PNW
Pacific Northwest Research Station

Science FINDINGS

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INSIDE

"Science affects the way we think together."
Lewis Thomas

100,000 TREES CAN'T BE WRONG: PERMANENT STUDY PLOTS AND THE VALUE OF TIME

"From the start, I was not interested in research for research's sake, but wanted to see research put into use."
—Thornton T. Munger

In the early days of the permanent study plot program, large calipers were used to measure tree diameter.

We used to believe that Douglas-fir seeds lying on the forest floor remained viable for some years before they germinated. We used to believe that forests could be managed only as a one-harvest crop. We used to believe that old-growth forests were "decadent" and therefore worthless. We used to believe that red alder was a pest. We used to believe that lengthening Douglas-fir rotations would decrease timber volume. There's more, there's plenty more, but you get the picture.

What was missing from each one of these belief sets was the element that cannot be left out of forestry research: time. If you're studying a species whose average lifespan is longer than 5 or 6 or 10 human lives, you need time, or you'll be looking at a trend that could send you down a bunny trail.

"Changes in the composition, structure, and functions of forest ecosystems typically occur over long periods of time. In the Pacific Northwest…for example, it is not unusual for individual dominant trees to survive for 500 years or longer," writes Steve Acker, formerly an Oregon State University forest researcher, in a book chapter on the PNW Research Station's permanent study plot (PSP) network. "Significant compositional and structural changes may continue to occur 750 years after a stand-initiating disturbance."

The PSP network began with the foresight of Thornton T. Munger, the Station's first director, who recognized the value of long-term research in considering forestry issues, particularly forest dynamics, which operate for the most part on long timeframes. He established the first permanent study plots in 1910, which became part of the larger network, today encompassing over 100,000 trees and 145 active plots.

IN SUMMARY

In 1910, Thornton T. Munger, the first director of the PNW Research Station, established the first forested permanent study plot in the Pacific Northwest. He recognized that long-term field observation was the only approach that could provide real data on forest dynamics, which occur over time scales longer than human lifespans.

For the next 80 years, Station scientists established additional plots and continued plot measurements throughout the region. The majority of plots were established in natural, closed-canopy forests, unaffected by harvest. Currently the Pacific Northwest Research Station manages this permanent study plot (PSP) network, which includes long-term measurements on over 100,000 trees in 145 plots.

Data from these plots have been used by scientists and managers around the country to address basic and applied questions in forest ecology and management, including development of old-growth structure, tree mortality, carbon sequestration, and timber yield. As the physical, social, and political landscapes have changed over the past century, so the findings from PSP data continue to inform and change the thinking about the future of forests in the Pacific Northwest.

The earliest plots were not initially established in protected areas, and over time some were lost to timber harvest and road building. Today the majority of the plots are in experimental forests, research natural areas, and national parks where research is a primary use, and the longevity of the plots will remain protected. Another protection comes in the form of exceptional individual commitment regardless of weather and terrain, and the long-term partnership between the PNW Research Station and Oregon State University, the University of Washington, and the National Park Service, in collecting and managing the data. The benefits of maintaining the PSP program have always been widespread.

KEY FINDINGS

- Analysis of tree locations and long-term mortality records from PSP data revealed that in order to monitor late-successional forest attributes accurately in the Pacific Northwest, the standard Forest Inventory and Analysis plot size had to be expanded for trees and snags in this region.
- Examination of 82 years of PSP Douglas-fir data showed that longer rotations of this species may not always result in large declines of timber growth and can also provide structural characteristics similar to old-growth forests.
- A study of three watersheds with stands of different age classes revealed that observed decline of biomass accumulation with stand age was a result, in equal parts, of both decreasing annual growth and increasing mortality.
- A study of effects of forest harvest on plant species diversity and occurrence over 30 years showed that loss of vascular plant diversity is fairly short lived following clearcut logging and broadcast burning. Most species recovered to preharvest levels before the new canopy closed.

THE NETWORK TAKES SHAPE

Munger's first plots were designed to estimate timber growth and yield in young stands of important commercial species. The oldest of these plots was measured for the 14th time in 2002.

Since then, the PSP program has seen the waves of research focus change and wash over it through nearly a century. During the 1960s, the emphasis was on intensive production forestry. Beginning in the late 1970s, the focus for much of the PNW Research Station research expanded beyond growth and yield to include the composition, structure, and population and ecosystem dynamics of natural forests. The matching goal in the PSP program was to establish plots that represented samples of most of the important environments and associated forest types of the region, at least on the west side of the Cascades. Most recently, the spotlight has turned onto forest-stream interactions and the dynamics of multiage stands.

