History of Silvicultural Research in the Douglas-fir Region

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Abstract

We review the history of silvicultural research in the Douglas-fir region, with emphasis on long-term studies over the past century. Although much of this is unfamiliar to the present generation of foresters, yet the older work still has value and its history provides perspective on present problems and trends.

Keywords: forest history, silviculture, Pacific Northwest, Douglas-fir

Introduction

We thought a historical review would be a useful introduction to today's subject. This will be limited to brief discussion of a few major topics. We focus on Douglas-fir research, with only brief mention of other species.

Silvicultural research in the Douglas-fir region dates roughly from 1900. There was some initial work by individuals, mostly descriptive, beginning in the old Bureau of Forestry in the 1890s. The first published work was a series of monographs on the important timber species (e.g.: Allen 1902; Frothingham 1909), based on field observation rather than planned experimentation. It was early recognized that Douglas-fir was a moderately intolerant species and that most of the region's forests owed their origin and characteristics to periodic fires.

Silvicultural Systems and Regeneration

Long-term silvicultural research began with the arrival in 1908 of Thornton Munger as leader of the newly established Section of Silvics in the District Forester's office in Portland. He and others recognized that the most crucial immediate problems were (1) fire protection, and (2) regeneration methods. Munger undertook extensive measurements in existing second-growth stands, published the first volume and yield tables and much other information, and recommended "clean" cutting with retention of seed trees, followed by slash burning and protection from fire (Munger 1911).

Seed and nursery production research began at Wind River Nursery in 1911, initially by C.P. Willis and Hofmann. The Wind River Experiment Station was established in 1913 (and was combined with the Division of Silvics in 1924 to form the present Pacific Northwest Research Station).

Julius Hofmann (Director of the Wind River Experiment Station 1913-1924) conducted extensive surveys of the distribution of regeneration on burns and logged areas, and came to the erroneous conclusion (later disproved by Leo Isaac) that much of this was from seed stored in the forest floor. Hofman established a series of plots along extensive transects in then unstocked areas, including the Wind River Valley; remeasurements in later years documented gradual restocking by seed wind-borne over long distances. He also established the first precommercial thinning study in the region (1920), was the first to link humidity and fire risk, and worked with Munger on the early heredity trials.

Leo Isaac began work in 1924, and devoted most of his working life to the problems of natural regeneration. He became the leading authority on Douglas-fir regeneration (Isaac 1943) and was an early advocate of tree improvement programs in the 1950s.

Abortive efforts at "selective timber management" in the 1930s (Kirkland and Brandstrom 1936; Isaac 1956; Curtis 1998) led many to conclude that there was no alternative to clearcutting. In the 1940s there was general adoption of dispersed moderate-sized clearcuts, first with natural regeneration and later with planting. The clearcut / burn / plant regime was highly successful for a timber production goal, and was almost universal up to the 1990s. Most silvicultural research was devoted to refining the system, although there were a few trials of shelterwood on problem sites.

In the early 1950s PNW Research Station and Oregon State University began extensive work on control of shrub competition. This was later concentrated at OSU and continues to the present.

In recent years environmental concerns, public pressures, and endangered species considerations have revived interest in alternative silvicultural systems, and these are a major aspect of current silvicultural research. These alternatives involve a wider range of species, harvest methods, silvicultural systems and regeneration methods (Curtis and others 1998).

Stand Density Control

Plantation spacing: Early plantations were established at close spacing --usually 6x6 ft or so. It was realized that costs could be reduced by wider spacing, and a number of plantation spacing trials were established over the years.

A Douglas-fir plantation spacing test was established by Leo Isaac in 1925 at Wind River on a relatively poor site. This has been remeasured at intervals through 1990 (Reukema 1979; Miller and others 2004). Results showed that the 10x10 and 12x12 ft spacings were markedly superior to the close spacings. These results led owners to abandon close spacing in favor of 10x10, or even 12x12 if thinning was not anticipated.

