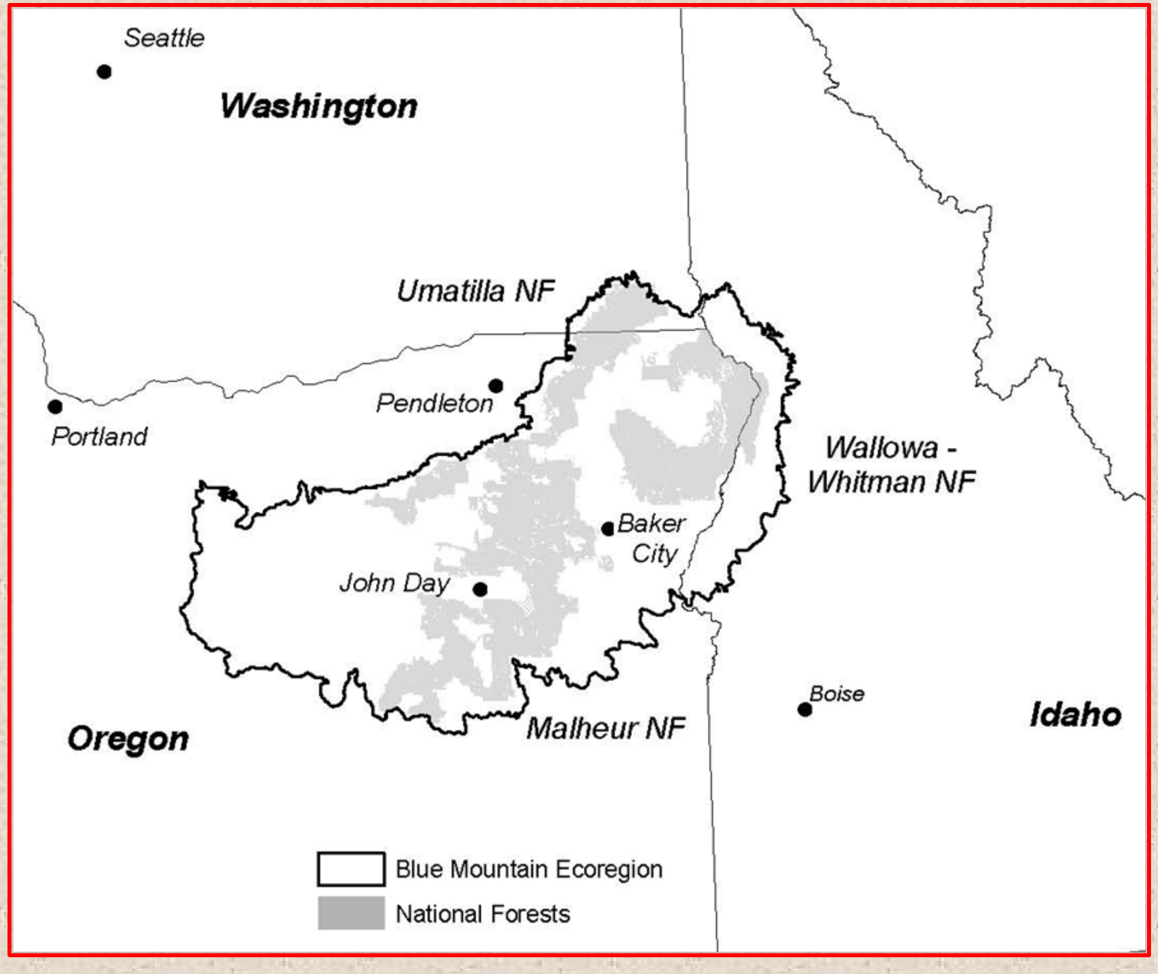
Development of suggested stocking levels for the Blue Mountains



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United States Department of Agriculture

Forest Service

Pacific Northwest Research Station

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Suggested Stocking Levels for Forest Stands in Northeastern Oregon and Southeastern Washington[1]

P.H. Cochran, J.M. Geist, D.L. Clemens, Rodrick R. Clausnitzer, and David C. Powell

Abstract

Catastrophes and manipulation of stocking levels are important determinants of stand development and the appearance of future forest landscapes. Managers need stocking level guides, particularly for sites incapable of supporting stocking levels presented in normal yield tables. Growth basal area (GBA) has been used by some managers in attempts to assess inherent differences in site occupancy but rarely has been related to Gingrich-type stocking guides. To take advantage of information currently available, we used some assumptions to relate GBA to stand density index (SDI) and then created stocking level curves for use in northeastern Oregon and southeastern Washington. Use of these curves cannot be expected to eliminate all insect and disease problems. Impacts of diseases, except dwarf mistletoe (*Arceuthobium campylopodum* Engelm.), and of insects, except mountain pine beetle (*Dendroctonus ponderosea* Hopkins) and perhaps western pine beetle (*Dendroctonus brevicomis* LeConte), may be independent of density. Stands with mixed tree species should be managed by using the stocking level curves for the single species prescribing the fewest number of trees per acre.

Keywords: Forest health, growth basal area, mountain pine beetle, stand density index, stressed sites, Oregon—northeast, Washington—southeast.

Introduction

Concerns about forest health east of the crest of the Cascade Range in Oregon and Washington have highlighted the need for site-specific information for a range of management practices, including stocking level control. Unfortunately, several insect pests and disease problems in northeastern Oregon and southwestern Washington cannot be prevented or controlled by density management. For example, spruce beetle (*Dendroctonus rufipennis* Kirby), western spruce budworm (*Choristoneura occidentalis* Freeman), Douglas-fir tussock moth (*Orgyia pseudotsugata* McDunnough), and laminated root rot (*Phellinus weirii* (Murr) Gilbertson) attack trees regardless of stand density. Thinning, however, is a

[1] Contribution of the Stressed Sites Cooperative in northeastern Oregon, an informal team formed to implement existing science and stimulate applied research.

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This presentation describes how suggested stocking levels were developed for upland sites in the Blue Mountains of northeastern Oregon and southeastern Washington.

The suggested stocking levels were published as a research note by the PNW station in April 1994, and as a follow-up implementation guide in April 1999.

