

# Understory Response Three Years After Thinning Pine<sup>1</sup>

BURT R. McCONNELL AND JUSTIN G. SMITH

Range Conservationists, Pacific Northwest Forest and Range Experiment Station, Forest Service, USDA, Portland, Oregon.

## Highlight

**Understory yield was greater on thinned than on unthinned plots. When pine canopy exceeded 45 percent, forbs produced more than grasses; below 45 percent, grasses were superior producers.**

Overstocked stands of regenerating ponderosa pine (*Pinus ponderosa*)<sup>2</sup> are common throughout eastern Washington. These areas contribute little timber or forage, but with improved management their productive capacity can be greatly increased for both. Thinning such stands just to increase forage is impractical. When considered as an adjunct to timber improvement, however, increased forage yields could become an important part of local farm forestry programs. Thinning pines to increase forage may also be justified on selected key range areas; e.g., big-game winter ranges where there are acute shortages of forage.

In view of these considerations, a joint pine spacing-growth increment and forage production

study was initiated in 1959 by the Washington Department of Game, U.S. Soil Conservation Service, Okanogan National Forest, and Pacific Northwest Forest and Range Experiment Station. This report is concerned only with the latter aspect of the study. It covers changes in yield of understory vegetation during the first three growing seasons after tree thinning. Information on the magnitude and character of initial responses is an important consideration in assessing benefits and planning programs utilizing this type of range improvement.

An inverse relationship between overstory canopy cover or basal area of a tree stand and the density or production of herbaceous and shrubby understory has been noted under a wide variety of conditions by Pase (1958), Pase and Hurd (1958), Arnold (1950), Adams and Dunaway (1960), Cooper (1960), and many others. The strength of this relationship has been variable.

## Study Area and Methods

The investigation was made in the upper Methow River valley near Winthrop in north-central Washington. The actual study site was located on the Methow Game Range which is owned and managed by the Washington State Department of Game.

Elevation of the study area was 2,350 feet. Temperature extremes range from 110°F. to -30°F. with average July temperatures of about 70°F. The frost-free growing period extends from mid-May until late September. Approximately 60 percent of the average annual precipitation of 14.5 inches falls during the period October-February and includes about 73 inches of snow.

Soils in this locality have been

typed by the U.S. Soil Conservation Service as predominately Katar stony, sandy loams, 0- to 25-percent slopes. Katar soils are tentatively described as deep, somewhat excessively drained, moderately coarse-textured Western Brown forest soils, intergrading to regosols, developed from granitic ablation till. The series model has characteristic stony surface layers and is common on many of the surrounding gentle-to-steep sloping glacial plains. On the study site itself, however, the soils have stone-free surface layers and are a phase of the model recognized as Katar sandy loams, 3- to 15-percent slopes.

Pre-thinning vegetation consisted of thick pine regeneration with a sparse understory of poorly growing shrubs and scattered forbs and grasses. Changes in timber stand structure resulting from thinning are presented in Table 1.

Treatments consisted of thinning pine trees to the following spacings, each replicated three times in a randomized block design: 13.2 by 13.2 feet (48 trees per plot), 18.7 by 18.7 feet (24 trees per plot), 26.4 by 26.4 feet (12 trees per plot), and unthinned. It was not possible to find good trees growing at precisely the desired points for even spacing, but in most cases the actual distance between trees did not vary by more than one-third of the spacing interval. Each treatment plot was 1.2 by 1.6 chains (approximately 0.2 acre) and was completely surrounded by a buffer strip one-half chain wide which received the same treatment as the plot. Additional thinning was done beyond the buffer strips but not necessarily to the same spacing as the treatments.

Although reasonable care was exercised in the thinning operation, some ground disturbance was unavoidable. The most troublesome aspect of the disturbance was small patches of litter burned by fires that escaped from the slash burning near the plot perimeters. These burned areas were avoided in locating the circular plots used for production estimates.

Basal area was derived from the d.b.h. measurement of all trees on treatment plots. Pine canopy was estimated with a spherical densiometer (Lemmon, 1956) using the modification suggested by Strickler

<sup>1</sup>In cooperation with the Washington State Department of Game and Soil Conservation Service and Okanogan National Forest, U.S. Department of Agriculture. The authors are indebted to the Washington State Department of Game for furnishing a portion of its Methow Game Range for the study and contributing all of the labor for thinning the study plots.

