The West-Wide Ponderosa Pine Levels-of-Growing-Stock Study at Age 40[1]

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Abstract

In the 1960s a series of levels-of-growing-stock studies was established in young, even-aged stands throughout the range of ponderosa pine in the western United States. Using a common study plan, installations were begun in the Black Hills of South Dakota, eastern and central Oregon, the Coconino Plateau of Arizona and the west slope of the Sierra Nevada in California. Innovative features for the time were tests of a wide range of stand densities from open-grown to densities high enough to jeopardize stand health, and to periodic rethinning of the plots back to the stand density level originally assigned. Perhaps the major reason for the longevity of this west-wide study was the foresight of the original planners in testing a range of stand densities far beyond those practiced at the time. Establishment of this range provided a demonstration of the long-term stand development of even-aged ponderosa pine applicable to many current management objectives.

Introduction

Ponderosa pine (*Pinus ponderosa* P. & C. Lawson) is one of the most widely distributed conifers in North America. It occurs in 15 western states, extending from the western Great Plains to the Pacific Coast and from southern British Columbia, Canada, to Baja California, Mexico. Ponderosa pine is found at elevations ranging from sea level in the northern part of its range to 10,000 ft in the southwestern United States (Oliver and Ryker 1990). Throughout this vast area ponderosa pine is one of the most valued tree species. Recognized initially for the quality of its wood yields and as a major source of forage for cattle, ponderosa pine forests are now recognized as vital wildlife habitat, and they provide abundant recreational opportunities. As a result, ponderosa pine forests have a long history of intensive management.

In the mid 20th century, however, management of young growth ponderosa pine forests was in its infancy. Results from studies conducted in one area (Gaines and Kotok 1954; Mowat 1953; Myers 1958) seemed to have limited use in another area. Dissimilar experimental designs and measurements that were incomplete or based on specific products further restricted comparability. Also, these early studies did not test the low reserve densities that may be desired for today's multi-resource management.

Consequently, growth information was needed over a wide range of stand and site conditions and with a minimum of operational restrictions to provide useful guides for a variety of management objectives. To fill this need three western

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[1] An abbreviated version of this paper was presented at the symposium on Ponderosa Pine: Issues, Trends and Management, October 18-21, 2004, Klamath Falls, Oregon.

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Research Stations of the U.S. Department of Agriculture, Forest Service, cooperated on a large scale levels-of-growing-stock study through the use of a common study plan (Myers 1967).

Many reports have been published on individual installations (*table 1*) of this west-wide study and two reports combining data from most of the installations were published more than 15 years ago (Oliver and Edminster 1986; Edminster 1988). This paper reports on the present status of the six installations after about 40 years. It describes the development of the stands, their value in demonstrating the influence of low reserve stocking, and the opportunities for satellite studies.

Original Study Plan

Five regions within the range of ponderosa pine in the western United States were arbitrarily selected for study and assigned to the participating Research Stations. These five "provinces" differ in many respects. Physiography ranges from the uplift of the Black Hills of South Dakota to the Coconino Plateau of Arizona, the Blue Mountains and Cascade Range of Oregon, and Sierra Nevada of California. Two varieties of ponderosa pine are recognized (*Pinus ponderosa* P. & C. Lawson var. *ponderosa* and *Pinus ponderosa* P. & C. Lawson var. *scopulorum*) (Conkle and Critchfield 1988). Some provinces are without summer precipitation; other provinces receive most of their annual precipitation during the growing season. Within each province, combinations of four tree-size classes from small saplings to large poles on areas of three site qualities of high, medium, and low were to be sampled, as available, in even-aged stands.

The initial plan specified that each study installation would consist of three replications of plots thinned to five or six different stand densities. Plots were to be at least 0.25 to 0.5 acre in size with 20-ft isolation strips for small saplings, and 0.5 to 1.0 acre with 30-ft isolation strips for the larger size classes. One plot in each replication was to be thinned to the density considered best for that site quality, based on past experience. Two or three plots were to be thinned to lower, and two or three plots to higher stand densities. The highest stand density would be chosen such that the production of merchantable material would be reduced below that of lower densities. And the lowest density level would be chosen such that cubic-foot volume production would be lower than that at higher densities.

