Response of Understory Vegetation to Ponderosa Pine Thinning in Eastern Washington[1]

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Highlight

Pine thinning caused highly significant increases in understory vegetation. After eight growing seasons, total understory yield increments ranged from 75 lb/acre on the unthinned plots to 417 lb under 26-foot pine spacing. The increase comprised 51% grasses, 37% forbs, and 12% shrubs. When pine canopy exceeded about 45%, forbs produced more than grasses; below 45%, grasses were superior producers. Shrubs were the least productive at all levels.

There are extensive acreages of overstocked ponderosa pine (*Pinus ponderosa*)[2] in the Pacific Northwest. In their present condition, these stands produce little timber or forage, but with improved management their productive capacities can be greatly increased. Large-scale thinning programs are currently underway, but specific tree spacing guides for optimum timber production are limited. Since thinned stands are also potential sources of forage for game and livestock, a joint pine spacing-growth increment and forage production study was initiated in 1959 by the Washington State Department of Game; U.S. Soil Conservation Service; and Okanogan National Forest and Pacific Northwest Forest and Range Experiment Station of the Forest Service, U.S. Department of Agriculture. This report describes changes that have occurred in understory vegetation during the eight growing seasons between 1959 and 1966. McConnell and Smith (1965) reported on the initial changes in understory vegetation following thinning, and Barrett (1968) presented data on the growth increment of pine.

Study Area and Methods

The study 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 is 2,350 feet. Temperature extremes range from 100 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% of the average annual precipitation of 14.5 inches falls between October and February and includes 73 inches of snow.

Soils in this locality have been typed by the U.S. Soil Conservation Service as Katar, stony, sandy loams, 0 to 25% slopes. Katar soils are 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 sloping glacial plains in the area. On the study site itself, however, the soils have stonefree surface layers and are a phase of the model recognized as Katar sandy loams, 3 to 15% slopes.

A vigorous 48-year-old stand of pine saplings was selected for study. The stand originated from natural seeding about 1911 following logging and fire. Surviving trees of the original stand, unmerchantable at the time of logging, indicated an above average site V. The area is not grazed by livestock, but it receives light deer use.

Prethinning vegetation consisted of thick pine regeneration with a sparse understory of poorly growing shrubs and scattered grasses and forbs (Fig. 1). Treatments consisted of thinning trees to the following spacings, each replicated three times in a randomized block experimental design: 13.2 by 13.2 feet (253 trees/acre), 18.7 by 18.7 feet (134 trees/acre), 26.4 by 26.4 feet (67 trees/acre), and unthinned (an average of approximately 2,800 trees/acre). 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

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[2] Scientific names for grasses and sedges are according to Hitchcock (1950); for forbs and shrubs, Hitchcock et al. (1955–64); for trees, Little (1953). Taxonomic assistance was provided by the Department of Forestry and Range Management, Washington State University.