"What is interesting is to see that, while we are still making essentially the same measurements, even in many cases with the same equipment, the resulting data are being used in a wealth of different ways," says Sarah Greene, forest ecologist with the PNW Station in Corvallis, Oregon. Greene has been a part of both the PSP program and the Research Natural Areas Program for the Station since the early 1980s. "Munger wanted to understand past forest development in order to predict growth and yield over time of Douglas-fir forests. We are now looking across a similar spectrum of attributes, and asking more and different questions about the future."

The majority of plots are located in western Oregon and Washington. The trees on these plots range in age from 6 to 1,200 years, and the plots range in size from about 0.2 to 11.6 acres. Five forest zones are represented, 83 of the plots have every stem mapped, and 88 carry measurements of coarse woody debris.

In the earliest days, data were collected on foot and on horseback, with paper and pencil, by using calipers, then a diameter tape (D tape) and an Abney level. Later, motor vehicles came into use to speed travel time, and today's laser range finder is quicker for measuring height, but other than write-in-the-rain paper, not much else has changed, Greene says.

"There are supposed to be permanent marks or tags on all trees larger than five centimeters in diameter at breast height, but animals, storms, changed roads, and logged plots have made it difficult to stay abreast of all the plots. The global positioning system is now used to locate plots when other methods can't help."

Over the years the collaborative database that has evolved from the PSP network has adapted to expansion, to outside requests, to multiple new uses, to computers and rapidly changing software. The database is managed by the PNW Research Station and the Oregon State University on the College of Forestry's forest science databank. Howard Bruner is one of the key liaisons for the PSP program. "It's amazing to learn just how many iterations this archive has gone through in our efforts to improve it, provide

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access, and share it as widely as possible," says Bruner, forest science faculty research assistant in Oregon State University's College of Forestry. "For this kind and size of data archive, we are in the forefront of data management."

Most of the study areas were established in natural, closed-canopy forest, including young (40 to 80 years old), mature (80 to 200 years old), and old-growth forests (more than 200 years old). Three kinds of plots are used: hectare reference plots subjectively placed within an area of homogeneous forest, circular plots likewise, and circular plots systematically located on long transects to sample an entire watershed or forest type.

LAND MANAGEMENT IMPLICATIONS

- Permanent forest plots with precise stem maps and long-term mortality data are ideal for evaluation of old-growth characteristics.
- Long-term observations from PSP plots are showing how long old-growth structure takes to develop, whether some aspects develop more quickly than others, and what management actions might enhance future timber yields.
- The rate and peak of biomass accumulation can be studied over the entire life cycle of a forest by using long-term PSP plots.
- Continued sampling of experimental PSP plots can provide insight into the relationship between overstory structure and understory composition during the dynamic period of canopy closure.

CONTRIBUTING TO SCIENCE

What have these quietly maintained plots of longevity contributed to the world of science?

The contribution started as early as 1930 with the publication of what became known as Bulletin 201. A handbook for timber growing and logging practices in the Douglas-fir region, this publication included what for the travel- and technology-limited time was a mind-boggling array of quantitative data, portions of which came from Munger's permanent plots. According to Greene, Bulletin 201 is one of the most influential publications in the history of Pacific Northwest forestry research.

Permanent study plot networks have continued since then to be used for a wide range of experimental calculations, from mortality and population dynamics of forest types, and dynamics of coarse woody debris and nutrient cycling, to changes of species composition and diversity in postlogging stands, and population structure of forest canopy arthropods.

Research emphases have of course changed through time. "Managing for mature and old-growth forest attributes has become an important emphasis for many federal and state forest managers in the PNW," says Kari O'Connell, forest director at the H.J. Andrews Experimental Forest, location of 43 of the PSP plots. "Permanent forest plots with precise stem maps and long-term mortality data are ideal for evaluation of old-growth characteristics."

Yet not all forest plots are alike. The national design for plot size to sample tree density, basal area, and volume in a grid across all forest lands in the country, and used by the Forest Inventory and Analysis (FIA) program, had been developed in forests in Maine and New Jersey. PNW researchers were concerned that the plot size was not sufficiently large to capture attributes of Pacific Northwest old-growth forests. Andy Gray, PNW research forester for FIA, used tree spatial locations and long-term mortality records from PSP data to simulate the effect of different plot sizes on the accuracy of measuring density of large live trees and snags, tree mortality, and tree species richness in mature forest stands in the region, O'Connell explains.