<sup>2</sup>Scientific names for grasses and sedges according to Hitchcock (1950); for forbs and shrubs, Hitchcock et al. (1955, 1959, 1961); for trees, Little (1953). Taxonomic assistance was provided by the Department of Forestry and Range Management, Washington State University.

**Table 1. Timber stand conditions on the treatment plots at start of study after thinning.**

| Stand data                        | Tree spacing treatments |                   |                   |                   |
|-----------------------------------|-------------------------|-------------------|-------------------|-------------------|
|                                   | Unthinned               | 13.2x13.2<br>feet | 18.7x18.7<br>feet | 26.4x26.4<br>feet |
| Trees per acre, No.               | 2,828                   | 253               | 134               | 67                |
| Basal area, ft <sup>2</sup> /acre | 93                      | 27                | 19                | 13                |
| Avg. d.b.h., inches               | 3                       | 4                 | 5                 | 6                 |
| Avg. canopy cover, %              | 90                      | 35                | 18                | 13                |

(1959). Six readings were taken on each treatment plot.

Production of understory vegetation by species was obtained using the weight-estimate method (Pechanec and Pickford, 1937). Weight of herbaceous perennials was estimated on 30 circular, 48-square-foot plots randomly located within each treatment plot. Annuals were counted in a square-foot frame superimposed upon the center of each circular plot. Shrub weights were estimated for the entire population of shrubs rooted within the large treatment plots.

The response of understory vegetation to thinning was analyzed in terms of the following changes in timber stand structure: (1) growing area per tree (spacing squared), (2) percent pine canopy, and (3) pine basal area in square feet per acre.

Use of pretreatment understory yield as a covariate indicated no gain in precision over the unadjusted analysis of variance, so the following discussion is based on mean unadjusted yield increments. Orthogonal comparisons in regression were used to test the significance between increased yield and level of change in the various stand structure conditions associated with the thinning treatments.

### Results and Discussion

Analysis of the relationship between understory yield and growing area per tree showed a significant difference between thinned and unthinned plots but no difference ( $P = 0.09$ ) between levels of thinning. When pine canopy and pine basal area were each considered, however, significant increases in yield occurred at all thinning levels. The above relationships are shown in Figure 1. Portions of the total variance attributable to these regressions were 63 percent for growing area per tree, 95 percent for

canopy, and 89 percent for basal area.

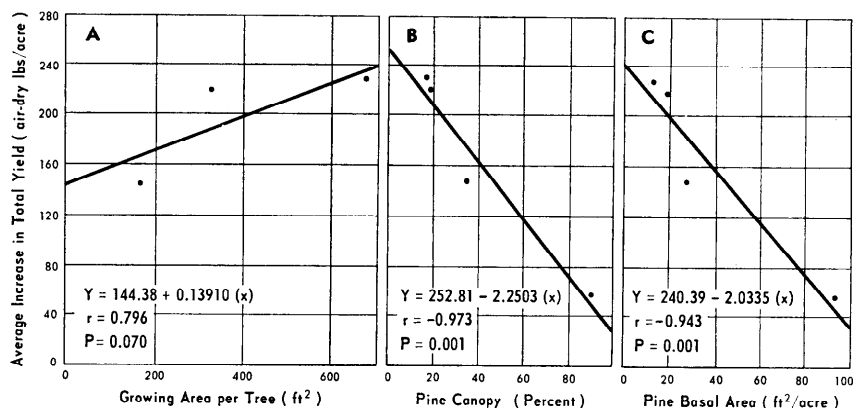
Since canopies were obviously influenced by the thinned tree spacings, total understory yields were adjusted by using canopy percent as a covariate. The original unadjusted yields were significantly different, but they did not differ significantly after being adjusted to a common canopy percent. This indicates that most of the effects of thinning can be attributed to changes in canopy. The adjustment was not made with basal area as the covariate, but the same general result would be expected. Basal area and canopy were both influenced by the thinning treatment and testing for linearity gave approximately the same result in each case. The methodology of this different use of covariance is discussed by Cochran and Cox (1962, p. 90).

Despite generally significant responses, initial rates of increase in understory yield were relatively minor. There was an increase of 0.14 pound of air-dry yield per acre for each additional square foot of tree growing area, or an increase of only

2 pounds for each 1-percent decrease in canopy cover or square foot of pine basal area. In contrast, Cooper (1960) reported a longtime increment rate of 21 pounds per acre for each 1-percent reduction in ponderosa pine overstory on a natural area in Arizona. Apparently, several more growing seasons will be needed for the sites treated in our study to respond fully.