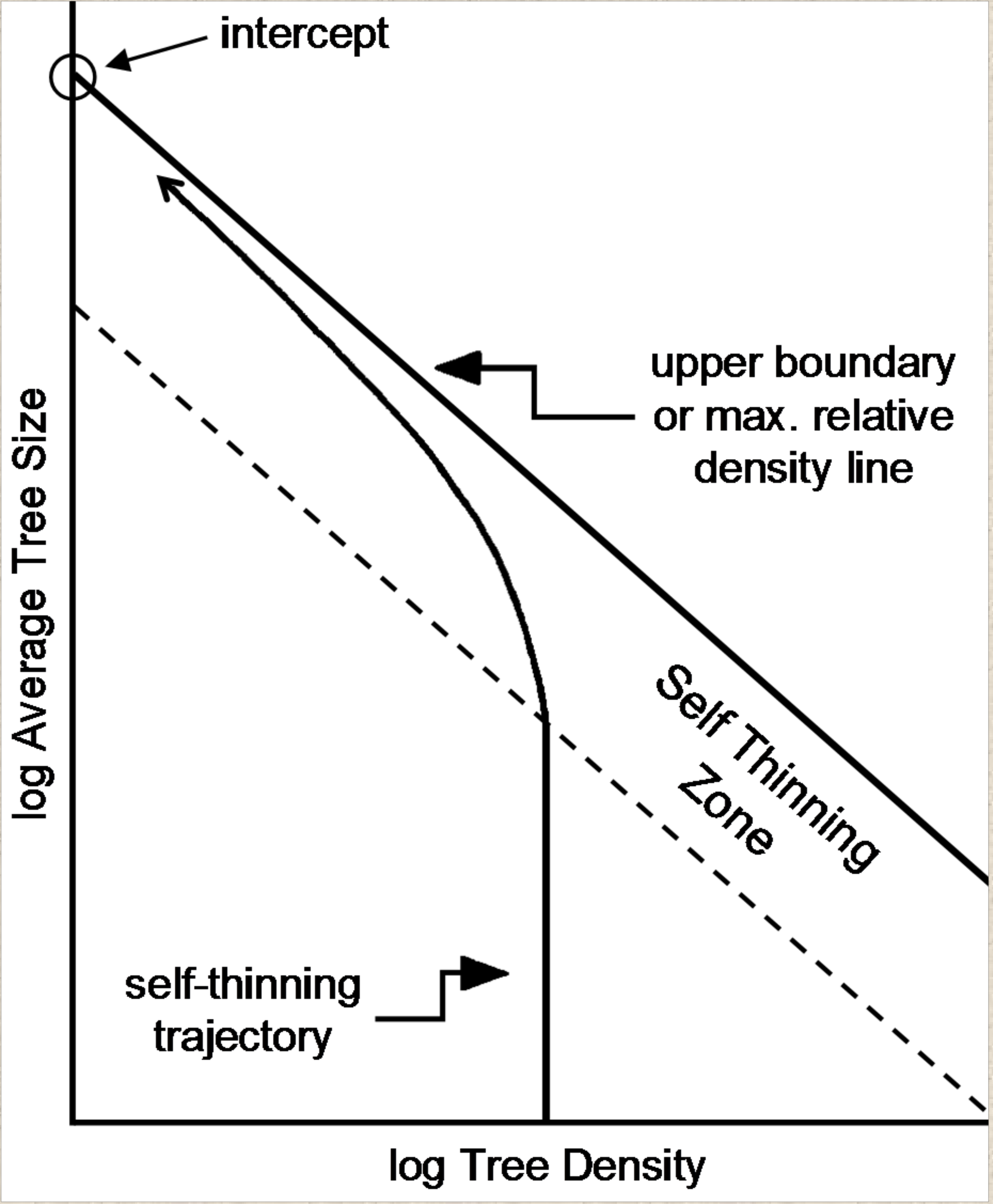

Diagram of self-thinning concepts (from Jack and Long 1996). Stocking or relative density systems often use the upper boundary as a reference level: existing density is compared with the reference level to calculate a stocking or relative density percentage. The self-thinning trajectory shows an even-aged stand that eventually enters the self-thinning zone, when its trajectory bends left and stays below the boundary. **Stands will not breach the upper boundary layer**.

PERFECTING A STAND-DENSITY INDEX FOR EVEN-AGED FORESTS[1]

By L. H. Reineke

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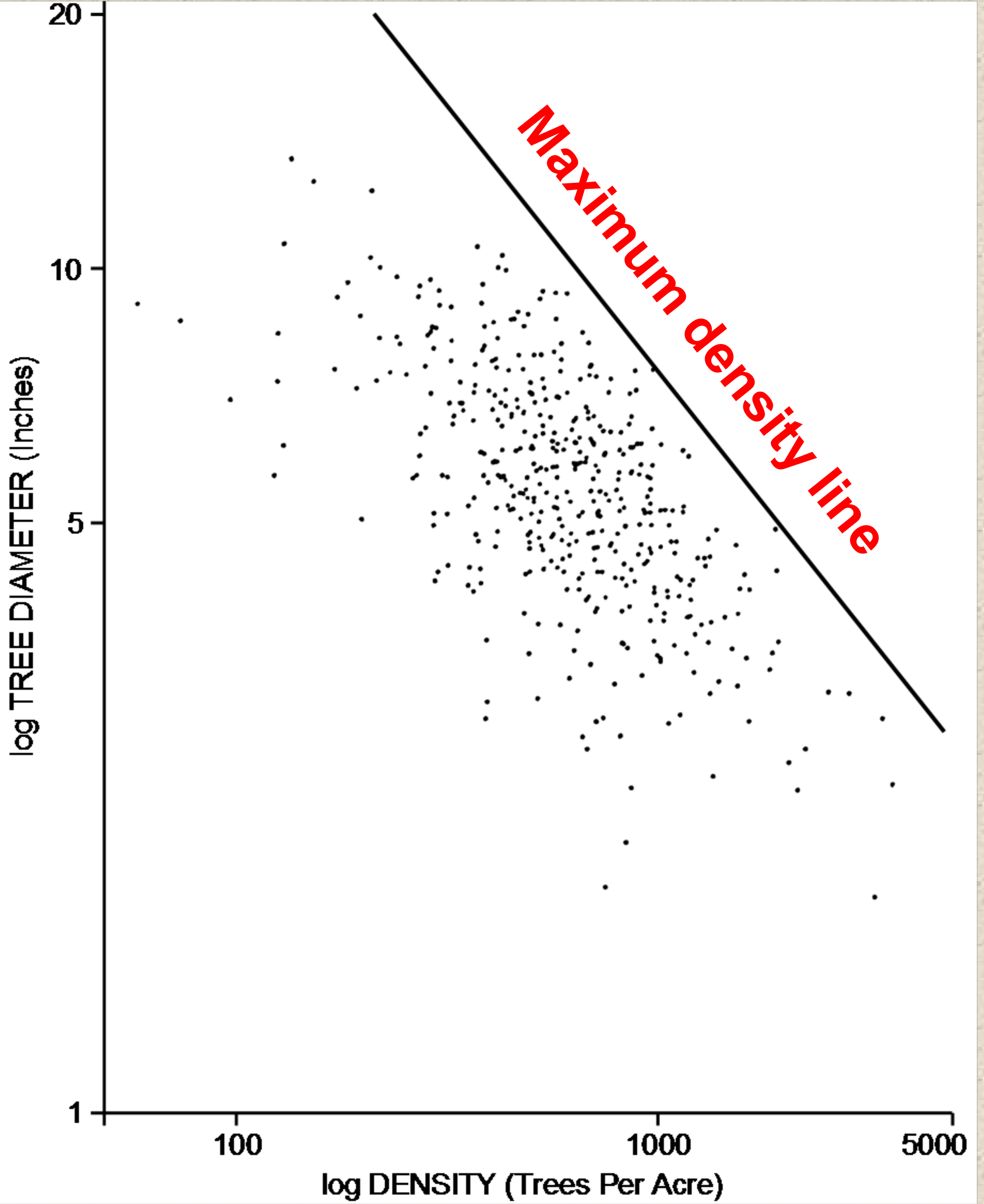
Lester Henry Reineke first proposed a new stand density metric called "stand density index" when he published this article in the Journal of Agricultural Research on April 1, 1933. Reineke examined size-density data for 14 forest types from across the U.S. and discovered that a fully-stocked, even-aged stand of a given average stand diameter had about the same number of trees per acre as other fully-stocked stands for the same species and diameter. And, this relationship occurred regardless of stand age or site quality:

AGE	SITE INDEX	QUAD. MEAN DIAMETER	TREES PER ACRE
160	70	10.0	510
100	90	10.0	510
60	130	9.9	510
50	170	10.0	510

Source: Barnes 1962 (Yield of even-aged stands of western hemlock, Tech. Bull. No. 1273, 52 p.)



