Light Intensity Related to Stand Density in Mature Stands of the Western White Pine Type

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Where tolerance of forest trees or subordinate vegetation is a factor in management, the forester needs a simple field method of estimating or forecasting light intensities in forest stands. The following article describes a method developed for estimating light intensity beneath the canopy in western white pine forests which may have application in other types.

THE use of partial cuttings in mature stands of the western white pine type introduces the need for a reasonably reliable yet simple method of estimating light intensity beneath the canopy. This is of special importance where partial cuttings are used as a means of ribes suppression in blister rust control because success of suppression depends upon the amount of canopy reserved in cutting. It is also important in determining the probable course of forest regeneration following cutting; certain light intensities are favorable for regeneration of desired species and other intensities are unfavorable.

One method of estimating light intensity beneath the canopy is to relate it to measures of stand density. This was done on a number of sample areas in mature uncut and cutover stands of the western white pine type. Light intensity on these sample areas was measured at midday during the growing season with a Shirley radiometer[2] and stand density was obtained from diameter measurements and expressed in terms of summation of diameters at breast height per acre, and basal area per acre.

The size of the crowns of the various species proved to be an important factor in the interception of light. Hence, the species were divided into two groups: (1) small-crowned trees, including western white pine, western larch, Douglas-fir, lodgepole pine, and ponderosa pine, and (2) large-crowned trees, including grand fir, western hemlock, western redcedar, Engelmann spruce, and alpine fir. When the field data were analyzed, the stands were separated into three composition classes based on the percentage of small-crowned trees in the summation of diameters or basal area.

The relationship of light intensity to stand density is shown in Figures 1 and 2. Table 1 was derived from these curves to aid in determining the light intensity beneath the canopy for any given stand density. Checks of these curves and the derived values indicate that two out of three estimates obtained from them will be within 10 percent of the actual light intensity.

Summation of diameters per acre is recommended as the most suitable measure of stand density to use in obtaining an estimate of light intensity. Basal area summaries give similar results but require one more arithmetic operation. Summation of diameters is simply the addition of diameters at breast height per acre. This measure can be obtained from cruise data if they contain a tally of all stems.

The principal use of this method of estimating light intensity is to determine how heavy a cut to make to obtain a desired light intensity. To illustrate, a partial cutting is to be made in the stand given in Table 2.

As the small-crowned species, white pine and Douglas-fir, make up 73 percent of the total of diameters, the average light intensity is estimated from column 6 of Table 1. The equivalent light intensity for 2,932 inches of diameter per acre is 25 percent (to the nearest 5 percent). If a light intensity of 40-50 percent is needed for ribes suppression, 2,100-1,650 inches of diameter per acre (Table 1) must be left after cutting. A trial marking is made in which all the Douglas-fir, the larger hemlocks, and poor-vigor white pines are marked for cutting, with due attention given to even spacing of trees to be left. This results in a "cut" tally per acre (Table 3).

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[2]Shirley, H. L. A thermoelectric radiometer for ecological use on land and in water. Ecology 11:61-70. 1930.