The University of British Columbia established a series of spacing trials in 1957 and following years on an excellent site, with generally similar results (Reukema and Smith 1987). In the 1960s additional trials were established by several companies and by the British Columbia Ministry of Forests, and in 1980 a much more extensive trial using five species was established at Wind River Experimental Forest.

There was also some use of the Nelder design in spacing trials by the University of British Columbia, Washington Department of Natural Resources, and Oregon State University, although most of these trials have never been published.

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All these trials showed markedly greater diameter growth at wide spacings. Some showed effects on height growth.

Thinning research: Pre-WWII | Thinning was long regarded as impractical under northwest conditions because of the low value of small material and the abundant supply of large timber. However, a number of | at the time | visionary studies were established in the period 1920-1940.

In 1920 Hofmann established a pre-commercial thinning trial in a 9-year old stand at Wind River. Meyer established an additional trial in 1933, thinned at ages 31 and 50.

The Schenstrom thinning plots on Vancouver Island were established in 1929 in an 18-year-old stand on an excellent site. These have been thinned repeatedly although the originally planned differences in treatments were more or less lost.

The Mt. Walker thinning study was established in a 60-year old poor site stand on the Olympic National Forest in 1934-37. Response was poor in the early years, but when remeasured in 1991 the thinned plots were in excellent condition and had not reached the peak of mean annual increment (Curtis 1995).

Thinning research: post-WWII to present | In addition to earlier trials in Douglas-fir, two extensive precommercial thinning trials were installed in hemlock at Cascade Head, OR and Clallam Bay, WA in 1963 and 1971 (Hoyer and Swanzey 1986). These showed striking response.

These and the earlier trials, plus observation of existing young stands, made it clear that many young stands were too dense for optimum growth and resistance to wind and snow breakage. With the changed economic outlook that followed WWII, precommercial thinning became common from the late 1960s on.

Interest in commercial thinning was stimulated by the economic revival after WWII, the increasing acreage of second-growth stand, and the foreseeable end of oldgrowth timber.

The Pacific Northwest Research Station undertook several operational-scale thinning experiments on industrial lands, under cooperative agreements with landowners. Three experimental forests were established for the primary purpose of thinning research; the Hemlock Experimental Forest near Hoquiam, WA; the Voight Creek Experimental Forest near Orting, WA; and the McCleary Experimental Forest near McCleary, WA. These were mid-age previously unmanaged stands of natural origin. Repeated thinnings included different thinning cycles. Growth and mortality was measured on a grid of permanent plots within treatment areas, over a period of about 20 years at Voight Creek and McCleary.

Results showed some increase in diameter growth and reduced mortality, but little volume gain from commercial thinning in these mid-age previously untreated stands (Reukema 1972; Reukema and Pienaar 1973). Together with higher logging costs and continued availability of mature timber, these results markedly dampened interest in commercial thinning.

Concurrently, a number of industrial owners established other thinning studies, most but not all of which used relatively small plots. Most have not been published.

Two long-term studies in older stands (ex: Williamson 1982) found little difference in gross volume growth but a large reduction in mortality on thinned plots.

Allen Berg of Oregon State University established an extensive series of thinning trials in the 1950s. These have had considerable use as demonstration areas, but no formal report has ever been published.

Most of these studies were begun comparatively late, after extensive crown reduction had occurred. The marked differences between initially overstocked stands and those established with early spacing control showed the need for plantation based thinning experiments. Several large-scale regional studies attempted to address these and related concerns.

The Cooperative Levels-of-Growing-Stock (LOGS) study in Douglas-fir was conducted jointly by several organizations (Curtis, Marshall and Bell 1987). Begun in1961, it was installed in stands in the pre-commercial thinning stage, and included a wide range of sites. Nine installations followed a common design originated by George Staebler and Richard Williamson, consisting of 27 plots with 3 replicates of 8 thinning treatments plus control. Principal results were:

- Gross volume increment was highest in the densest stands, contrary to a belief widely held at the time the study was initiated.
- Volume increment was much more closely related to growing stock level than was basal area increment.
- Net volume increment of unthinned controls exceeded that of thinned plots, although there are indications that the relationship may be reversing with advancing age.
- All thinning treatments markedly increased diameter growth, and had striking effects on understory composition and development.