Stand densities to be retained after thinning were specified as a series of growing stock levels (GSLs) (Myers 1967). These levels were defined by relationships between basal area and average stand diameter. Numerical designation of the level assigned to a plot was the basal area per acre that would remain after thinning when mean stand diameter was 10 inches or more. Stands with trees smaller than 10 inches when thinned would contain residual basal areas that were less than the designated GSL.

Table 1— *Installations in the west-wide levels-of-growing-stock study fore even-aged ponderosa pine.*

Geomorphic Province	Name & Year	Site Index[1]	Size class	Growing stock levels	Periods analyzed	References
Black Hills South Dakota	Black Hills Saplings 1964	55	large saplings	20,40,60, 80,100, 120	7	Boldt and Van Deusen 1974
Black Hills South Dakota	Black Hills Poles 1964	55	small poles	20,40,60, 80,100, 120	7	Boldt and Van Deusen 1974
Coconino Plateau Arizona	Taylor Woods 1962	62	small poles	30,60,80, 100,120, 150	7	Ronco and others 1982 Schubert 1971
Blue Mts. Oregon	Crawford Creek 1967	60	small poles	30,60,80, 100,120, 140	6	Cochran and Barrett 1995
East-side Cascade Range Oregon	Lookout Mt. 1966	92	large poles	30,60,80, 100,120, 150	7	Barrett 1983 Cochran and Barrett 1999
West-side Sierra Nevada California	Elliot Ranch 1969	140	Small poles	40,70,100, 130,160	6	Oliver 1979 Oliver 1997

[1] feet at 100 yrs (Meyer 1938).

Thinning was to be from below, primarily, with the smallest trees and rough dominants removed first. Each installation was scheduled to run for 20 years, with measurements at 5-year intervals. At the end of 10 years, plots were to be rethinned to the specified GSLs.

Before the growing season following initial thinning, all trees were to be tagged and measured for diameter at breast height (dbh) to the nearest 0.1 inch. Tree damage and diseases were to be noted. Various sampling schemes could be used to select trees for total height and height to the living crown, measured to the nearest 1 ft. Total stem volume was obtained either by the use of local volume tables or by an optical dendrometer. All measurements were to be repeated on the same trees after each 5-year period.

The Installations

The study as envisioned was ambitious, requiring prodigious amounts of land, labor, and money. Cooperators experienced difficulty both in finding sufficient areas of uniform site and stand conditions, and in allocating sufficient resources to sample but a few of the province/size/site combinations. Although many fewer than planned, the five installations established in naturally regenerated stands and the one installation established in a plantation (Elliot Ranch) nearly spanned the geographic range of ponderosa pine (*table 1*).

During the planned 20-year life of the study, the six installations were established and maintained in general conformance with the plan except as follows: (1) two rethinnings were performed at Elliot Ranch at five-year intervals rather than ten-year intervals because of rapid growth (*fig. 1*); (2) only one rethinning was performed in the lowest GSL plots at Lookout Mountain because a second rethinning would have resulted in too few trees for a sufficient sample; (3) only one rethinning has been performed in both of the Black Hills installations; (4) the controlling measure of stand density was changed to stand density index (SDI; Reineke 1933) at Lookout Mountain, Crawford Creek and Elliot Ranch Because basal area (GSL for mean stand diameters above 10 inches) as a measure of stand density is not independent of tree size and age. Remarkably, all installation have been continuously maintained and remeasured for twice as long originally envisioned, albeit not always on a rigid 5-year interval.

