TECHNICAL NOTES

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WOOD-10
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FOREST STAND DENSITY GUIDE

Improperly managed forests are commonly too densely or too sparsely stocked with trees. If timber production is an objective, both extremes are detrimental. Deficient stocking is most prevalent in the early life of a stand and results from inadequate provision for regeneration; the unoccupied spaces are unproductive and trees in such stands are often too limby to produce high quality timber. Excessively dense stocking causes the wood production of the stand to be distributed over so many individual trees that none can grow at the optimum rate.

Any well-conceived program of forest management for a particular area should be governed by some reasonably definite schedule indication the density of the trees in a stand at all stages of their development. The purpose of a "forest stand density guide" is to give such a schedule. A "stand" is defined as a contiguous group of trees sufficiently uniform in species composition (including mixed stands), age and condition to be a homogenous and distinguishable unit.

The FOREST STAND DENSITY GUIDE, Table 1, gives the optimum stand densities by stage of development for 15 commercial tree species common to the State of Washington. Densities for minimum reforestation (naturally established and planted), young stands (sapling and small poles) and older stands (small and large sawtimber) are based on recent research and the cumulative experience of foresters and conservationists over the past 30 years. Important notes that explain the use of the density guide are listed on the back of the table.

The guide should be used during the planning process with forestland owners on units where the primary objective is wood production. Forest stands can be analyzed and compared to it by using the results of the zig-zag transects, fixed-area plots or other suitable sampling methods. The guide is applicable to analyzing and establishing proper densities for natural and planted reforestation, pre-commercial thinning, commercial thinning and any other intermediate harvesting <u>not</u> involving provisions for tree or forest regeneration. It is critical that the trees left to occupy the site after a "density control" practice are of good quality for the intended future product, have an adequate crown to respond to release, are well distributed, and are relatively free of insects, disease or other damage. If the trees do not exhibit these critical characteristics, other alternatives for treatment should be explored. The guide is not applicable for establishing densities for seed tree, shelterwood, group selection or other "natural regeneration" harvest methods.

Because of the dynamic nature of economic, personal or site specific conditions, the bounds of acceptable stand densities must necessarily be broader than those considered to

be optimum. For example, the flexibility of selling products from intermediate harvests during strong market periods (or avoiding "soft" ones) would not be available to the forest manager or land-owner if a rigid "optimum" schedule were followed. Table 2 expresses the range of acceptable stand densities for the various shade tolerance grouping of species. It was developed by taking optimum densities from Table 1 and broadening them, on a stems-per-acre basis, by plus or minus 25 percent. Forest stands that are more densely or more sparsely stocked than those broadened ranges are considered extreme and detrimental to the sustained growth of the unit. Figures 1 through 9 show how tables 1 and 2 relate for developing stands of varying-tolerance species.

Table 1: FOREST STAND DESITY GUIDE for 15 commercial species common to the State of Washington. (Important notes are listed on the backside.)

	A	B	C	D	E
Shade Tolerance Class	Species	Minimum Reforestation Density (<2" dbh)	Young Stand Density (2-9" dbh)	Older Stand Density (≥10"dbh) Thin To:	Thin Again When:
Very Shade Tolerant	Subalpine fir Pacific silver fir Western red cedar	9' x 9' or 538 spa	9' – 11' or 360-538 spa	D + 3	D + 0
Shade Tolerant	Western hemlock Sitka spruce Englemann spruce Grand fir	10' x 10' or 436 spa	10' – 12' or 302-436 spa	D + 4	D + 1
Moderately Shade Tolerant	Douglas-fir (coastal)	11' x 11' or 360 spa	11' – 13' or 258-360 spa	D + 5	D + 2
Moderately Intolerant	Douglas-fir (inland, S.I.>100) Ponderosa pine (S.I.>100) Western white pine	12' x 12' or 302 spa	12' – 14' or 222-302 spa	D + 6	D + 3
Intolerant	Red alder Western larch Lodgepole pine Black Cottonwood	13' x 13' or 258 spa	13' – 15' or 194-258 spa	D + 7	D + 4
Intolerant (edaphic)	Douglas-fir (inland, S.I. 80-100) Ponderosa pine (S.I. 80-100)	14' x 14' or 222 spa	14' – 16' or 170-222 spa	D + 8	D + 5
Intolerant (edaphic-climate)	Douglas-fir (inland, S.I. <80)	15' x 15' or 194 spa	15' – 17' or 151-194 spa	D + 9	D + 6