Understory responses have also been considered in terms of the three vegetal classes: grasses and sedges, forbs (these two classes contributed about 97 percent of the total understory production), and shrubs. Except for shrubs, which showed a general nonsignificant initial response, results were essentially the same as reported for total yields.

Figure 2 shows that the overall rate of increase in grasses was higher than for forbs. For each 1-percent decrease in canopy cover, there was an average grass yield increment of about 1.3 air-dry pounds per acre. The corresponding increase in forb yield was 0.86 pound per acre. Figure 2 also shows that although grasses had a higher rate of increase than forbs, forb yields exceeded grass yields at the more dense levels of pine canopy. For example, under an 80-percent canopy, forbs increased about 43 pounds per acre compared to 28 pounds for



**FIGURE 1.** Relationship between total yield of understory vegetation and A, growing area per pine tree; B, pine canopy percent; and C, pine basal area three growing seasons after pine thinning.

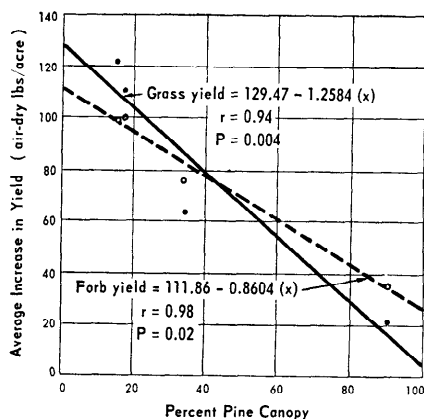


FIGURE 2. Comparison of average yield increments of grasses and forbs in relation to pine canopy percent.

grasses. Forb production superiority diminished as canopy diminished, and at 40- to 45-percent canopy, forb and grass increases were approximately equal. As the canopy continued to open up, the situation was reversed with grasses showing progressively larger increases than forbs. Donald and Black (1958) point out that forbs may be more efficient users of low light because their more horizontally disposed leaf habit enables them to achieve a fuller canopy of foliage. In contrast, because the leaves of grasses are disposed at various levels and angles, they do not form such a continuous cover of foliage.

Behavior of some of the individual species is also of interest. For example, the average increase of pinegrass (*Calamagrostis rubescens*) on the thinned plots was 47 percent greater than on the unthinned plots, with the big percentage gains recorded on the heavier thinnings. Since pinegrass comprised 78 percent of all increases in grass yield and 42 percent of the total increase in yield, its response contributed greatly to the significance of overall treatment effects. Quite possibly the rhizomatous root habit of pinegrass provided a competitive advantage which facilitated more pronounced initial yield increments

than was possible for many of the other grasses that reproduce only from seed. Species comprising approximately equal amounts of the remaining increase in grass yield were needlegrass (*Stipa* spp.), beardless bluebunch wheatgrass (*Agropyron inerme*), Idaho fescue (*Festuca idahoensis*), June grass (*Coeleria cristata*), and sedges (*Carex* spp.).

Arrowleaf balsamroot (*Balsamorhiza sagittata*), the principal forb, also showed good initial response to pine thinning. Its average increase on the thinned plots was 59 percent greater than on the unthinned, and again the larger percentage gains were associated with the heavier thinnings. Of the total forb response, balsamroot made up 14 percent and was surpassed by silky lupine (*Lupinus sericeus*) and western yarrow (*Achillea lanulosa*), which comprised 27 percent and 19 percent, respectively. Most of the rest of the total increase in forb yield consisted of pussytoes (*Antennaria* sp.), wayside gromwell (*Lithospermum ruderales*), purple daisy fleabane (*Erigeron corymbosus*), woollyweed (*Hieracium scouleri*), and gland cinquefoil (*Potentilla glandulosa*). Milkvetch (*Astragalus miser* var. *serotinus*), which occurred on only 1 of the 12 treatment plots, was the only forb showing a substantial decrease. The reason for this decrease was not apparent. As a group, forbs accounted for about 52 percent of the increase in all species.

The shrub and tree species encountered included willow (*Salix* sp.), snowbrush ceanothus (*Ceanothus velutinus*), quaking aspen (*Populus tremuloides*), currant (*Ribes* sp.), and bitterbrush (*Purshia tridentata*), but only the latter occurred in sufficient volume to record, and it made up only about 6 percent of the total increase in understory yield.