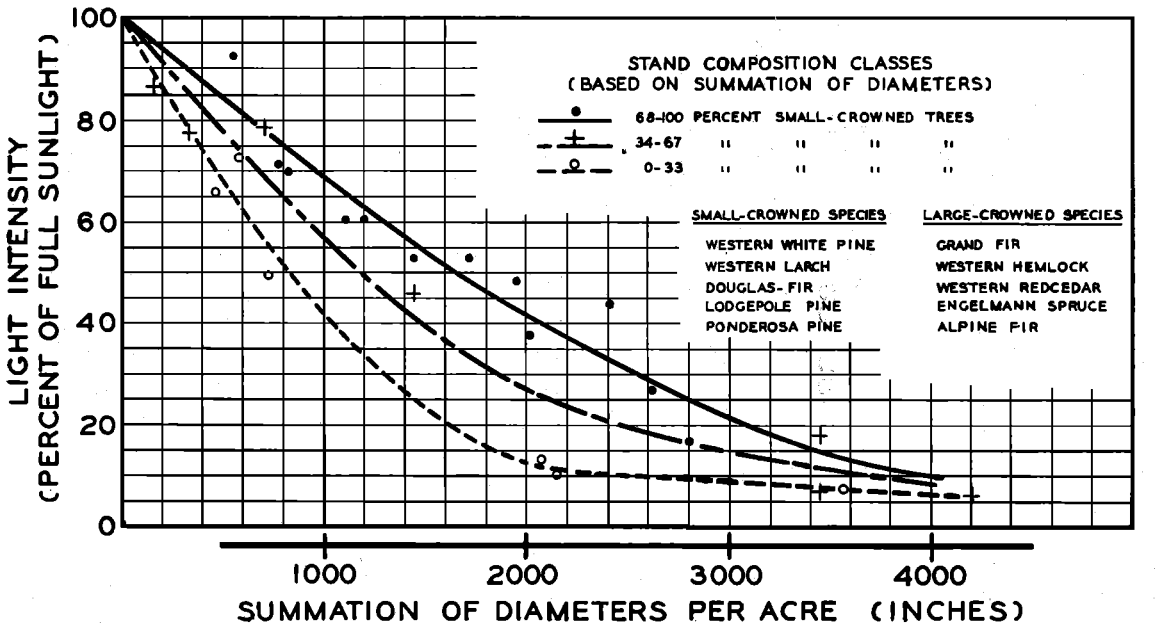

FIG. 1.—Light intensity beneath the canopy in mature stands of the western white pine type related to summation of diameters per acre for three stand composition classes.

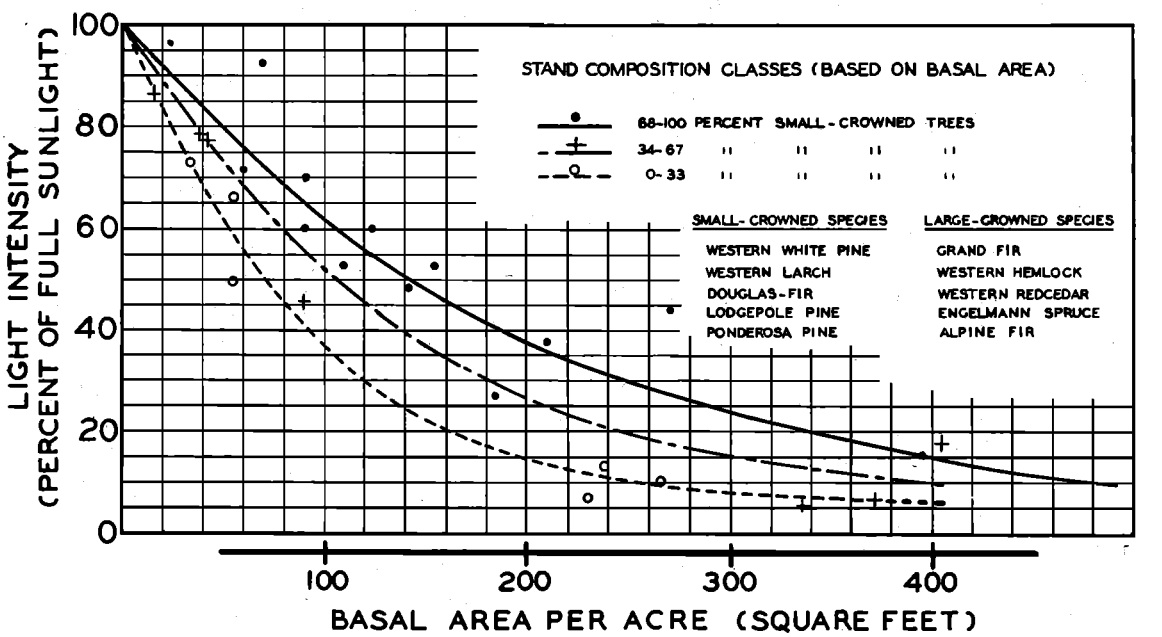

FIG. 2.—Light intensity beneath the canopy in mature stands of the western white pine type related to basal area per acre for three stand composition classes.