NOTES

Table 1 lists optimum stand densities for various shade tolerant species for three stages of development: 1) reforestation (trees <2" dbh) , 2) young stands (2-9" dbh trees), and 3) older stands (trees ≥ 10" dbh). Forest stands having combinations of species that fall within two or more shade tolerance groupings will require a "combination" of spacing densities. Several abbreviations are used in the table: "dbh" is diameter-at-breast-height, "spa" is stems-per-acre, "D" is the average stand diameter with units-in-inches replaced with units-in-feet, and "S.I." is site index. Specific notes for each column follow:

(A) Shade tolerance is the relative ability of a species to survive a deficiency of light. Species that are very shade tolerant can be maintained at more dense stocking levels and still grow at optimum rates. Intolerant species must be at a lower stocking level to grow at optimum, i.e. more light must reach each individual tree. Certain edaphic (e.g. a soil with a low available water capacity) and climatic (e.g. low annual precipitation) factors require a further lowering of stocking of some species to maintain optimum rates.

(B) Species are listed by preferred common name. The coastal form of Douglas-fir occurs west of the crest of the Cascades; the inland form occurs east of the crest. Site index for inland Douglas-fir and Ponderosa pine should be computed using USDA Forest Service Technical Bulletin No. 630 by Walter H. Meyer (if USDA-FS Research Paper PNW-263 by P.H. Cochran is used for inland Douglas-fir, "T.B. 630" site indexes of 80 and 100 equal 55 and 70, respectively).

(C) Minimum reforestation densities were developed with the expectation that up to about 25 percent mortality would occur. They are applicable for natural regeneration and planted seedlings. Adverse site factors may require increasing the desired density or measures that would lessen their effects.

(D) Densities for young stands (sapling and small poles) are those necessary to reach an average stand diameter of 8 to 10 inches dbh. This is considered the objective for the desired, future size for the first removal of commercial products, usually small sawlogs. Where an average stand dbh of less than or greater than 8 to 10 inches is desired, subtract or add 1' per 1" of decrease or increase, respectively, to the range of spacings. For example, a 6 inch desired size would result in an 8 to 10' spacing for western hemlock (8" – 6" = 2" or a 2' decrease to the 10 to 12' spacing). A 14 inch desired size (a possible goal on steeply sloping land where intermediate harvests are not planned) would result in a 15 to 17' spacing for coastal form Douglas-fir (14" – 10" = 4" or a 4' increase to the 11 to 13' spacing).

Where grazing and browsing of understory vegetation by wildlife or domestic stock is an important concurrent objective on the unit being treated, add 1 to 2' to the range of spacing.

(E) Densities for older stands (small and large sawtimber) are based on the average dbh and the "D+" concept of tree-to-tree spacing. For example, a stand of Ponderosa pine (S.I. = 90) with an average dbh of 15" and an average distance between trees of 19' would have a D + 4 spacing (19 – 15 = +4). Using the left-hand portion of the column, a thinning to achieve optimum growth could be conducted to reflect a final space of D + 8. Because the dbh of "leave" trees increases somewhat from 15" (poor growers are generally of smaller dbh, hence their removal increases the overall mean dbh by 1' or 2'), an average of 24' to 25' between results (16 to 17" + 8 = 24 to 15'). When the stand reaches 19" to 20" dbh, or D + 5, the right-hand portion of the column indicates it is time to thin again if the "optimum" schedule is to be kept.