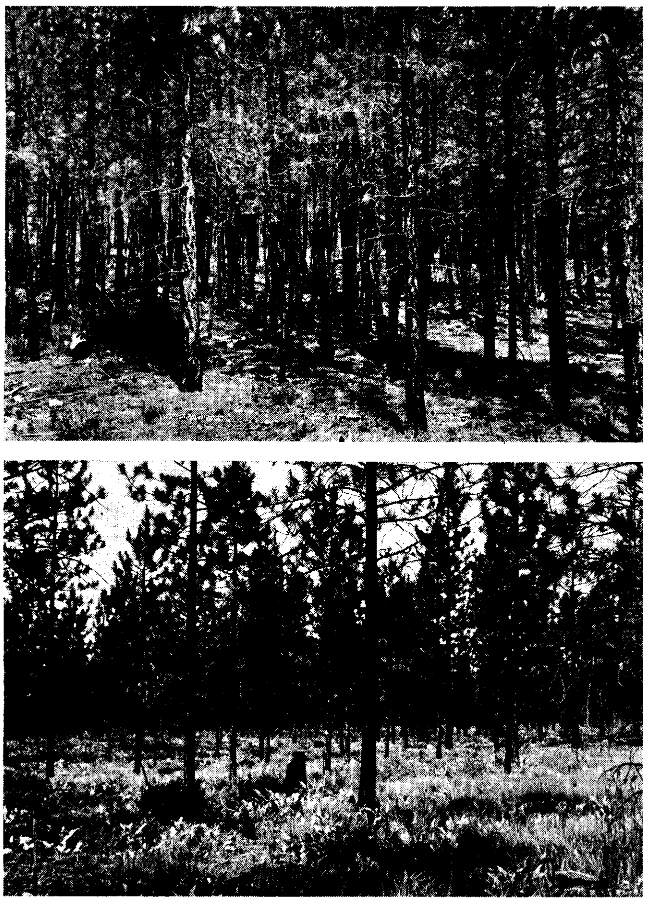

FIG. 1. Only an occasional shrub and a few scattered grasses and forbs made up the understory before thinning (upper). Seven years after thinning to 18.7-foot spacing, 550 pounds of understory vegetation were being produced, including many desirable forage species (lower).

chains (approximately 0.2 acre) and was completely surrounded by a buffer strip one-half chain wide which received the same treatment as the study plot. Additional thinning was done beyond the buffer strips but not necessarily to the same spacing as the treatment. Slash was removed from all treatment plots and buffer strips.

Pine canopy was measured with a spherical densiometer (Lemmon, 1956) modified as suggested by Strickler (1959). Readings were taken in four directions at six mechanically spaced locations on each treatment plot.

Production of understory vegetation by species was obtained with the weight-estimate method (Pechanec and Pickford, 1937). Weight of herbaceous perennials was estimated on 30 circular, 48 ft^2 plots randomly located within each treatment plot. Shrub weight was estimated for the entire population of shrubs rooted within the treatment plots. The response of understory vegetation was analyzed in terms of tree spacing and tree canopy percent.

Results

Analysis of variance indicated that pine spacing had a highly significant effect on increase in total understory yield. As shown in Figure 2, the accompanying comparison in regression revealed a significant curvilinear trend in the relationship be-

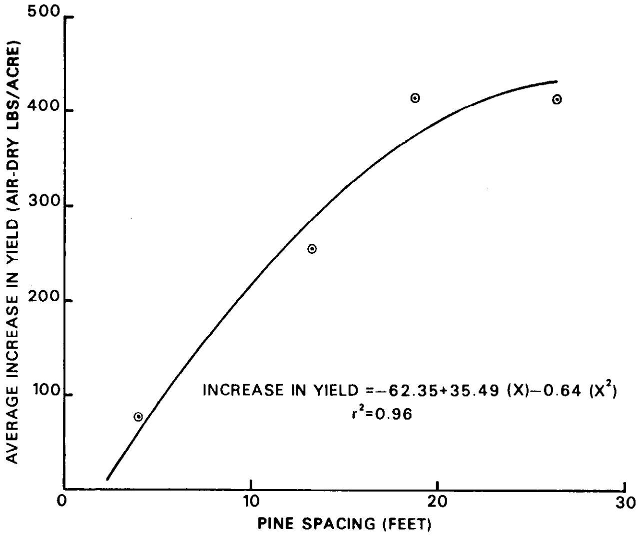

FIG. 2. Relationship between pine spacing and increase in total understory yield.

tween yield and spacing. After eight growing seasons, the net average yield increment due to thinning (total increase minus increase on control) ranged from 181 lb/acre air-dry (79%) at the 13-foot spacing to 342 lb/acre (246%) at the 26-foot spacing.

The 8-year increase in total understory yield was also related to tree canopy percent. As shown in Figure 3, there was a highly significant negative

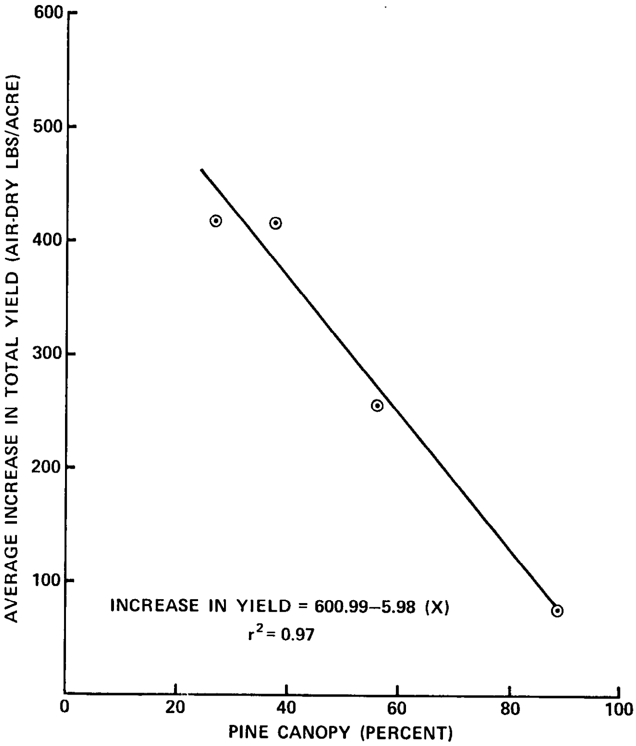

FIG. 3. Relationship between average increase in total yield and percent pine canopy.