TABLE 1.—STAND DENSITY EQUIVALENTS FOR GIVEN LIGHT INTENSITIES BENEATH THE CANOPY IN MATURE STANDS OF THE WESTERN WHITE PINE TYPE
(From Figures 1 and 2)

Mean light intensity[1] beneath the canopy	Overwood stand density as measured by summation of diameters and by summation of basal area per acre for stands composed of					
	0-33 percent small-crowned trees[2]		34-67 percent small-crowned trees[2]		68-100 percent small-crowned trees[2]	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Percent	*Inches*	*Square feet*	*Inches*	*Square feet*	*Inches*	*Square feet*
10	2500	255	3700	400	4000	480
15	1850	200	3000	305	3450	400
20	1600	160	2450	245	3100	340
25	1450	135	2100	210	2800	290
30	1300	120	1850	180	2550	250
35	1150	105	1650	160	2300	215
40	1050	90	1500	140	2100	190
45	950	80	1350	120	1850	165
50	850	70	1200	105	1650	145
55	750	60	1050	90	1450	125
60	650	55	900	80	1300	105
65	550	45	800	70	1100	90
70	450	35	700	55	950	75
75	400	30	550	45	800	60
80	300	25	450	35	650	50
85	200	20	350	30	500	35
90	150	10	200	20	300	25
95	50	5	100	10	150	15

[1]In percent of full sunlight at midday during the growing season.

[2]Small-crowned trees with respect to interception of light include western white pine, western larch, Douglas-fir, lodgepole pine, and ponderosa pine. Large-crowned species include grand fir, western hemlock, western redcedar, Englemann spruce, and alpine fir.

TABLE 2.—STAND TABLE FOR A MATURE UNCUT STAND OF THE WESTERN WHITE PINE TYPE

D.b.h. class	Number of trees per acre				Summation of diameters per acre	
	White pine	Douglas-fir	Western hemlock	All species	White pine and Douglas-fir	All species
Inches	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*
2			10	10		20
4			12	12		48
6	2		13	15	12	90
8	4		15	19	32	152
10	6		12	18	60	180
12	8		11	19	96	228
14	14	1	8	23	210	322
16	17	2	3	22	304	352
18	18	3	2	23	378	414
20	20	1	1	22	420	440
22	12	1	1	14	286	308
24	8		1	9	192	216
26	4			4	104	104
28	1			1	28	28
30	1			1	30	30
All classes					2152	2932

TABLE 3.—STAND TABLE OF TREES TO BE CUT

D.b.h. class	Number of trees per acre				Summation of diameters per acre	
	White pine	Douglas-fir	Western hemlock	All species	White pine and Douglas-fir	All species
Inches	*Number*	*Number*	*Number*	*Number*	*Inches*	*Inches*
14	8	1		9	126	126
16	7	2	3	12	144	192
18	8	3	2	13	198	234
20	5	1	1	7	120	140
22	3	1	1	5	88	110
24	2		1	3	48	72
26	2			2	52	52
28	1			1	28	28
30	1			1	30	30
All classes					834	984

The summation of diameters of trees to be cut is 984 inches. It is estimated that an additional 150 inches of small-diameter hemlock will be destroyed in the logging operation. Therefore, 1,798 inches of diameter will be reserved, of which 1,318 inches or 73 percent are white pine and Douglas-fir. The light intensity beneath this residual stand is shown by column 6 of Table 1 to average about 45 percent, which is within the range of light intensities desired.

If the trial marking had resulted in a light intensity greater or less than the desired intensity, Table 1 would provide a guide for increasing or decreasing the cut to arrive at the desired intensity.

Small trees in the understory and culls often intercept considerable light. The possibility of many of these kinds of trees being inadvertently destroyed in logging should be taken into account. Failure to allow for loss of unmarked trees or to provide for necessary protection will result in a higher light intensity than planned.

Table 1 also provides a means of estimating light intensities in cutover stands. This is frequently useful in classifying residual stands with respect to probable success or failure of regeneration of desired species. Of course, there are other methods for directly measuring light intensity that can be used in such instances.

SUMMARY

The use of partial cuttings in mature stands of the western white pine type has introduced the need of a method for estimating light intensity beneath the canopy. A workable method of estimating light intensity is to relate it to measures of stand density. Figures are given based on light intensity determinations in a number of uncut and cutover mature stands of the white pine type, relating light intensity to two measures of stand density: (1) summation of diameters per acre, and (2) basal area per acre. These relationships are given for three stand composition classes. The figures and a derived table should prove a useful guide in deciding how heavy to cut a given stand in the western white pine type to obtain light intensities necessary for ribes suppression in blister rust control or for natural regeneration of desired species.