A STUDY OF WINDFALL LOSS OF WESTERN YELLOW PINE IN SELECTION CUTTINGS FIFTEEN TO THIRTY YEARS OLD

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A few years ago several violent wind storms did a great deal of damage in yellow pine timbersale cuttings on the Whitman and Crater National Forests in Oregon. On one cutting with an area of 1,624 acres, nearly one million board feet of yellow pine was blown down in the storms of May 26, 1913, and September 18, 1914. This blowdown included 17½ per cent of all the reserved trees on the area. So heavy a loss occurring so early in the local timbersale experience (the cutting had been in progress only four years) was a most alarming condition, particularly since the Weather Bureau records showed that regional winds of equal velocity occurred every three or four years. It was feared that a similar heavy windfall loss might occur periodically and that at this rate all the reserved trees would eventually be blown down and the selection method of cutting would become prohibitive in this region.

Since that time a comprehensive increment study of yellow pine on old private cut-over areas has been in progress in Oregon, and has offered an excellent opportunity to examine in detail the history of windfall loss on areas upon which had been practiced, years ago, partial cutting methods resembling the present selection cutting of timbersales. This windfall study aimed to determine the volume of the loss through a long period of years and to ascertain the actual years, with relation to the time of cutting, in which the trees were blown down. With this information at hand it would be possible to say whether all the trees left standing in selection cuttings would eventually be blown down, or whether the greater precentage of them would, in reality, become gradually windfirm and survive the later storms. The ideal conditions for securing the data would have been furnished by areas cut over by a regulated selection method, but forest management is not old enough in this region to furnish such cuttings. Old private cuttings in yellow pine up to thirty years old and more do

exist, however, and for the purposes of this study the stands left after cutting on these areas are not essentially different from those left in Forest Service timbersale cuttings. The old private cuttings contain just as great a proportion of trees left standing as the timber sales, and sometimes a greater; and the trees are nearly as well distributed over the ground. The degree of wind-firmness on the old private cuttings is not appreciably poorer than on those timbersale cuttings which suffered so heavily a few years ago. The reason for this is that the latter contained a greater number of tall and full-crowned trees which, observation has shown, are just as lacking in windfirmness as the trees with defective trunks and basal fire scars found on the private cuttings. Both classes of cuttings contain about the same number of young trees. By old cuttings are meant those cut twenty years and more ago, when logging in eastern Oregon was in its early stages and the logger left a great many trees which he takes to-day with the present closer utilization.

In securing the present windfall data, plots 20 acres or larger were laid out and all the standing and down trees over 12 inches in diameter breast-height were cruised. In addition, the down trees were carefully analyzed as to the year when each tree was thrown, which was readily determined from the number of accelerated annual rings the down tree showed as compared with those of the standing trees. In the few cases in which there was doubt as to whether the down trees had first been killed by fungi or insects and had then been blown down, the trees were not included as windfalls in the compilations of this article.

The plots were located in representative conditions in and near three National Forests in the Blue Mountain region of eastern Oregon. There were three 20-acre plots, one 40-acre plot, and a total of 24 acres of smaller plots, primarily studied for another purpose, but upon which careful notes of windfall occurrence were made. Plots I and II were located in areas of severe wind risk, and Plots III and IV in comparatively sheltered areas. The numerous smaller plots were located in both exposed and sheltered situations and the results given for the aggregate plot are therefore average for a wide range of conditions. The proportion of trees left standing at the time of cutting amounted to the following percentages by volume of the original stand in each case: 12 per cent on Plot I, 8 per cent on Plot II, 40 per cent on Plot III, 8 per cent on Plot IV, and 16 per cent on Plot V.

Table 1 shows for each plot the total number of trees thrown, the volume of these trees, and the percentage of loss. The last is based

upon the ratio of the volume of the thrown trees to that of the total number of trees left standing at the time of cutting.

TABLE 1.—*Total number of trees thrown, volume of the trees, and the percentage of loss for each plot.*

Plot	Area, acres	Windfall loss since cutting			Years since cutting	Year when cut
		No. of trees	Volume in bd. ft.	Per cent thrown of volume left standing		
I	20	43	10,745	24[a]	20	1896
II	40	40	8,995	22	15	1900
III	20	11	11,775	2	27	1889
IV	20	4	1,510	4	18	1897
V	24	34	12,150	14	15	1899

[a] Estimated.