Where grazing and browsing of understory vegetation by wildlife or domesticated stock is an important concurrent objective on the unit being treated, add 1 to 2' to the range of spacing.

TABLE 2

ACCEPTABLE FOREST STAND DENSITIES for various shade tolerance groupings (developed by taking optimum densities from Table 1 and broadening them, on a stem-per-acre basis, by plus or minus 25 percent).

Average Stand DBH (in.)	STEMS-PER-ACRE (minimum to maximum) (1) Very Shade-Tolerant	(2) Shade Tolerant	(3) Moderately Shade Tolerant	(4) Moderately Intolerant	(5) Intolerant	(6) Intolerant (edaphic)	(7) Intolerant (edaphic-climate)	(8)* Column 6+2', and 7+1'	(9)* Column 7+2'
≤2	404+	327+	270+	227+	193+	167+	145+	145+	145+
2-9	270-672	227-545	193-450	167-378	145-322	128-278	113-242	101-213	90-189
10	193-545	167-450	145-378	128-322	113-278	101-242	90-213	82-188	74-168
11	167-450	145-378	128-322	113-278	101-242	90-213	82-188	74-168	68-151
12	145-378	128-322	113-278	101-242	90-213	82-188	74-168	68-151	62-136
13	128-322	113-278	101-242	90-213	82-188	74-168	68-151	62-136	57-123
14	113-278	101-242	90-213	82-188	74-168	68-151	62-136	57-123	52-113
15	101-242	90-213	82-188	74-168	68-151	62-136	57-123	52-113	48-103
16	90-213	82-188	74-168	68-151	62-136	57-123	52-113	48-103	45-95
17	82-188	74-168	68-151	62-136	57-123	52-113	48-103	45-95	42-87
18	74-168	68-151	62-136	57-123	52-113	48-103	45-95	42-87	39-81
19	68-151	62-136	57-123	52-113	48-103	45-95	42-87	39-81	36-75
20	62-136	57-123	52-113	48-103	45-95	42-87	39-81	36-75	34-69
21	57-123	52-113	48-103	45-95	42-87	39-81	36-75	34-69	32-65
22	52-113	48-103	45-95	42-87	39-81	36-75	34-69	32-65	30-61
23	48-103	45-95	42-87	39-81	36-75	34-69	32-65	30-61	28-57
24	45-95	42-87	39-81	36-75	34-69	32-65	30-61	28-57	27-53

* NOTE: Wider spacing to benefit grazing of understory.

FOREST STAND DENSITY DIAGRAMS

(Minimum, Optimum and Maximum Densities by D.B.H.)

