Douglas-Fir Growth and Yield: Research 1909-1960

Robert O. Curtis *and* **David D. Marshall,** *Pacific Northwest Research Station, USDA Forest Service. 3625-93rd Avenue SW, Olympia, WA 98512-9193.*

ABSTRACT: *Systematic research on growth and yield of Douglas-fir began in 1909. This line of early research evolved over time and culminated in publication of USDA Bulletin 201,* The Yield of Douglas-fir in the Pacific Northwest. *B201 had an enormous influence on development of Douglas-fir forestry and was arguably the most influential single research publication ever produced in the Pacific Northwest. We review the evolution of this research and some associated topics, and the role of the major personalities involved. West. J. Appl. For. 19(1):66-68.*

Key Words: *Pseudotsuga menziesii,* growth, yield table, site index.

All older coastal Douglas-fir foresters are well acquainted with *The Yield of Douglas-fir in the Pacific Northwest* (McArdle et al. 1961), often referred to simply as "Bulletin 201." Some younger foresters and those from east of the Cascades may be aware only that it exists. Yet, B201 was perhaps the most influential single research publication ever produced in the Northwest. It was the culmination of an evolving line of research that began in 1909, and it set the pattern for similar efforts in a number of other Pacific Northwest species. This aricle discusses the evolution of this effort and its applications, and some of the people involved.

The story begins with Henry S. Graves, one of the pioneers of North Arnerican forestry. After graduation from Yale in 1892, he studied forestry in France and Germany. On returning to the United States he worked briefly as a forestry consultant, and then entered the USDA Bureau of Forestry (the ancestor of the research arm of the Forest Service) in 1898, as assistant to Gifford Pinchot. When the new School of Forestry was established at Yale University in 1900, he moved to New Haven as Director and then Dean. He had a strong interest in forest mensuration, taught the subject, and published one of the first textbooks of Forest Mensuration to appear in North America (Graves 1908). This included considerable material from European literature and practice, and is still well worth reading. Graves included a discussion of yield tables, their preparation and use in Europe, and and modifications for application to even-aged stands in the United States where no historical growth data were available. He distinguished three types of yield table for even-aged stands: (1) normal yield tables for thinned stands. (2) normal yield tables for unthinned stands, and (3) empirical yield tables. At the time there were no thinned stands in North America, and in North American usage the term "normal yield table" came to mean a table for natural well-stocked unthinned stands only. (Whereas, in Europe the term is also applied to tables that assume some standard thinning regime.)

The next major figure in the story was Thornton T. Munger, who became one of the outstanding figures in northwestern forestry. Prior to graduation from Yale College in 1905, he took a summer course given by the Forestry School, spent a summer working on a white birch research study, and one at the Yale summer camp. He then went on a European tour, which included three months with German foresters. facilitated by introductions furnished by Graves. On return, he enrolled. at the Yale School of Forestry.

After graduation, he joined the recently created Forest Service and worked briefly under Raphael Zon in Washington. He was shortly sent west to do a report dealing with lodgepole pine and ponderosa pine in central Oregon, and within a few months was appointed "head" of the section of silvics in Portland (which section at that time consisted of Munger alone).

In 1909 he began work on a study of growth and yield of Douglas-fir, using the techniques that he had learned from Graves. In 1911 he published *Growth and Management of Douglas fir in the Pacific Northwest*. This was in part a discussion of the characteristics and prospective management of the species, surprisingly perceptive for the time and still correct in its essentials. It also included a volume table and the first yield table prepared in the Northwest. The yield table was based on measurements of a series of temporary plots in young-growth stands. He subdivided these into good and poor sites, and presented average values for the

Note: Robert O. Curtis can be reached at (360) 753-7669; Fax: (360) 956-2346; E-mail: rcurtis@fs.fed.us. This article was written by U.S. Government employees and is therefore in the public domain.

good sites only. He argued, correctly, that the high yields shown indicated promising prospects for long-term management.