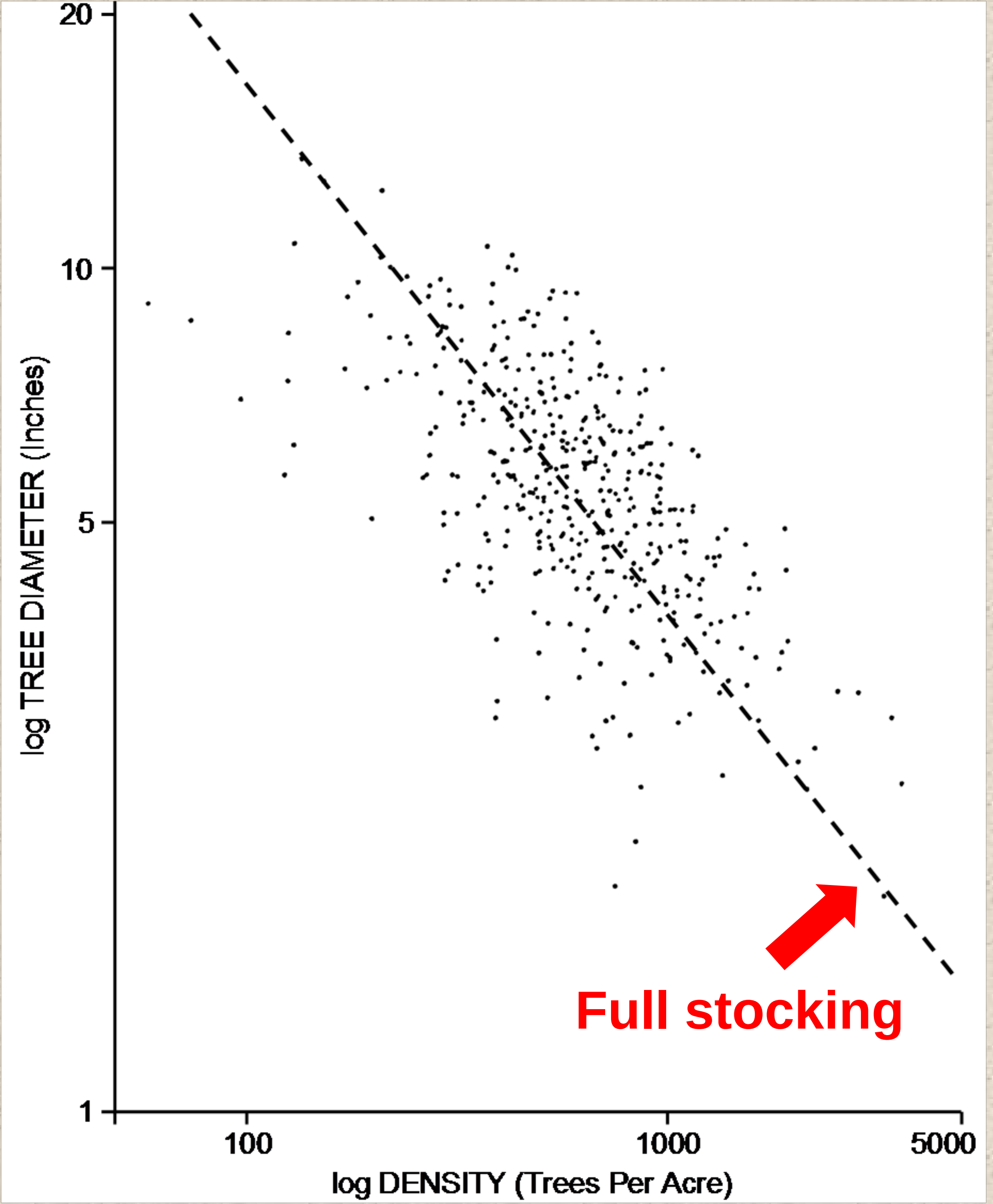
When Reineke plotted data for well-stocked stands, the result was a scatterplot where each dot represents a stand's QMD and trees per acre. Reineke drew a line skimming the outermost data points – this line represents maximum density. He proposed that the maximum density lines for redwood and red fir (SDI = 1,000) be used as a Reference Curve for the stand density index system.

Selected values of maximum density

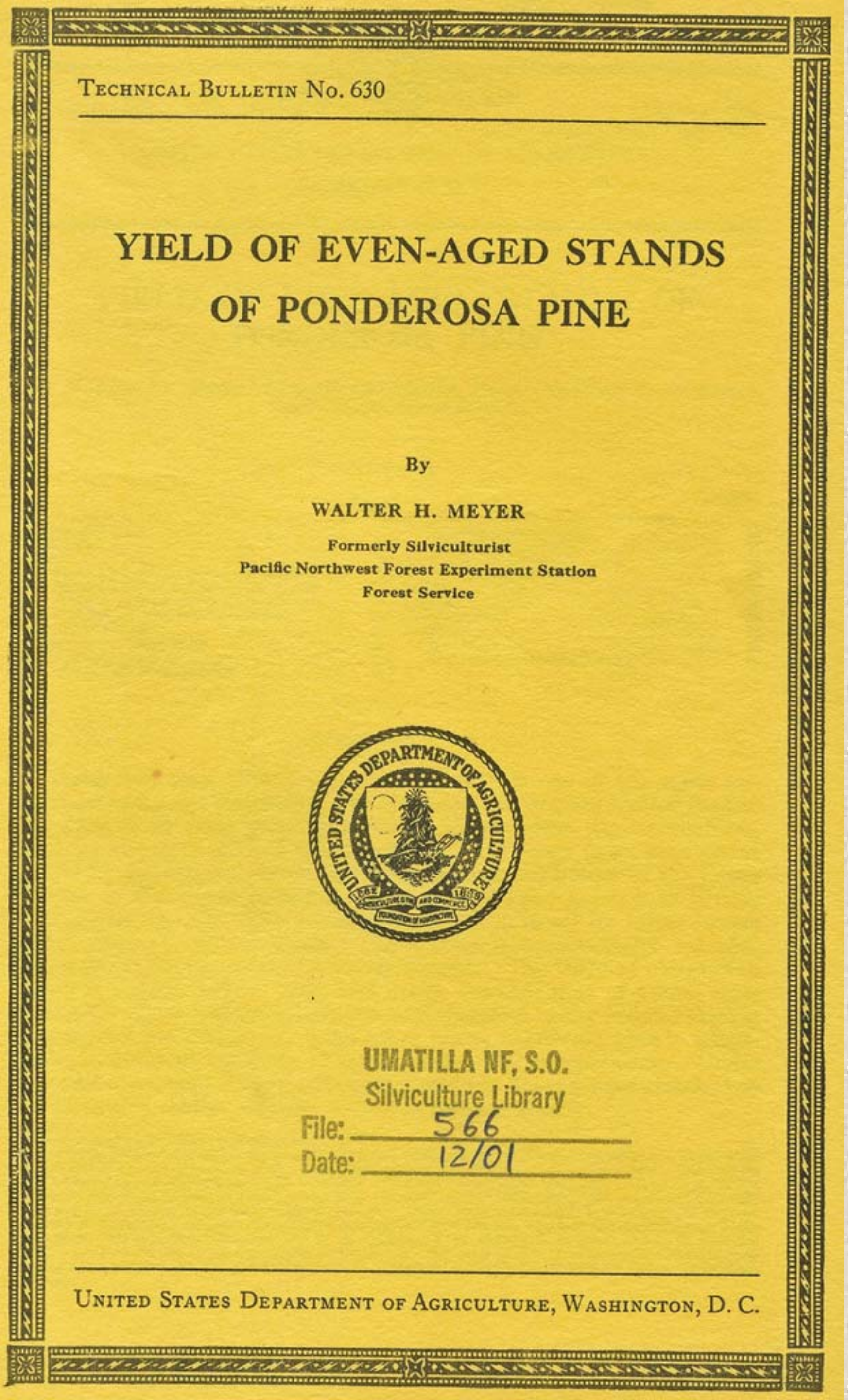
TREE SPECIES	MAXIMUM SDI (ENGLISH)	MAXIMUM SDI (METRIC)	SOURCE
White fir	830	2050	Reineke 1933
Red fir	1000	2470	Reineke 1933
Mixed conifer for CA	750	1850	Reineke 1933
Douglas-fir (WA-OR)	595	1470	Reineke 1933
↓ (CA)	600	1480	Reineke 1933
	587	1450	Long 1985
Eucalyptus	490	1210	Reineke 1933
Redwood	1000	2470	Reineke 1933
Ponderosa Pine	800	1980	Reineke 1933
↓	830	2050	Long 1985
	450	1110	Long and Shaw 2005
Loblolly Pine	450	1110	Reineke 1933
Longleaf Pine	400	990	Reineke 1933
Slash Pine	400	990	Reineke 1933
Shortleaf Pine	400	990	Reineke 1933
Upland Oak	230	570	Schnur 1937
Lodgepole pine	690	1700	Long 1985
Western Hemlock	790	1950	Long 1985