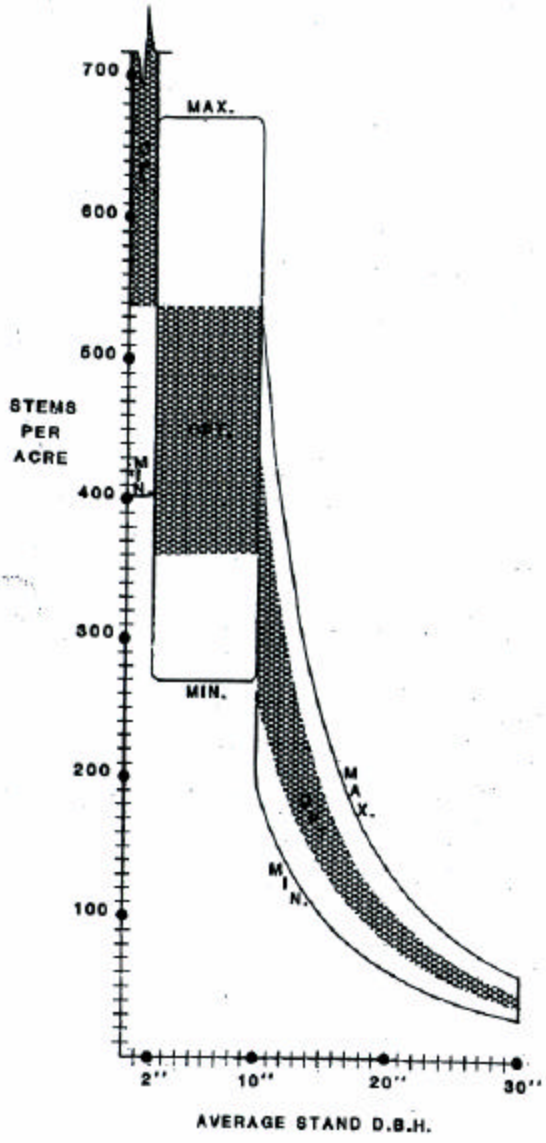

FIGURE 1. VERY SHADE TOLERANT SPECIES

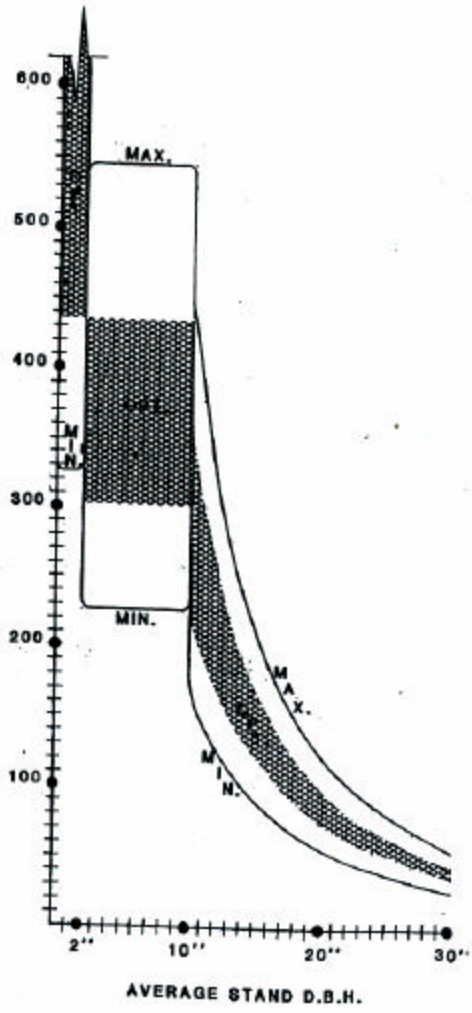

FIGURE 2. SHADE TOLERANT SPECIES

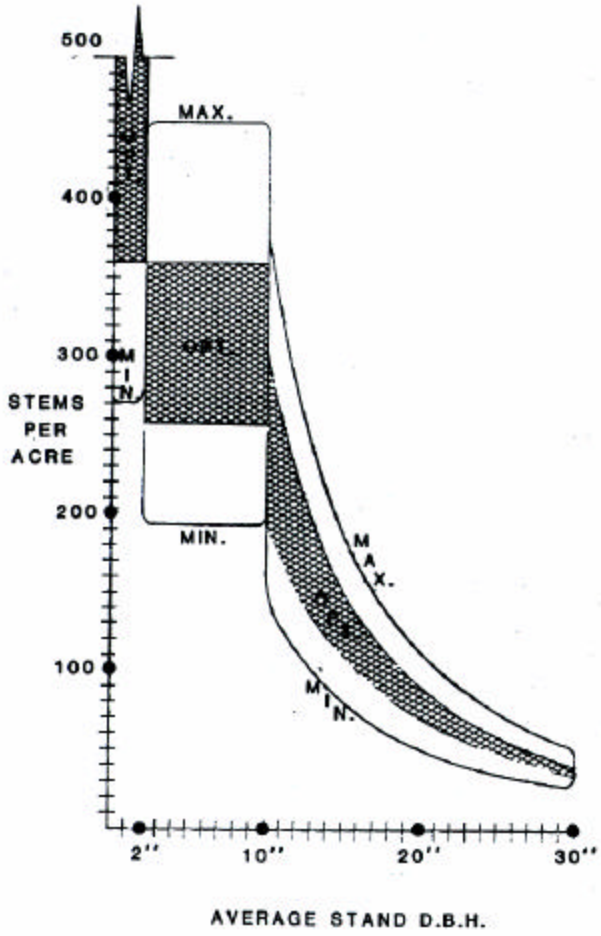

FIGURE 3. MODERATELY SHADE TOLERANT SPECIES