"This analysis revealed that in order to measure late-successional and old-growth forest attributes in the Northwest within an acceptable level of accuracy, the national FIA plot size needed to be expanded for the measurement of live trees and snags." Plot size appropriate for the region has become a significant matter in terms of the late successional reserve development and monitoring strategy under the Northwest Forest Plan.

Thornton T. Munger held the vision behind the permanent study plot program, believing Western forests could not be managed without a growing base of longitudinal data.

Sometimes serendipity helps out. In 1995 PSP plots at Waldo Lake in Oregon were burned by wildfire, allowing nearly 20 years of data to provide the baseline and "before" data for following natural succession.

THE RIDDLE OF BIOMASS ACCUMULATION

Trends in biomass accumulation are a key focus in research today, with carbon credits, fuel loading, and global warming as immediate context. Another Northwest Forest Plan issue was the concern that extending the rotations of Douglas-fir stands would result in a significant decline in volume growth—a matter of considerable economic concern in the area. Again, long-term records, up to 82 years, from 20 permanent plots in Douglas-fir stands were used to examine the implications of extended rotation length.

Greene notes that scientists generally agree that the rate of biomass accumulation in forests peaks at canopy closure, which occurs around 30-40 years of age for Douglas-fir forests, and declines thereafter. "However, the data supporting this idea come largely from chronosequence studies and from intensively managed plantations, which typically constitute a very small portion of the life cycle of forests," she says. "Long-term observations from the PSP program provide

Measurements of permanent study plots continues today, with the 14th measurement of the original plots completed in 2002.

opportunities for examination of this issue over the entire life cycle of PNW forests." (A chronosequence study takes data from a single point in time in different-aged stands, rather than following a number of stands over a long period.)

The findings? After looking at volume growth and development of old-growth structural features, researchers found that volume at 80 years of age was still going strong and not showing a major decline in biomass accumulation, according to O'Connell.

Data from such experiments are helping to modify the Forest Vegetation Simulator, the Forest Service's widely used and nationally supported framework for forest growth-and-yield modeling, to improve its capabilities for simulation of late-successional conditions.

In another assessment using PSP data, a combination of chronosequence approach and long-term plot observations served to examine how biomass accumulation in Douglas-fir forests is affected by age. Three small watersheds (29, 100, and 400 years old) in and near the H.J. Andrews Experimental Forest illustrated distinct trends in accumulation rate of bole biomass.

"Biomass was positive and increasing in the young watershed, positive and constant in the mature watershed, and fluctuating between positive and negative in the old-growth watershed," O'Connell explains. "This analysis showed that the observed decline in biomass accumulation with stand age resulted in equal parts from decreasing annual growth and from increasing mortality."

Bruner notes that a recent request for use of PSP data came from researchers wanting to test the feasibility of predicting the number of trees in a forest stand based on variation in their size. This is but one of many outside requests for data that will bring new angles and perspectives to forest management from mining a long-term database, he says.

DATA-MINING FOR FOREST MANAGEMENT EFFECTS

The relationship between resource management and conservation of biological diversity in the Pacific Northwest is controversial at best, most researchers would agree. While much attention has been paid to effects of management on wildlife, few studies have focused on the dynamics of the forest understory.