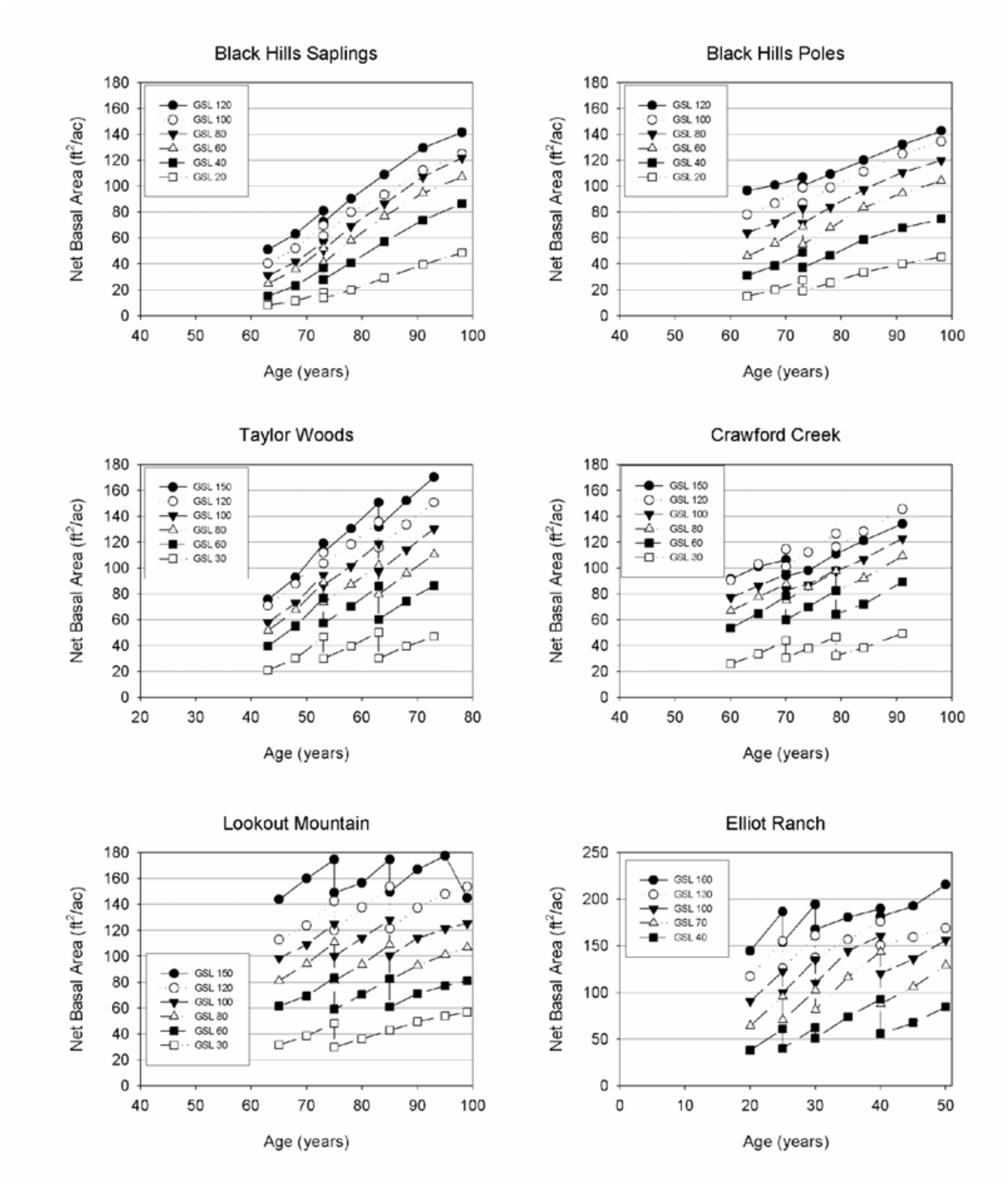

Figure 1—Net basal area development of the Growing Stock Level (GSL) treatments at six installations of the west-wide ponderosa pine levels-of-growing-stock study.

Results and Discussion

Treatment Effects on Stand Growth

An unthinned stand treatment was not included in the original plan. Neither is information available on the stand before thinning. Presuming that the stands before treatment were similar to those of normal density (Meyer 1938), the thinning treatments created a uniform array of stand densities ranging from those containing essentially open-grown trees to those retaining about half of the original basal area after light thinning.

Mortality (primarily in the higher reserve densities) tended to blur this uniform array. Mortality from mountain and western pine beetle was especially prevalent 10 to 20 years after initial thinning in the GSLs above 100 at Elliot Ranch. Mortality from mountain pine beetles was also high at Crawford Creek and breakage from a heavy wet snow was so severe at Taylor Woods that the two highest GSLs at these two installations differed little in actual density for the first 10 years. Mortality by all agents has declined over the years. Except for recent killing by mountain pine beetles at the highest GSL at Lookout Mountain, the treatments are now distinctly different in stand density.