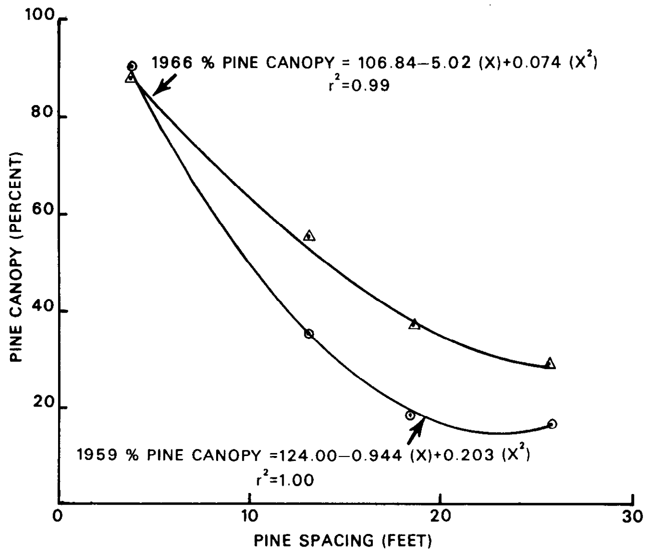

FIG. 4. Comparison of relationship between pine canopy and pine spacing in 1959 and 1966.

linear trend between these two variables, which indicated that a 6-lb increase in understory yield occurred for each 1% decrease in tree canopy. This was triple the rate of increase of 2 lb/acre reported three growing seasons after thinning (McConnell and Smith, 1965).

There were also some important changes in tree canopy during the study interval. As shown in Figure 4, significant negative curvilinear relationships were found between percent tree canopy and tree spacing in 1959—when the study was started—and 1966. Covariance analysis indicated that these two regressions were significantly different at the 0.05 level.

Note that the relationship between yield and spacing (Fig. 2) is curvilinear and between yield and canopy (Fig. 3) is linear even though there is almost a perfect correlation between spacing and canopy (Fig. 4). This apparent discrepancy reflects the difference in sensitivity with which the tests were made. The relationship shown in Figure 2 was estimated from analysis of variance whereas those shown in Figures 3 and 4 were estimated with less sensitivity from regression analyses.

Understory responses were also considered in terms of the three vegetal classes: grasses (including grasslike), forbs, and shrubs. Eight years after thinning, total understory increases were made up of: grasses, 51%; forbs, 37%; and shrubs, 12%. By comparison, 3 years after thinning, the understory increment was: grasses, 54%; forbs, 40%; and shrubs, 6%.

A highly significant linear trend was found between increased grass yield and pine spacing which indicated a 9-lb increment in grass yield for each 1-ft increase in pine spacing. The relationship between grass yield and pine canopy percent was not

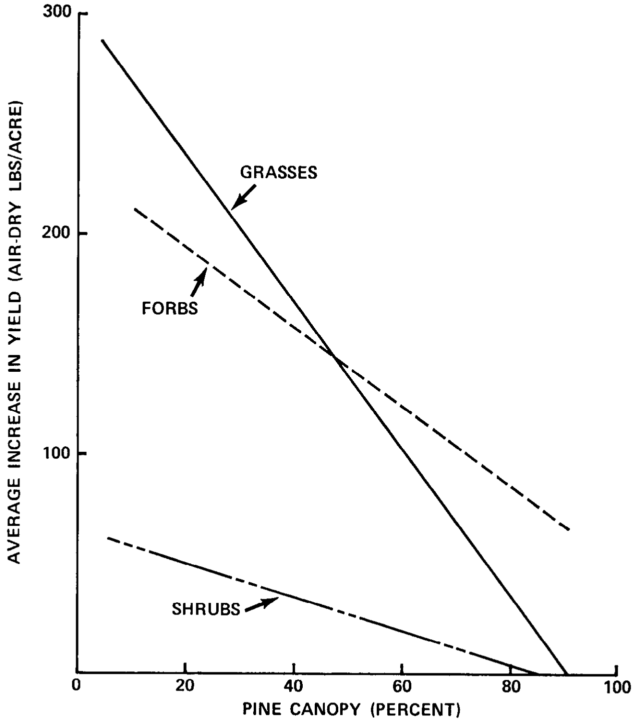

FIG. 5. Comparison of relationship between pine canopy percent and increase in grass, forb, and shrub yields.