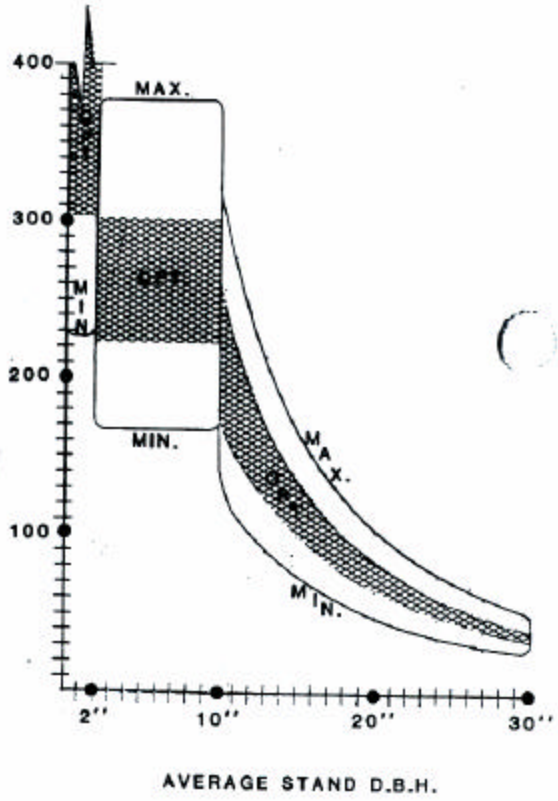

FIGURE 4. MODERATELY INTOLERANT SPECIES

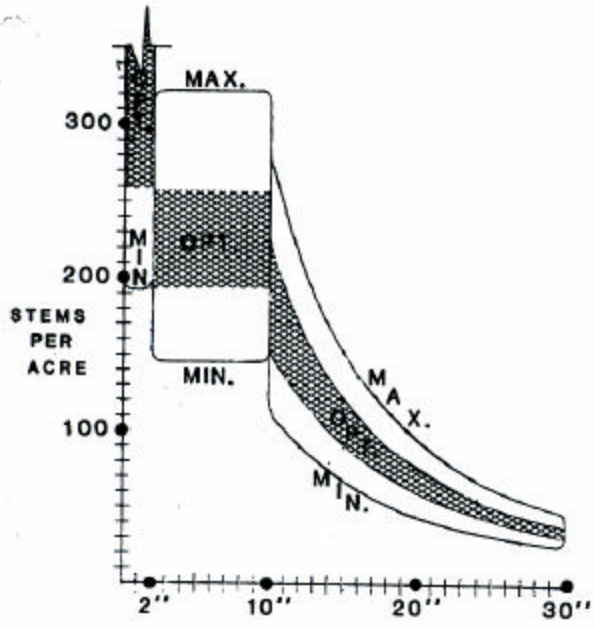

FIGURE 5. INTOLERANT SPECIES

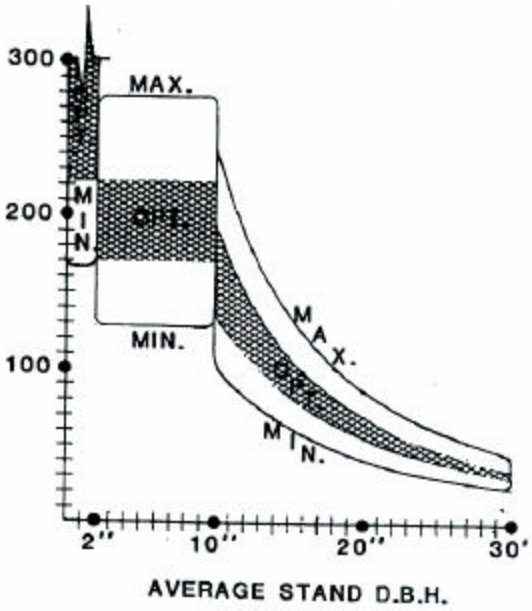

FIGURE 6. INTOLERANT (EDAPHIC) SPECIES