The value of this table is that it shows in actual figures the total volume of windfall loss for a long period of years and gives the percentage of the original reserved stand which this figure represents. Plot I shows the heaviest loss in proportion to the stand left at the time of cutting. On this plot nearly 45,000 board feet had been left standing on 20 acres, and the volume thrown in 20 years was 10,745 board feet, or 24 per cent. On Plot II, where the next greatest proportional loss occurred, 41,310 board feet had been left standing on 40 acres and the volume blown down in 15 years amounted to 8,995 board feet, or 22 per cent. The significant thing about these figures is that the loss is not the result of exposure to one or two storms, but of 15 and 20 years of exposure on bad windrisk sites.

An apparent irregularity in Table 1 will be noticed, in that the heavy volume loss on Plot III is represented as an exceedingly small loss in per cent. This is explained by the fact that the plot was located in an unusually heavy body of timber, which ran 30,250 board feet per acre before cutting, and in which the logger cut only very lightly, leaving fully 40 per cent of the original stand. In the case of the other plots the stand before cutting averaged from 13,000 to 25,000 board feet per acre.

Table 2 shows, by half decades, for each plot, the number of trees thrown since cutting. It also shows the percentage of total thrown volume in each five-year period.

TABLE 2.—*Occurrence of windfall by half decades following cutting.*

Half decades after cutting.....	0–5	6–10	11–15	16–20	21–25	26–30
Plot I—20 acres—20 years since cutting.						
Number of trees thrown.....	28	12	2	1	.....	.....
Per cent oy volume.....	54	30	5	11	.....	.....
Plot II—40 acres—15 years since cutting.						
Number of trees thrown.....	31	6	3	.....	.....	.....
Per cent by volume.....	94	4	2	.....	.....	.....
Plot III—20 acres—27 years since cutting.						
Number of trees thrown.....	3	3	2	1	1	1
Per cent by volume.....	33	28	16	1	1	21
Plot IV—20 acres—18 years since cutting.						
Number of trees thrown.....	3	1	.....	.....	.....	.....
Plot V—Aggregate plot of 24 separate acres—15 years since cutting.						
Number of trees thrown.....	23	7	4	.....	.....	.....
Per cent by volume.....	67	12	21	.....	.....	.....

The interesting point brought out by Table 2 is that, of all the trees that are windthrown over a long period of years, a strikingly large proportion—often as much as two-thirds or more—is blown down in the first five or six years immediately following cutting. The remainder is thrown in rapidly decreasing proportions year by year until about twenty years after cutting when the loss for a five-year period becomes but 3 or 4 per cent of the total volume thrown. In the actual case of Plot I, 54 per cent of the volume of the entire windfall loss for twenty years occurred in the first half-decade after cutting, and but one tree fell in the fourth half-decade—a 30-inch tree which would not have fallen had the area been under management, because so big a tree would not have been left standing. On Plot II, 94 per cent of the loss for fifteen years occurred in the first five-year period and only 2 per cent in the third five-year period. The same preponderant percentage in the first half-decade holds true for the other plots, except

that it is not so marked in Plot III, where but eleven trees fell in 27 years and most of these were large trees between 24 and 38 inches in diameter.

This concentration of windfalls in the first few years after cutting, with the gradual decrease thereafter, is a striking but not unnatural condition. When the forest in a region of severe winds is opened by heavy selection cutting, it is quite obvious that the weakest of the remaining trees will be blown down by the first strong winds, and that thereafter there will be a natural falling off of the loss as the less weak trees become gradually windfirm.

It will be remarked, however, that the uniform decrease of percentages in Table 2 is disturbed in the later half-decades by unusually high percentages of volume. As can be readily seen from a comparison of the small number of trees thrown with the corresponding high percentages of volume, the trees must have been of unusually large size. This was actually the case, for on Plot I the last tree thrown was 30 inches in diameter, on Plot III the last tree lost was 35 inches, and on Plot V there were two large trees, 26 and 30 inches, included in the last half-decade. Because of their large size and the deep basal fire scars on several of them, these trees were exceedingly bad windrisks, and would not have been left standing under any circumstances by a timbersale marker.