At this time Munger also began a program of establishing long-term permanent plots in uniform young growth stands. These were large plots (0.5-1.0 ac), often with several such plots within a stand. They were models of detailed description and record keeping. A number of these are still in existence, including the first three - established in 1910 - on what is now the Willamette National Forest.

E.J. Hanzlik picked up the yield table work, added some additional data, and prepared a new and considerably more elaborate yield table (Hanzlik 1914). This included a division into three site classes, additional descriptive information, and a discussion of mean annual increment and appropriate rotations.

By the 1920s similar efforts were underway for many species around the country, and in 1924 the Society of American Foresters appointed a committee, including three representatives each from the Forest Service, Society of American Foresters, and the Association of State Foresters, to examine volume and yield table methodology and make recommendations for standardization of procedures. Membership included such prominent figures as C.E. Behre, Donald Bruce, and David Mason. The recommendations in their report (Munns 1926) became standard procedure for the many normal yield tables prepared around the country over the next half century, including B201.

The Wind River Experiment Station was established in 1913. The Pacific Northwest Forest Experiment Station was established in 1924 with Munger as Director (a post that he held until 1938). This absorbed the previous work and staff at Wind River Experiment Station, which now became the Wind River Experimental Forest. The program of permanent growth plot establishment begun by Munger in 1910 was continued through 1940 (Williamson 1963). Early measurements were included in yield analyses.

Richard E. McArdle came to the Station in 1924, following graduation from Michigan. Walter H. Meyer joined in 1925, after graduation from Yale in 1922, a period of study in Europe, and a brief period with the Forest Service in the Northeast. Together, they continued and greatly expanded the work on Douglas-fir yield, with an extensive program of field data collection that produced a database of 2,052 sample plots on 261 tracts, distributed throughout the Douglas-fir type in western Washington and western Oregon. Munger (1927), in *Timber Growing and Logging Practice in the Douglas-fir Region*, gave some revised yield values based on an interim report by McArdle.

This work culminated in publication of Bulletin 201 in 1930. This bulletin included a vast amount of detailed quantitative information: site index curves, volume tables, board foot, and cubic foot volume yields by site class and utilization standard, diameter distributions by site class, increment curves, etc. It was a mind-boggling achievement for a time when travel was slow and when data summarization and analysis depended on the slide rule, the mechanical adding machine, and graph paper.

Revised versions were issued in 1949 and 1961. The principal change was the 1949 addition of supplemental tables and discussion by Donald Bruce, which related stand characteristics to stand average diameter. For some purposes this introduced considerable simplification.

B201 was arguably the most influential single publication in the history of Pacific Northwest forestry research. It clearly showed the enormous productivity of Douglas-fir forests and had a great influence on owners' decisions to convert from liquidation to planned long-term management. It provided a quantitative basis for management planning and various economic analyses, and was the bible of Douglas-fir foresters for half a century.

Like all normal yield tables of the period, B201 was based on data from stands subjectively judged to be of "normal" - i.e., near-maximum - stocking. Meyer (1930) compared B201 estimates by site and age with observed values in strip and plot surveys of existing second-growth stands. He found that actual empirical volumes were about 80% of B201; also, that volumes were related to slope and aspect, being, highest on 40% slopes and north and east aspects.

Normal yield tables present average values for stands of "normal" stocking for various cornbinations of age and site. There is an implied assumption that these values represent points along a growth curve. Since in reality many stands differed from "normal" stocking, there there were a number of attempts to define a "trend toward normality" that could be used to predict future development of stands now above or below "normal" stocking. These utilized the data from the permanent sample plots and included publications by Meyer (1933), Briegleb (1942) and Johnson (1955).