Stand Structure Changes

Thinning, especially heavy thinning, has had a profound influence on the structure of the plots (*fig. 2a, 2b*). In general, maintaining plots at the highest reserve densities, GSLs 120 to 160 has over the period of observation transformed the diameter distribution from one resembling a reverse "J' shape to one resembling a normal distribution. Heavy thinning, in contrast, immediately created a normal distribution that has been maintained for 40 or more years.

Opportunities for Satellite Studies

Studies continuously maintained for 40 years are rare in forestry. Research interests and priorities can change over such a long time and make such long-term studies obsolete. Nevertheless, silvicultural studies in which vegetation is manipulated in a statistically valid field design and with well-documented treatment responses afford many opportunities for studies never anticipated by the original researchers. Such is the case in this west-wide levels-of-growing-stock study. This study has already answered many of the questions for which it was first designed. The wide range of stand densities created under carefully controlled manipulations, however, provides opportunities for many satellite studies. One example has been a study demonstrating the efficacy of low reserve densities in maintaining stand health. Because most tree mortality, whether it is caused by biotic or abiotic factors, is episodic, evaluations of forest health are meaningful only if reserve stand densities are maintained over a long period of time. Another use of the overall data is in the construction of growth models for even-aged ponderosa pine stands. The database for these models is restricted to remeasured permanent plots, of which the data from the west-wide levels-of-growing-stock study is a critical part. Some examples of these studies follow.

Figure 2a—Diameter distributions for the extreme Growing Stock Level (GSL) treatments after initial thinning and 30 or more years later for three installations (Black Hills Poles, Black Hills Saplings and Taylor Woods) in the west-side ponderosa pine levels-of-growing-stock study.