Hierarchy of maximum density values for ponderosa pine

ECOLOGICAL SETTING	SDI VALUE	SOURCE
Species-wide (full range)	800	Reineke 1933
Blue Mountains	456	Cochran et al. 1994/Powell 1999
PP on ABGR/LIBO2	456	Cochran et al. 1994/Powell 1999
PP on ABGR/VAME	365	Cochran et al. 1994/Powell 1999
PP on ABGR/SPBE	319	Cochran et al. 1994/Powell 1999
PP on ABGR/CARU	395	Cochran et al. 1994/Powell 1999
PP on ABGR/CAGE	263	Cochran et al. 1994/Powell 1999
PP on PSME/PHMA	343	Cochran et al. 1994/Powell 1999
PP on PSME/HODI	425	Cochran et al. 1994/Powell 1999
PP on PSME/SYAL	341	Cochran et al. 1994/Powell 1999
PP on PSME/CARU	329	Cochran et al. 1994/Powell 1999
PP on PSME/CAGE	278	Cochran et al. 1994/Powell 1999
PP on PIPO/SYOR	325	Cochran et al. 1994/Powell 1999
PP on PIPO/CARU	456	Cochran et al. 1994/Powell 1999
PP on PIPO/CAGE	251	Cochran et al. 1994/Powell 1999
PP on PIPO/FEID	243	Cochran et al. 1994/Powell 1999
PP on PIPO/AGSP	166	Cochran et al. 1994/Powell 1999



An average line fitted to the same scatterplot data used by Reineke to determine maximum density is called normal density. Normal density is sometimes called average-maximum density because it represents an average of the same data used to determine maximum density. Normal density information was published in normal yield tables for many different forest types in the United States. **In Cochran et al. 1994, normal density is the same as full stocking.**


TECHNICAL BULLETIN No. 630

YIELD OF EVEN-AGED STANDS OF PONDEROSA PINE

By

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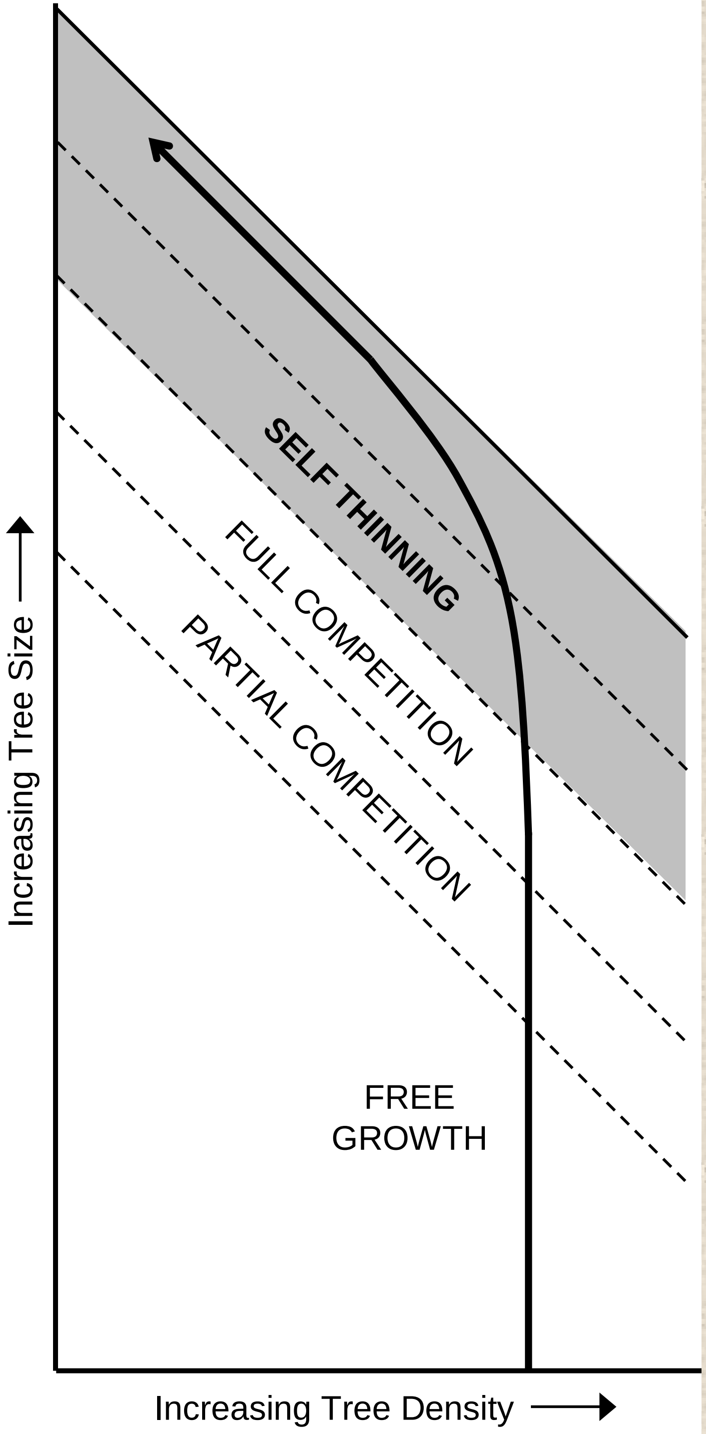
Walter Meyer developed normal yield tables for ponderosa pine (Meyer 1961). I'm glad that Cochran et al. 1994 referred to **normal density as full stocking** because this data is really not from "normal" stands – it came from well-stocked plots only. "Meyer (1961) excluded all sample plots having a stand density index of 250 or less during development of normal yield tables for ponderosa pine" (Cochran et al. 1994, pg. 2). Why was this done? I believe Meyer assumed that plots with low SDIs were under-stocked, rather than recognizing that some of them came from fully-stocked stands on sites with low stockability (PIPO/AGSP, PIPO/FEID, etc.).



