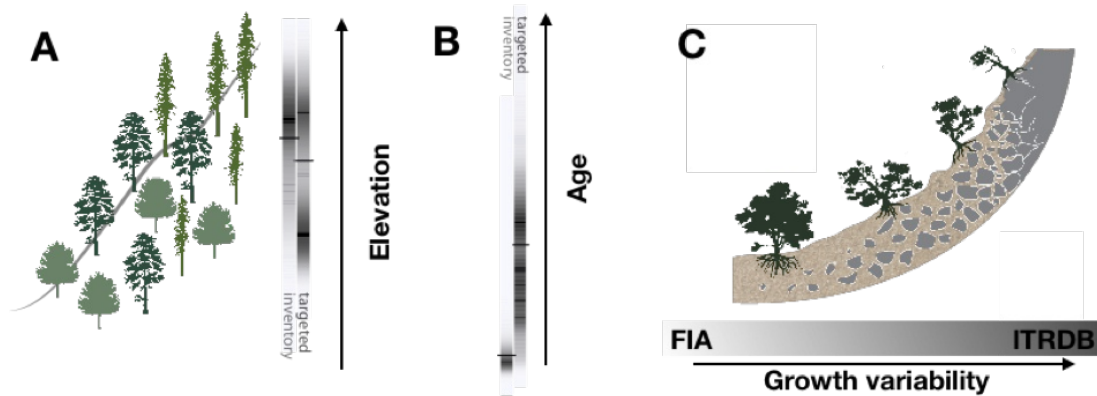


Figure 1: A) Schematic of the forest community in the southwestern U.S. along a mountain slope, with elevation data for Douglas-fir sampling locations. Targeted (ITRDB) samples of Douglas-fir tend to be taken from lower and warmer locations in this species' elevation range. B) Targeted (ITRDB) trees also tend to be much older compared to the forest inventory trees. C) Selection of trees on steep, rocky slopes with little soil water capacity leads to greater ring-width variability in ITRDB trees compared to FIA trees.



Figure 2: Contrasting site and tree conditions. At left is an upper elevation (2743 meters), Douglas-fir dominated forest inventory plot, with fertile growing conditions and high tree density. At right is another Douglas-fir dominated site, but this one at lower elevation (2286 meters), targeted for its older trees and nearly non-existent

soils. Site conditions such as those at right limit moisture available for tree growth and result in higher ring width variability and a stronger response to climate variation. The two forests are just 27 km apart. The site in the right-hand photo would be considered a good sampling site for answering questions about historic climate variation, and thus may be typical of ITRDB sampling sites. In contrast, the site in the left-hand photo would not be considered a desirable sampling site for research questions aimed at better understanding the climate system. Photos by C. Guiterman.



Figure 3: Two radial growth patterns of a typical “targeted” ITRDB sample (top) and an inventory FIA sample (bottom). The ITRDB sample shows much higher year-to-year variability in ring widths compared to the more stable, “train track” growth pattern in the FIA sample.

The implications of these differences become evident when we predict future tree growth. The ITRDB and FIA tree-ring data unequivocally agree that tree growth declines with increases in temperature. Changing climate is increasing regional temperatures, causing drought stress to trees. However, the projections for decline are less extreme when based on the FIA dataset. A direct comparison between the two indicates that ITRDB-based projections overestimate tree growth decline by 41 percent. These findings suggest a certain degree of resilience of forested landscapes – not all trees will go the way of the ITRDB trees. They also remind us that we need data from a broader range of study designs to fully understand – and predict – the effects of climate change on forests.