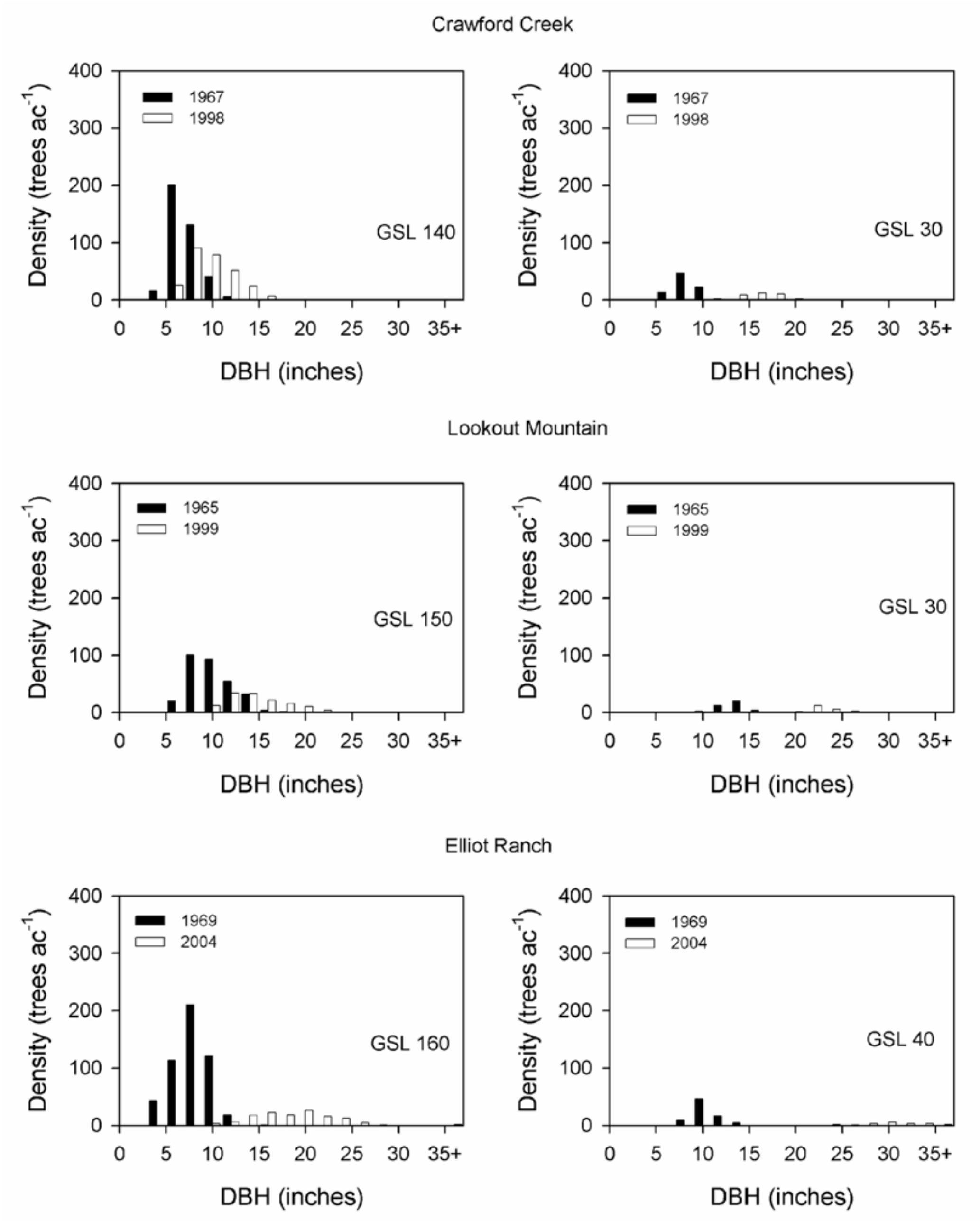

Figure 2b—Diameter distributions for the extreme Growing Stock Level (GSL) treatments after initial thinning and 30 or more years later for three installations (Crawford Creek, Lookout Mountain and Elliot Ranch) in the west-side ponderosa pine levels-of-growing-stock study.

Elliot Ranch

- Influence of overstory stand density on amount and availability of deerbrush (*Ceanothus integerrimus* Hook. & Arn.*)* browse for cattle and deer.
- Influence of overstory shade on growth of five species of conifer seedlings (Oliver and Dolph 1992).
- Influence of *Dendroctonus* bark beetles on maximum stand density for ponderosa pine (Oliver 1995).
- Demonstration of how to create complex species and stand structures in a mono-specific plantation. This has been of particular interest to visitors because of the abundant regeneration of mixed conifers and the interest in speeding development of more “natural” appearing forests. Unfortunately, leaving this advance regeneration unchecked would jeopardize the original study objectives.

Taylor Woods

- Forage production under different overstory stand densities
- Testing differences in canopy cover as measured by spherical densiometer and moosehorn.
- Contribution to database for simulating potential production for various combinations of stand density, site index, age and thinning schedule (Alexander and Edminster 1980).

Black Hills

- Forage production under different overstory stand densities (Severson and Boldt 1977)
- Influence of stand density on wood quality (Markstrom and others 1983)
- Costs and returns from pruning stands thinned to various stand densities (Smith and others 1988)
- Contribution to database for simulating potential production for various combinations of stand density, site index, age and thinning schedule (Myers 1966; Alexander and Edminster 1980).

Conclusions

Although the scientists involved in establishing the installations have retired (four scientists from the Rocky Mountain Research Station have been responsible for Taylor Woods throughout their careers) and the Pacific Northwest Research Station has officially abandoned Lookout Mountain and Crawford Creek, the commitment to maintain the study remains firm. The Rocky Mountain Research Station continues to maintain Taylor Woods and the two Black Hills installations. The Pacific Southwest Research Station has assumed responsibility for Crawford Creek and, with the assistance of Oregon State University, Lookout Mountain.

Early in the life of the study, meetings were held periodically to exchange information and coordinate activities. Several decades have elapsed since the last such meeting. Now may be time for another meeting. It has been evident for some time that another rethinning of the lower reserve densities is no longer possible in most installations. Increasing tree size would result in reducing the number of trees on the half-acre plots below the 12 to 15 considered to be the minimum needed to characterize growth response. A restructuring of the array of treatments might be discussed as well as an exploration of satellite studies that could be undertaken on more than one installation.

Perhaps the major reason for the longevity of this west-wide study is the foresight of the original planners in testing a range of stand densities far beyond those practiced at the time, thus providing a demonstration of the long-term stand development of even-aged ponderosa pine applicable to many current management objectives.

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