There were also increases in the density of several annual forbs such as bigflower groundsmoke (*Gayophytum diffusum*), cryptantha (*Cryptantha torreyana*), Douglas knotweed (*Polygonum douglasii*), and pink microsteris (*Microsteris gracilis*) on the thinned plots but essentially no change on the control plots.

It is evident that tree spacing, tree canopy, and tree basal area are closely interrelated in their effects on understory vegetation. It is also apparent that the bulk of these effects operate as climatic influences. Consequently, since temperature, light, and water are probably the most critical climatic factors as far as plants are concerned (Bonner and Galston, 1952), studies of these factors have been initiated as part of the present investigation.

The importance of pine litter accumulations on the germination and survival of grasses is being considered in a separate investigation. All of these aspects will be combined in a future report.

### Summary

Responses of understory vegetation to thinning of dense pine stands were analyzed in terms of the following changes in timber stand structure: (1) growing area per tree, (2) pine canopy, and (3) pine basal area. When growing area per tree was considered, increases in average total understory yield were significantly greater on thinned plots than on unthinned, but differences between thinned plot averages were not significant. When canopy and basal area were tested, however, there were negative linear relationships with total understory yield.

Responses of understory yield were also analyzed in terms of the three vegetal classes: grasses, forbs, and shrubs. Except for shrubs, which showed a non-

significant response at the 5-percent level, results were essentially the same as for total yields.

When pine canopy exceeded 45 percent, forbs showed a greater capacity to produce dry matter than grasses; below 45 percent, grasses were the superior producers.

#### LITERATURE CITED

- ADAMS, L. AND D. J. DUNWAY. 1960. The effect of timber overstory on deer habitat in mixed conifer type. U.S. Forest Serv. Pac. SW. Forest & Range Expt. Sta. Res. Note 158. 2 pp.
- ARNOLD, J. F. 1950. Changes in ponderosa pine bunchgrass ranges in northern Arizona resulting from pine regeneration and grazing. J. Forest. 48:118-126.
- BONNER, J. AND A. W. GALSTON. 1952. Principles of plant physiology. McGraw-Hill Book Co., New York. 499 pp.
- COCHRAN, W. G. AND G. M. COX. 1962. Experimental designs. 2nd ed. John Wiley & Sons, New York and London. 611 pp.
- COOPER, C. F. 1960. Production of native and introduced grasses in the ponderosa pine region of Arizona. J. Range Manage. 13:214-215.
- DONALD, C. M. AND J. N. BLACK. 1958. The significance of leaf area in pasture growth. Herb. Abs. 28:1-6.
- HITCHCOCK, A. S. 1950. Manual of the grasses of the United States. U.S. Dept. Agr. Misc. Pub. 200. 1051 pp.
- HITCHCOCK, C. L., A. CRONQUIST, M. OWNBEY AND J. W. THOMPSON. 1955. Vascular plants of the Pacific Northwest. Pt. 5. Univ. Washington Press, Seattle. 343 pp.
- HITCHCOCK, C. L., A. CRONQUIST, M. OWNBEY AND J. W. THOMPSON. 1959. Vascular plants of the Pacific Northwest. Pt. 4. Univ. Washington Press, Seattle. 510 pp.
- HITCHCOCK, C. L., A. CRONQUIST, M. OWNBEY AND J. W. THOMPSON. 1961. Vascular plants of the Pacific Northwest. Pt. 3. Univ. Washington Press, Seattle. 614 pp.
- LEMMON, P. E. 1956. A spherical densiometer for estimating forest overstory density. Forest Sci. 2:314-320.
- LITTLE, E. J., JR. 1953. Check list of native and naturalized trees of the United States (including Alaska). U.S. Dept. Agr. Handb. 41. 472 pp.
- PASE, C. P. 1958. Herbage production and composition under immature ponderosa pine stands in the Black Hills. J. Range Manage. 11:238-243.
- PASE, C. P. AND R. M. HURD. 1958. Understory vegetation as related to basal area, crown cover and litter produced by immature ponderosa pine stands in the Black Hills. Proc. Soc. Amer. Foresters (1957):156-158.
- PECHANEC, J. F. AND G. D. PICKFORD. 1937. A weight estimate method for the determination of range or pasture production. J. Amer. Soc. Agron. 29:894-904.
- STRICKLER, G. S. 1959. Use of the densiometer to estimate density of forest canopy on permanent sample plots. U.S. Forest Serv. Pac. NW. Forest & Range Expt. Sta. Res. Note 180. 5 pp.