An offshoot of B201 that is not widely known is Meyer's 1936 publication *Height Curves for Even-aged Stands of Douglas-fir*. This presented average height over diameter curves by age and site classes, and was seemingly unknown to a number of authors who published on the subject in the 1960s through the 1990s. The original intent was to provide generalized curves that could be used for volume computation when the only height information available was a site index estimate. But his curves also strikingly illustrate a point that is still ignored by too many people; namely, that application of a single height-diameter curve over successive ages can seriously bias volume growth cornputations. Another offshoot of the B201 work was Meyer's (1930) *Diameter Distribution Series in Even-aged Forest Stands*. This was an early attempt to describe diameter distributions by mathematical functions.

Staebler (1955) combined B201 yields with estimates of mortality derived from the permanent plot series to estitnatc gross yield of normal stands. He then (1960) used these estimates, together with the assumption of approximately equal gross increment over a range of stocking, to derive estimates of development of thinned stands. This work and the questions it raised provided the impetus for organization of the Levels-of-Growing-Stock Cooperative Study (Curtis et al. 1997), and was a first step in later development of simulators capable of representing a range of management regimes.

Like all normal yield tables, B201 had definite limitations. The assumptions involved in constructing normal yield tables from temporary plot measurements introduced some biases. Thus, the guide curve method used to prepare the site curves is based on the untestable assumption that average site of the temporary plots is the same for all ages. Compared to more recent work such as King (1966), Bruce (1981), and Harm and Scrivani (1987), the site index curves appear to be biased. This bias carries over into all the other tables that involve site index, although Bruce's diameter-based table is unaffected (and is still a convenient reference base for some purposes). Approximate adjustments for this bias are possible, and the adjusted values indicate relatively greater volume growth at later ages and later culmination of mean annual increment than estimated by B201 (Curtis 1992).

B201 (and other near-contemporary tables produced for other species and regions) represented the apex of development of the concept of "normal" yield tables based on one-time measurements. B201 described the characteristics of untreated well-stocked natural stands. The usefulness of it (and other normal yield tables of the period) faded as foresters moved from one-cut-per-rotation management of natural stands to more intensive management involving early density control, plantations, and intermediate thinnings. Although B201 provided a starting point for some attempts at yield estimates for managed stand, satisfactory alternatives had to await the accumulation of remeasured plot data and the computer revolution. These made possible the development of computerized simulation models beginning in the 1970s. B201 and similar tables still have some usefulness as a quick reality check on other estimates, and the methods have some application in regions and species lacking remeasured plot data.

The authors all had distinguished careers elsewhere. McArdle moved into fire research, and then became Dean of the School of Forestry at University of Idaho. He later rcturncd to Forest Service research administration, and eventually became Chief of the Forest Service. Meyer went on to produce similar yield tables for even-aged ponderosa pine, for Sitka spruce/western hemlock, and for eastern red spruce, and worked on a number of early Douglas-fir thinning studies at Wind River. He then left the Forest Service to go to the University of Washington, and then to Yale, where he was a noted professor for many years. He authored standard textbooks on forest mensuration (Chapman and Meyer 1949) and forest valuation (Chapman and Meyer 1947) that are familiar to the older foresters among us and that include some useful information omitted from recent mensuration texts. Donald Bruce was another of the pioneers of northwestern forestry and the author of many publications in forest mensuration, including another widely used mensuration textbook (Bruce and Schumacher 1935, revised 1942). After a career with the Forest Service and a period at the University of California at Berkeley, he became a partner in the well-known consulting firm of Mason, Bruce, and Girard.

Many people lack an appreciation of the long history of forest research and its evolutionary nature, and often seem unaware of information and procedures developed many years ago. Contributing factors include generational turnover, reliance on computerized, bibliographies that do not include the older literature, and the tendency of authors to cite as sources the most recent publication that mentions a topic which may be far removed in time and context from the original work. We have attempted to provide some perspective on the early development of growth and yield work in the Douglas-fir region, and the role in it of solve truly remarkable people who should not be forgotten.

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