The concentration of windthrow immediately after cutting now suggests the question: Have not the several discouraging windfall losses on timbersale cuttings in the Whitman and Crater National Forests been the result of normally severe storm-winds striking remaining stands when they are most susceptible; that is, in the first few years after cutting, just as in the case of the losses in the old private cuttings described in this article? The specific case of the loss on the Eccles timbersale affords an opportunity for comparison. On this timbersale cutting, which was less than four years old, 17½ per cent by volume of the yellow pine trees in the reserved stand were blown down by the storms of May 26, 1913, and September 18, 1914. This amounted to an average loss of one tree per acre on 1,624 acres. On a permanent 45-acre sample plot, which was established on this timbersale area in 1914 and has been examined annually, the loss for the remainder of the five-year period following the two severe storms was an average of 0.2 tree per acre. Accordingly the loss on this area was 1.2 tree per acre for the first half decade. On the three plots of this study which suffered the heaviest windthrow, the loss for the first

five-year period was 1.4, 0.95 and 0.77 tree per acre, respectively. Thus, it is seen that the loss on the Eccles timbersale is less as compared with one plot and only slightly more as compared with the others; and the cutting which had a more alarming loss in the first years of its existence still has over 75 per cent of its reserved trees standing after 20 years of exposure.

It is of interest and practical value to express windfall loss in number of trees per acre. In order to have a uniform basis with respect to the time element, the loss for the five plots of this study was computed for the first 15 years following cutting in each case. On Plots I to V this was found to be, respectively: 2.1, 1.0, 0.4, 0.2, and 1.42 trees per acre.

In predicting the future yield of areas under management, it is useful to have these actual figures of windfall loss in order to make allowance therefor. It will immediately be said, however, that such allowance is of little value if loss through other causes than windthrow is not considered also. This point was kept in mind in the present study and total loss was carefully investigated on Plots III and V and on another area. The results of this investigation are quite interesting and will be presented very briefly. The total loss on the 24 acres of Plot V amounted to 46 trees in 15 years, as follows: 34 windfalls, 8 insect-killed and 4 killed by unknown causes. On the 20 acres of Plot III, where the total loss was very light, it amounted in the 27 years since cutting to 29 trees. The causes were recorded as: 11 windfalls, 8 insect-killed, and 10 killed by agencies which could not be definitely determined though believed to be mostly insects. Though fewer trees were windthrown than lost through other causes, the windfall volume loss was 11,775 board feet as compared with 10,245 board feet through other causes. Total loss has also been observed annually on a permanent 45-acre sample plot in a timbersale cutting which is now six years old. On this plot, which suffered in its first year from the severe storm of September 18, 1914, 75 trees have been lost to date: 61 windfalls, 11 insect-killed, 2 fungi-weakened and withthrown, and 1 lightning-killed. It is apparent that windfall makes up the great proportion of total loss, comprising 53 per cent by volume on Plot III and 80 per cent on the other two plots. It should be added that Plot III was located near a large area which suffered a severe epidemic infestation of Dendroctonus 10 or 12 years ago.

The value of this study is that it dispels the fear, inspired by the alarming losses experienced on several yellow pine timber sales in

Oregon, that these losses, if continued, would prohibit the selection method of cutting. The results are reassuring on this point, inasmuch as they indicate that, on areas subject to severe winds, a loss as great as 25 per cent may be expected before the reserved stand becomes resistant and that thereafter the big part of the stand will remain permanently on the ground. The results are also important in that they furnish actual figures of windfall loss in number and volume of trees per acre covering a long period of years, which can be used as a basis for the correction of such loss in yield tables—a correction which has heretofore been made upon assumption.

It is unfortunate that it was beyond the possibilities of this study to furnish information by means of which large windrisk areas may be recognized in the virgin forest before cutting is begun. If such information were available, it would be possible, by a modified treatment of the area, to reduce greatly the loss which seems so certain to occur in the first several years after cutting.

The important conclusions of the study may be summarized as follows: Heavy windfall in the first few years following cutting, like that of the timber sale in which 17½ per cent of the stand was blown down, does not presage the total destruction of the reserved stand or even endanger the method of cutting. As high a loss as 25 per cent by volume on bad windrisk areas may be expected in the course of 20 years. Of all the windthrow which occurs over a long period of years, a proportion as great as two-thirds or more usually takes place in the first four or five years immediately after cutting, and the remainder is thrown in rapidly decreasing percentages until about 20 years later when the windfall is so slight as to be negligible. Measured by the heaviest windfall loss encountered, the selection method of cutting is not prohibitive in the yellow pine stands of eastern Oregon.