As a tree stand develops, it passes through successive stand density thresholds. This chart illustrates the thresholds using a format similar to Reineke's graph (the sloping line at the top of the gray zone is Reineke's maximum density; the dashed line in the middle of the gray zone is normal density). At first, a young stand (plantation, etc.) has little or no tree competition – this is "free growth" because it is free of competition. Competition occurs after crowns or roots interact – this is partial and then full competition. As competition intensifies, a stand enters the self-thinning zone, when stand density is high enough for overstory trees to kill understory trees by suppressing them.

A Practical Approach to Density Management

by

James N. Long[1]

Abstract

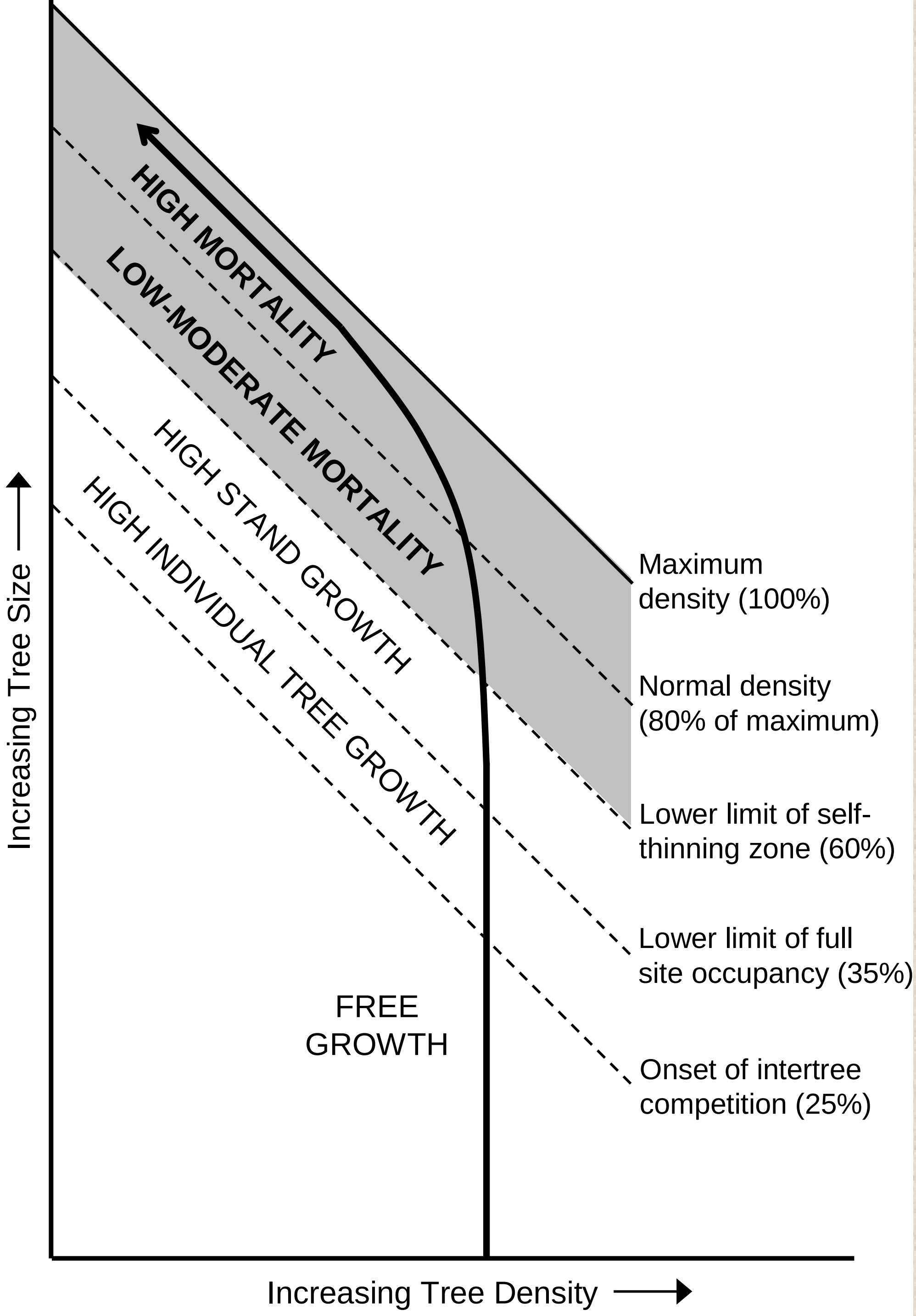
Density management is the control of growing stock, through initial spacing or subsequent thinning, to achieve specific management objectives. A biologically sound and easily applied approach to density management is illustrated for a hypothetical, even-aged stand under two contrasting types of management objectives.

Résumé

L'aménagement par densité est le contrôle du volume sur pied grâce à l'esplacement initial et aux éclaircies subséquentes pour atteindre des objectifs d'aménagement spécifiques. Une approche biologiquement solide et facilement applicable de l'aménagement par densité est illustrée pour un peuplement équienne hypothétique selon deux différents types d'objectifs d'aménagement.

Long (1985) described 3 stand development thresholds:

- crown closure/onset of intertree competition (25% of maximum)
- lower limit of full site occupancy (35% of maximum)
- lower limit of self-thinning zone (60% of maximum)