The Stand Management Cooperative (SMC) is a large cooperative effort, headquartered at the University of Washington (Chappell and others 1987). Its formation in 1985 stemmed from the realization that existing data (1) did not provide adequate coverage of young stands with early density control, (2) did not cover a sufficient range of initial plantation spacings, and (3) were often of poor quality and inconsistent in measurement standards. SMC involves many of the larger landowners in the region and uses standardized design and measurement procedures. Its activities include work on timber quality and fertilization as well as work on stocking control per se. The data are rapidly becoming the major source of information on young stand development of Douglas-fir and western hemlock.

The Hardwood Management Cooperative at Oregon State University is a somewhat similar though smaller program.

Forest Fertilization

Stimulation of tree growth by added nitrogen was first demonstrated in the late 1940s. Several organizations began research on forest fertilization (Chappell and others 1992).

The Regional Forest Nutrition Research Project (RFNRP) was established in 1969 under the leadership of Stanley Gessel of the University of Washington. This was a cooperative program (since merged with SMC) financed by many of the major landowners in the region. Over the years this has established and maintained a very extensive series of long-term field trials that are now the principal source of information on the subject.

In general, results showed that Douglas-fir response to nitrogen is inversely related to site index, and is greater in combination with density control. Response to nutrients other than N is highly variable. Response of hemlock to N fertilization has also been erratic.

Tree Improvement

In 1912 Munger established the Douglas-fir heredity study, a pioneering provenance trial, maintained until 1993, that clearly demonstrated the importance of seed source. He also established the Wind River Arboretum as a long-term trial of exotic species. Although some exotics showed initial promise, their long-term survival and growth proved far inferior to the native species.

Beginning in the period 1950-1960s, several programs in tree improvement were established. John Duffield and Roy Silen were prominent in the early work. Several tree improvement cooperatives have been established. Additional provenance trials were established, seed collection zones were defined, breeding programs were undertaken, and a large number of field trials were established. This work continues.

Growth and Yield Research

In 1910 Munger began a program of establishing permanent growth plots in second-growth stands, which continued until 1940 (Williamson 1963) and formed the basis for a number of publications over the years.

Richard McArdle began work in mensuration in 1925, and was joined by Walter Meyer in 1926 in mensuration and early thinning research.

In 1930 McArdle and Meyer published an elaborate normal yield table for Douglas-fir (McArdle and Meyer 1930), which had a great influence on Northwest forestry. It served for half a century as **the** guide to stand development and management planning (Curtis and Marshall 2004). But, like all normal yield tables, it represented natural unmanaged stands and could not provide the information needed for intensive management.

Staebler combined McArdle's net yield table with mortality data from the permanent plot series begun by Munger, to develop estimates of gross yield. He then used these to produce estimates for thinned stands under the then current assumption that gross yield would be little affected by differences in stocking (Staebler 1960). He recognized that this assumption was uncertain and that existing data did not cover a wide range of stocking, and went on to design the LOGS study referred to earlier.

By the 1970s a large number of permanent plots were in existence, including natural unmanaged stands, some fertilized stands, thinned stands, and some young plantations. The advent of the computer made it possible to handle large amounts of data and to construct stand simulators that summarized the results of many studies. There were efforts to assemble existing data and construct simulation programs that could produce estimates of stand development under a variety of management regimes (ex: Curtis 1981).

It quickly became apparent that, although large quantities of remeasured plot data existed and some covered quite long periods of time, the data were not well distributed geographically, were primarily from stands of natural origin without early stocking control, and did not include extreme treatments. Much existing data were of little value because of inconsistent measurement standards and procedures, poor quality control, inadequate documentation, and frequent use of excessively small plots.