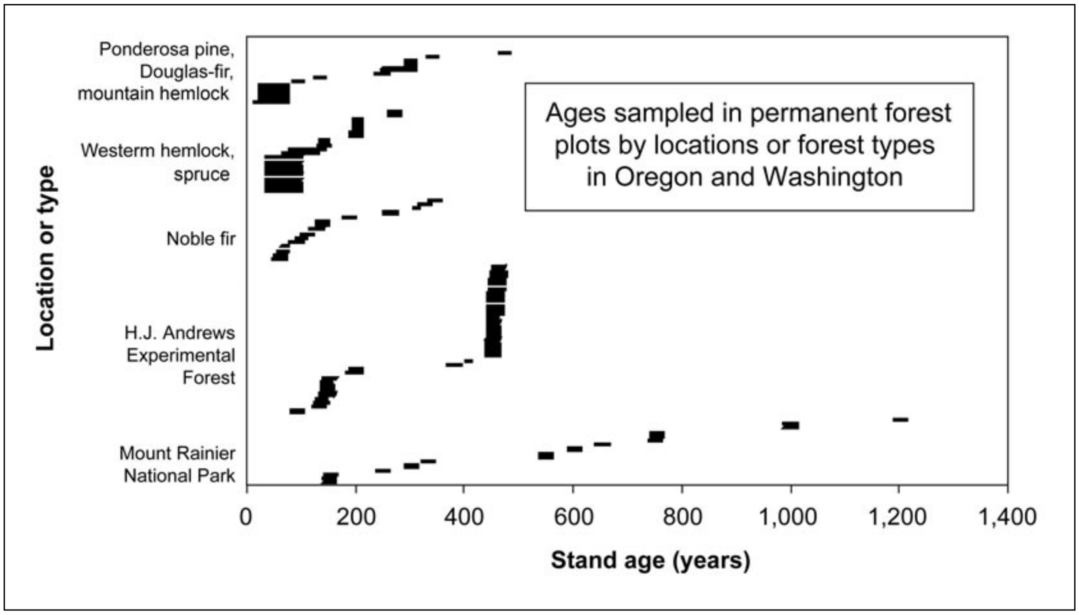
To date, models of how understory species respond to harvest and postharvest practices have been based on short-term or chronosequence studies, Greene explains. However, long-term studies at the Andrews now provide an unprecedented view of early-successional change and the factors that contribute to loss and recovery of plant diversity following natural or human-induced disturbance.

"Two watersheds were experimentally harvested—one clearcut completely and one patch-cut—then the vegetation changes were tracked from the baseline to see how diversity was affected," O'Connell explains.

WRITER'S PROFILE

Sally Duncan is a science communications specialist and writer focusing on forest resource issues. She is also a candidate for a Ph.D. in Environmental Sciences at Oregon State University in Corvallis, Oregon, where she lives.

"Observations over a period of nearly three decades reveal that loss of vascular plant diversity is fairly short lived following clear-cut logging and broadcast burning—most species recovered to preharvest levels before the stands reached canopy closure."



The graph plots the age distribution of trees on permanent study plots across the network.

Continued sampling of these experimental plots will provide insight into the relationship between overstory structure and understory composition during the dynamic period of canopy closure.

The Northwest Forest Plan also recognizes the role of old-growth forests in protecting biological diversity and directs management towards protecting and enhancing old-growth conditions. However, until recently little has been known about the development of old-growth structure over time or how this development may be accelerated.

"Long-term observations from the PSP program are providing information for managers about how long old-growth structure takes to develop, whether some aspects develop more quickly than others, and what management actions could be taken to enhance the development of old-growth structure," O'Connell says.

Echoes of Munger's forest development interest, only with a 21st-century twist.

COMPARATIVE ADVANTAGES AND SHORTCOMINGS

The PSP program distinguishes itself from other forest inventories in several ways. It has its shortcomings. Plots are subjectively placed, unevenly spread, and very biased toward the west side of the Cascades, Greene admits. The rectangular reference plots, established in an effort to provide coverage of all age classes and habitat types, are not randomized, and are therefore less apt to pick up variations.

"However, no other forest inventories have the decades-long data sets associated with the PSP program's plots," Greene notes. "Measurement protocols for the FIA plots have changed over time, limiting potential for analysis of plot-level trends through time. The PSP network is much better suited to this task. Other programs are typically designed to assess broad-scale patterns in forest conditions and trends."

The combination of remote sensing and precise geographic coordinates for all permanent plots allows PSP observations of structure and dynamics to provide a check on inferences from remotely sensed data. Conversely, the applicability of plot-based analyses over broad areas can be most efficiently assessed by using remote sensing.

Other programs tend to be based on systematic grids of points, therefore offering no control of anthropogenic disturbance and no ability to focus on systems of particular interest such as riparian areas, Greene explains. Their plot designs also make it difficult to analyze spatial patterns within plots. "In short, other programs are less likely to provide the most suitable data for understanding detailed processes of specific forest types."

Funding squeezes can threaten such quiet programs as the PSP, she says, but its careful maintenance over nearly a century means that when any plots are "put to bed" during tight funding, they are well documented, marked, and likely to remain extremely valuable in the future.

When Thornton Munger established the first permanent study plots more than 90 years ago, he couldn't have imagined the myriad questions that have been addressed with the PSP network data. One can only guess at what questions will face us in the future. As OSU's Bruner points out, "It is highly likely that in the future, these databases will be able to provide answers to some of the most difficult questions arising from anthropogenic change."

"Nought's permanent among the human race..."

—Lord Byron, 1788–1824

FOR FURTHER READING

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