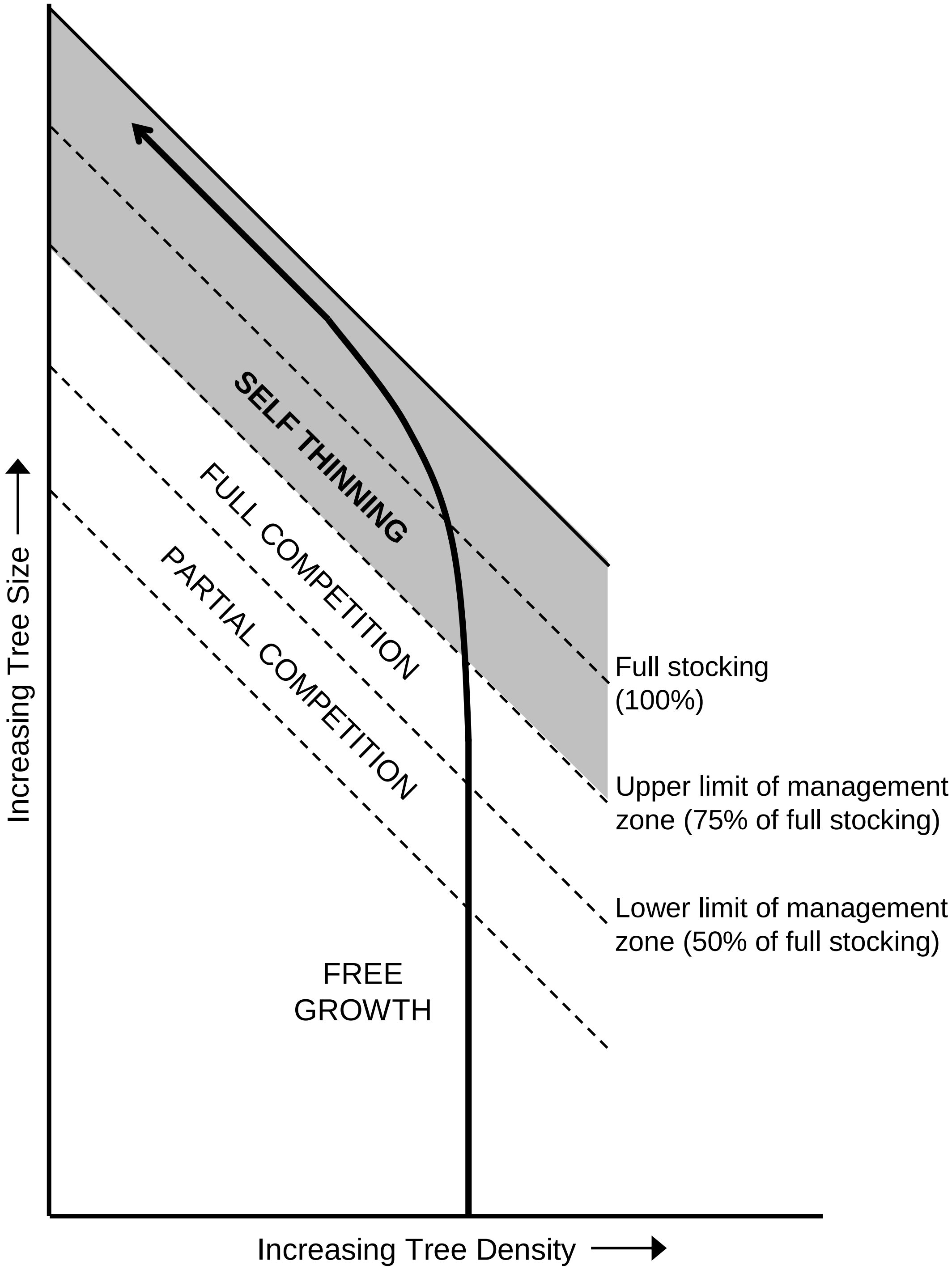


This chart has the same diagram from two slides ago, but now every threshold is named and its percent-age of maximum density is shown. Just as before, the solid line at the top of the gray zone is maximum density. The bottom 3 thresholds came from Long 1985 as describ-ed in the previous slide. Also, note that the zones between thresholds now show growth and mortality relationships (instead of competi-tion and self thinning as shown before).

Stand Development Benchmark or Stocking Level Threshold	Percent of Maximum Density[1]	Percent of Full Stocking[2]
Maximum density[3]	100%	125%
Full stocking (normal density)[4]	80%	100%
Lower limit of self thinning zone[5]	60%	75%
Upper limit of the management zone	60%	75%
Crown ratio of 40 percent	50%	~63%
Lower limit of full site occupancy	35%	~45%
Lower limit of the management zone	~40%	50%
Onset of competition/crown closure	25%	~30%

Reference level

This slide shows the thresholds and relates them not only to maximum density but to full stocking. Reineke 1933 used maximum density as a reference level; Cochran et al. 1994 used full stocking (normal density) as a reference level. Two thresholds (35% and 60% of maximum) were used by the Cochran group as upper and lower limits of a management zone (the red boxes).

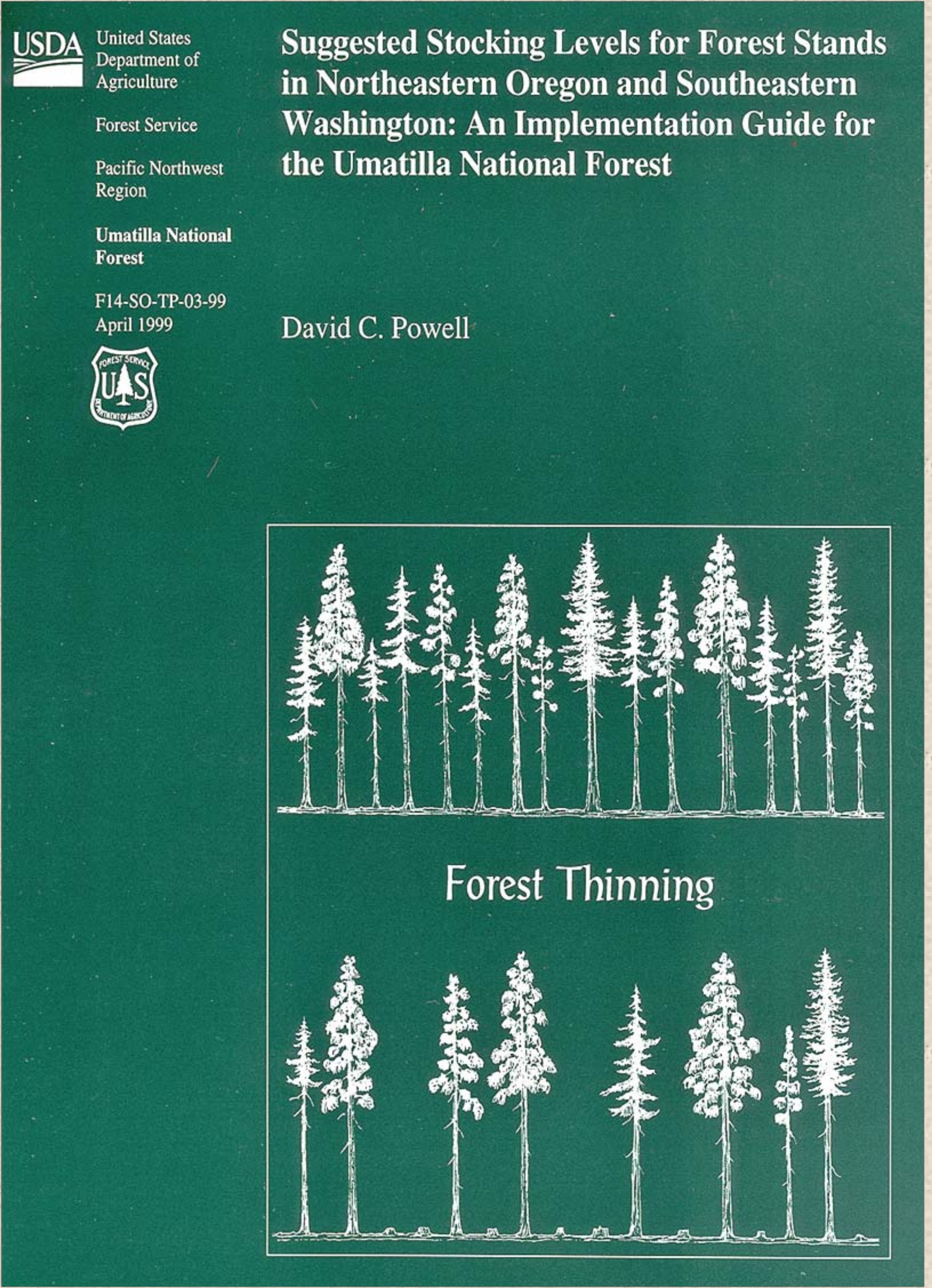


In Cochran et al. 1994, a goal was to avoid self-thinning mortality. A management zone was defined, and its upper limit (ULMZ) was set at the lower limit of the self-thinning zone: any stand maintained below the ULMZ would avoid self-thinning mortality. For all species except ponderosa and lodgepole pines, the **ULMZ is 75% of full stocking**. The ULMZ for ponderosa and lodgepole pines was adjusted for bark-beetle risk. The lower limit of the management zone or **LLMZ is 67% of the ULMZ** for all 7 species.