These deficiencies provided the motivation for establishment of the Stand Management Cooperative (referred to above), and for associated efforts to improve long-term experimental plot procedures.

Efforts to improve simulation programs such as ORGANON (Hann and others 1997) continue. These provide the best means of summarizing the results of the numerous existing long-term silvicultural experiments. The ultimate objective is models that integrate the results of all aspects of silvicultural research into a coherent framework for predicting stand dynamics and forest productivity.

Changes in Experimental Designs

Early (pre-WWII) field experiments commonly used large plots (0.5-1.0 acre), usually without replication or randomization. Statistical designs were introduced from agriculture in the late 1930s.

Following WWII, many though not all field studies were designed for statistical analysis, with replication and randomization. The difficulty of finding uniform areas that could accommodate the necessary numbers of plots, plus cost considerations, led many to use quite small plots--often 1/10 acre and sometimes as small as 1/20 acre. This severely limited the usefulness of the data for many purposes, and made extension of results to larger and more heterogeneous areas problematic.

In recent years the problems associated with very small plots have been commonly recognized and recent studies have usually avoided these.

Social Change and Silvicultural Objectives

Until quite recently, most silvicultural research was directed at timber production as the major objective. For some 40 years after WWII, the standard regime was to clearcut, burn, and plant, usually to Douglas-fir; with or without later thinning. There was a progressive reduction in rotations, while replacement of natural regeneration by planting eliminated the need to limit size of clearcuts. The result was large areas in the unsightly early regeneration stage, with most of the remainder in uniform young stands that much of the public regarded as not particularly attractive and that are the least productive condition for wildlife.

These factors combined with widespread urbanization and the associated rise of the environmental movement to produce conflicts between public perceptions and attitudes vs. economic objectives, with associated constraints on management. These conflicts are the most serious forestry problem we have in the Northwest today.

There were now considerable differences in objectives among public, industrial, and small private owners. Much current silvicultural research is concerned with efforts to minimize conflicts between diverse resource management goals, economics, and social considerations that include public attitudes and various legal constraints such as NEPA, ESA, and state forest practice rules.

There is much current interest in landscape-scale visual effects and in wildlife and biodiversity concerns that cannot be evaluated on small plots. This has led to a number of long-term studies using large operational-scale treatment units (Poage and Anderson 2007). These are expensive and they are heavily dependent on close cooperation between land management and research organizations, and on continuity in personnel and funding. They are therefore difficult to maintain. But they are essential to addressing many current questions.

In Conclusion

Formal silvicultural research in the Douglas-fir region can be roughly divided into three periods with differing emphases:

- 1908-c.1945: Primary research emphasis on regeneration of logged areas and unstocked burns and on yield tables, with a beginning on thinning research. Most research was conducted by the Forest Service.

- 1945-c.1990: Research emphasis on questions and practices directly related to a timber production objective. Shift to intensive silviculture in the 1960s. The universities assumed a major role in research. Several companies (Weyerhaeuser, Crown Zellerbach, MacMillan-Bloedel) developed strong in-house research programs.

- c. 1990 to present: Research aimed at timber production as a primary goal was de-emphasized by the federal agencies. Primary emphasis of public agencies was now on environmental, scenic, and biodiversity goals, with efforts to reconcile these with some level of timber production. In-house industrial research declined sharply, although it was replaced in part by various land-owner supported research cooperatives (usually at universities), that still had timber production as a major objective.

The Douglas-fir region has a long history of silvicultural research involving long-term silvicultural observation and experimentation. A large part of our present knowledge is derived from this work. Data from these experiments have often been found useful for a variety of purposes, additional to those envisioned at the time the experiments were established.

This has been a very sketchy account of a large subject. Much more thorough presentations are available in Curtis and others (2007) and Herring and Greene (2007).

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