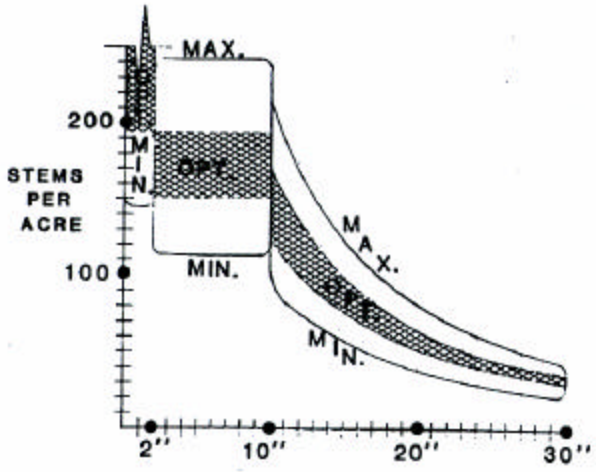

FIGURE 7. INTOLERANT (EDAPHIC/CLIMATIC) SPECIES

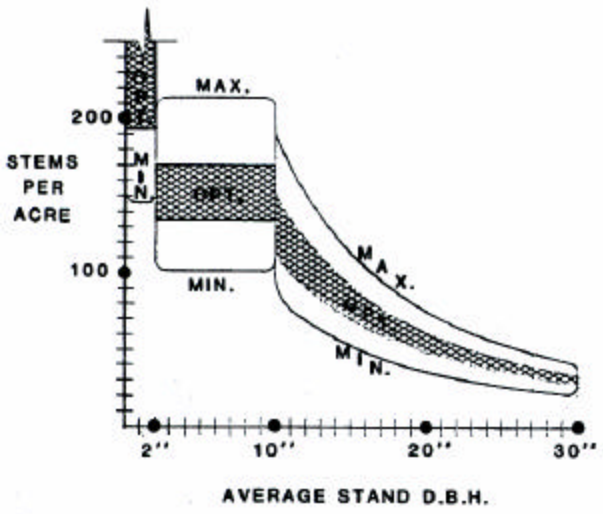

FIGURE 8. (FIGURE 6 PLUS 2' and FIGURE 7 PLUS 1')

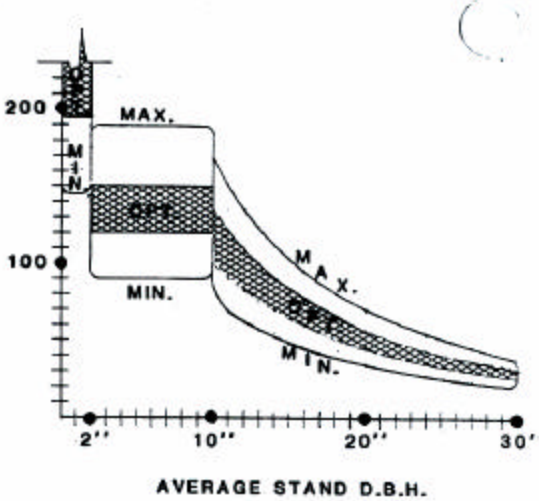

FIGURE 9. (FIGURE 7 PLUS 2')