The Cochran note provides province-wide, full-stocking data for the Blue Mountains (all of eastern OR for some species). Full-stocking data is crucial for applying the stocking levels.

Tree Species	Intercept Value[1]	Slope Factor[1]	Province-Wide Full Stocking[1]
Ponderosa pine	9.97	1.77	365
Douglas-fir	9.42	1.51	380
Western larch	10.00	1.73	410
Lodgepole pine	9.63	1.74	277
Engelmann spruce	10.13	1.73	469
Grand fir	10.31	1.73	560
Subalpine fir	10.01	1.73	416
Reineke 1933	**10.00**	**1.605**	**320-800**

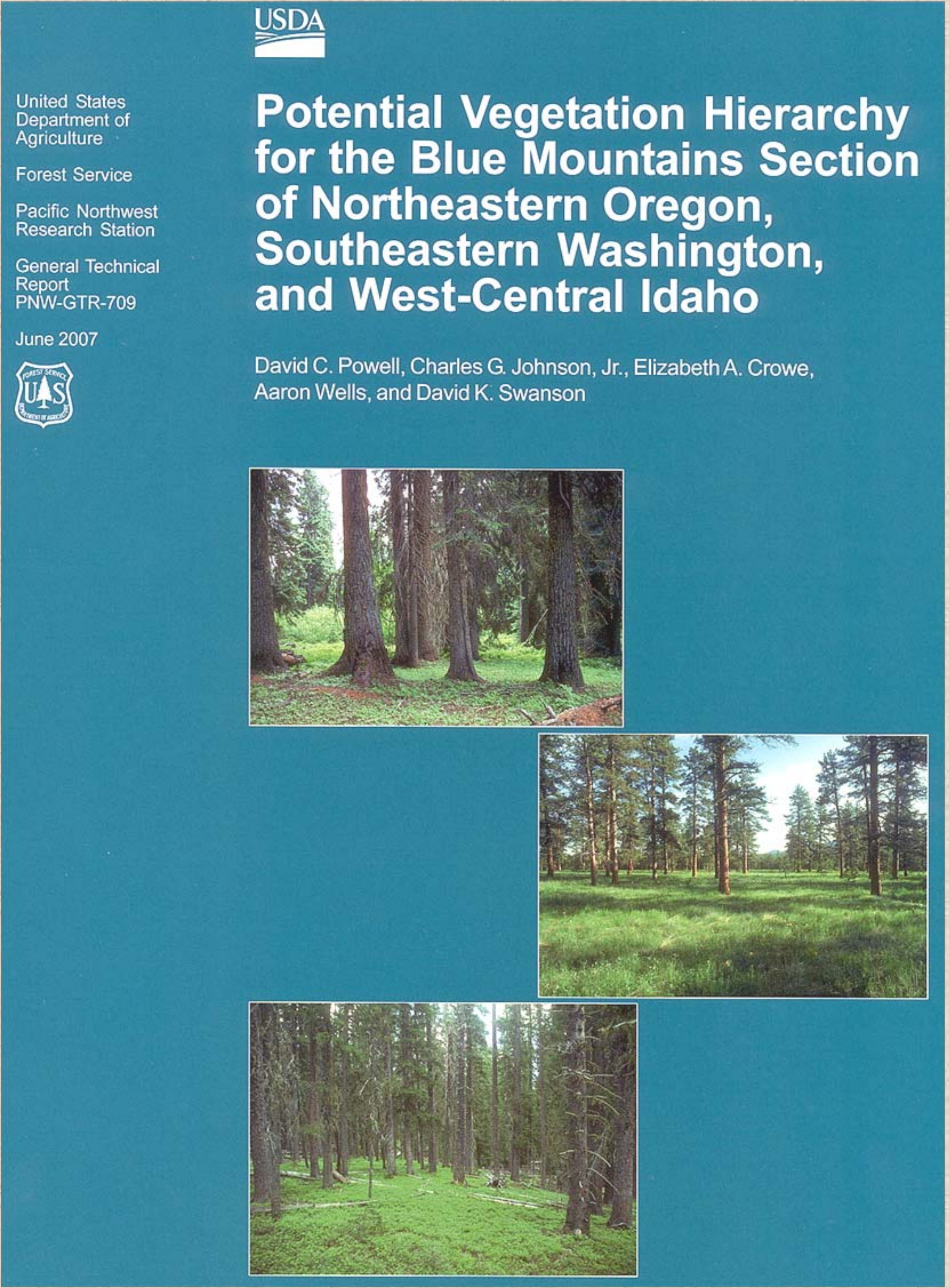
This table shows the 7 conifers included in Cochran et al. 1994. Intercept shows where the size-density line hits the vertical axis. Slope refers to the steepness of the size-density line. Full-stocking is for the whole province (not specific to any particular plant association). Reineke 1933 is included for comparison purposes.



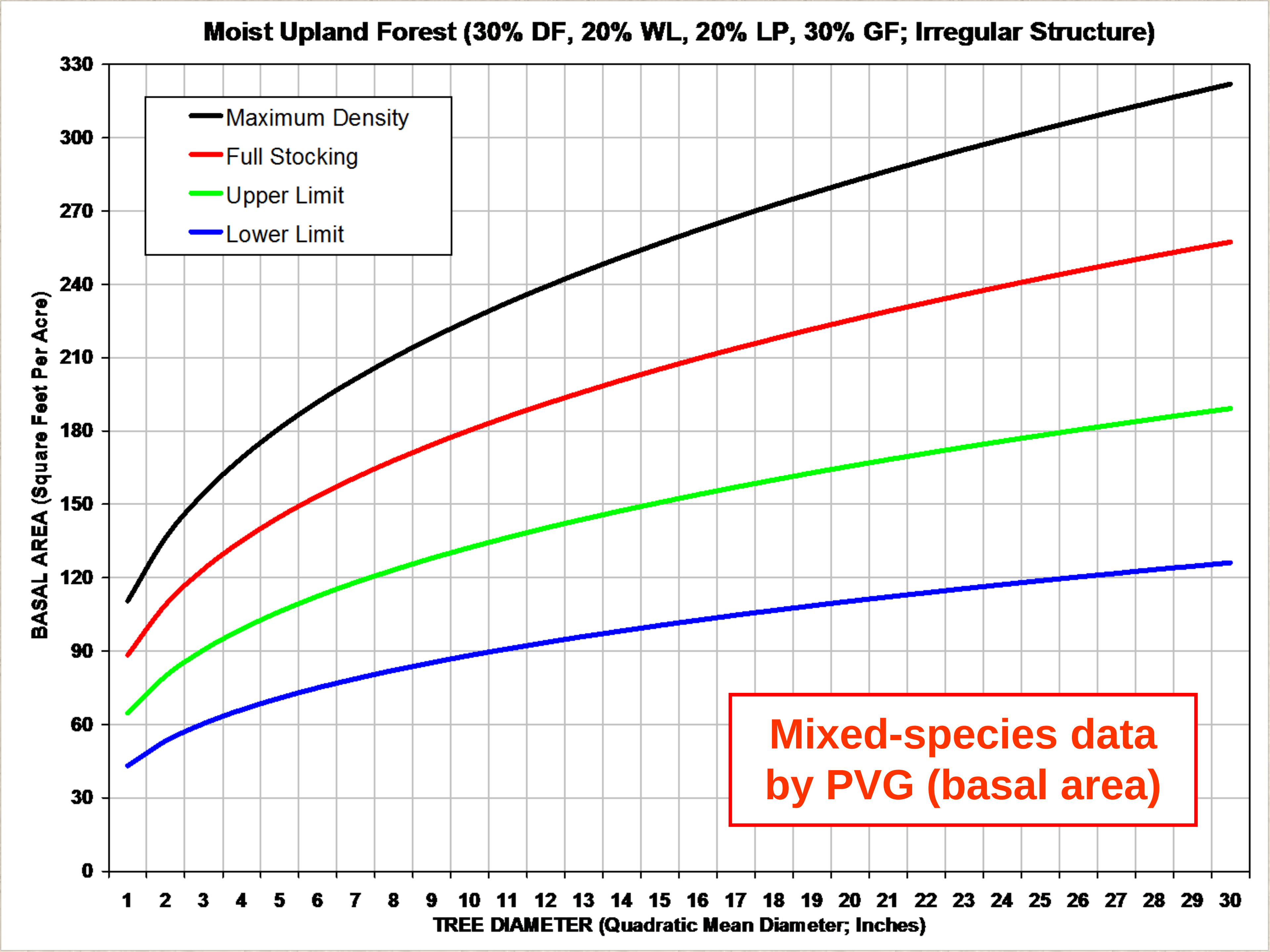
After the Cochran research note was published in 1994, Umatilla NF silviculturists began asking for additional stocking information to help apply the Cochran results:

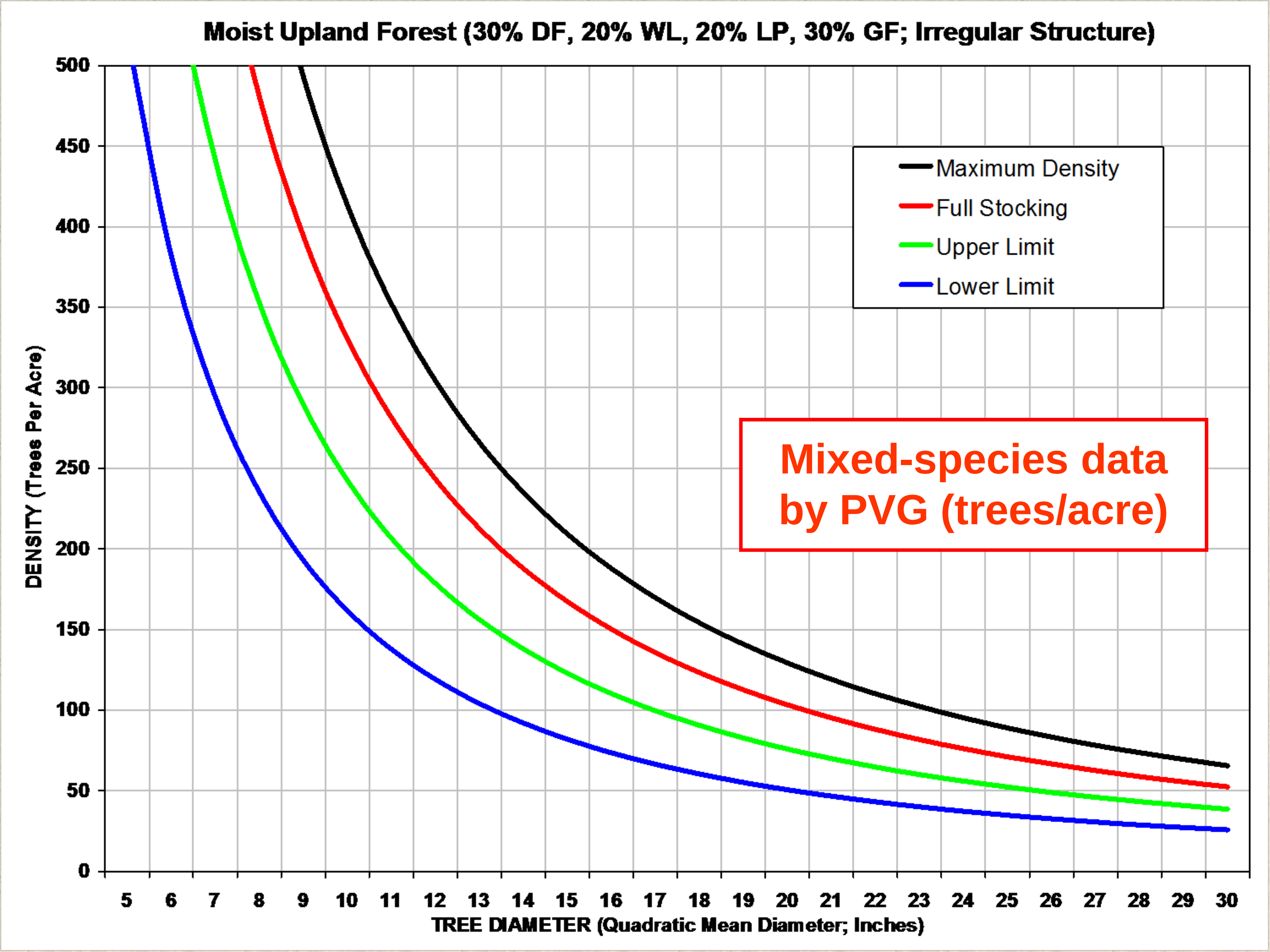
- SDI values for the ULMZ
- SDI values for the LLMZ
- Basal area for all levels
- Data for irregular stands
- Data for uneven-aged stands
- Data for range of QMDs
- Data by canopy cover
- Data by intertree spacing

So in 1999, I put out an imple-mentation guide to provide this information and help **users apply the Cochran stocking results**.



The Blue Mountain national forests spent many years (more than a decade) working with our area ecologists to develop a system for assigning the 507 potential vegetation types (plant associations, plant community types, and plant communities) to plant association groups (PAG) and potential vegetation groups (PVG). **This GTR provides tables showing how all 507 ecoclass codes for the Blues were assigned to PAGs and PVGs.**


Moist Upland Forest (30% DF, 20% WL, 20% LP, 30% GF; Irregular Structure)
Maximum Density
Full Stocking
Upper Limit
Lower Limit
Mixed-species data by PVG (basal area)
BASAL AREA (Square Feet Per Acre)
0
30
60
90
120
150
180
210
240
270
300
330
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
TREE DIAMETER (Quadratic Mean Diameter; Inches)


Moist Upland Forest (30% DF, 20% WL, 20% LP, 30% GF; Irregular Structure)
Maximum Density
Full Stocking
Upper Limit
Lower Limit
Mixed-species data by PVG (trees/acre)
DENSITY (Trees Per Acre)
0
50
100
150
200
250
300
350
400
450
500
5
6
7
8
9
10
11
12
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30
TREE DIAMETER (Quadratic Mean Diameter; Inches)

Handouts

Questions?