quite significant at the 0.05 level with a 3-lb increase in grass yield for each 1% decrease in pine canopy. The average increase of grasses ranged from 62 lb (54%) at 13-ft spacing with 55% canopy, to 192 lb (218%) at the 18-ft spacing with 37% canopy.

A significant linear trend was also found between increase in shrub yield and both spacing and percent canopy of pine. Shrubs—mostly bitterbrush (*Purshia tridentata*)—increased about 2 lb per acre for each 1-ft increase in spacing, and 1 lb/acre for each 1% decrease in canopy. The average shrub increment was 45 lb/acre (1,100%) at the two wider spacings compared with 15 lb (166%) at the 13-ft spacing.

There was a noticeable difference in forb increments on the thinned and unthinned plots, but it was not statistically significant. The apparent lack of forb response was probably due to the predominance of arrowleaf balsamroot (*Balsamorhiza sagittata*), which grows well in either open sunlight or partial shade.

Regressions of yield increments of the three vegetal classes over tree canopy percent are presented in Figure 5. These data show that the overall rate of increase of grasses was higher than for forbs and shrubs. Although grasses had a higher rate of increase than forbs, forb yields exceeded grass yields under denser canopies. For example, under 90% canopy, forbs produced about 65 lb/acre whereas grasses yielded only 2 pounds. As the canopy was opened, however, forb production superiority declined; and at about 45% canopy, forb and grass production was approximately equal. As the canopy continued to open, grasses became progressively more predominant producers.

It is interesting to note—except for higher increment rates—that the response of grasses and forbs to changes in pine canopy are almost identical to the findings of our earlier study. As we pointed out then, forbs are more efficient at lower light intensities because their horizontally disposed leaf habit enables them to produce a fuller canopy of foliage. In contrast, the leaves of grasses are disposed at various levels and angles so they do not form such a continuous cover of foliage (Donald and Black, 1958).

Response of individual species is also of interest. Pinegrass (*Calamagrostis rubescens*), an acceptable forage species and the predominant grass in this area, did not increase on either the 13-ft spacing or the unthinned plots between 1961 and 1966. This suggests that it may have made its maximum contribution to the understory composition at the narrower spacings. During this same period, an average increase of about 40% occurred at the two wider spacings. Pinegrass contributed 77% of the total increase in grass yield and 39% of the increase in total understory yield. Other grasses showing minor but consistent gains were beardless bluebunch wheatgrass (*Agropyron inerme*), Junegrass (*Koeleria cristata*), needlegrass (*Stipa* spp.), and Idaho fescue (*Festuca idahoensis*). Increases of sedge (*Carex* spp., mostly *C. geyeri*) varied from 0.5 lb/acre on the 13-ft plots to 16 lb/acre at 26-ft spacing.

Balsamroot, the principal forb, increased about 75 lb/acre (140%) on the 13-ft plots and an average of about 25 lb (96%) on the two wider spacings. It produced 89% of the total forb yield on the unthinned plots as compared with 72% on the 13-ft spacing and 22% on the two wider spacings. It also contributed 66% of increase in total understory vegetation on the unthinned plots, 41% on the 13-ft spacing, and an average of 7% at the two wider spacings.

Silky lupine (*Lupinus sericeus*) was also a prominent forb. It increased 55 lb (1,100%) at the 26-ft spacing as compared with no increase on the unthinned plots. Most of the remaining forb increase was from woollyweed (*Hieracium scouleri*), yarrow (*Achillea lanulosa*), western gromwell (*Lithospermum ruderale*), longleaf fleabane (*Erigeron corymbosus*), pussytoes (*Antennaria* spp.), and gland cinquefoil (*Potentilla glandulosa*).

The tree and shrub species encountered were willow (*Salix* sp.), snowbrush ceanothus (*Ceanothus velutinus*), rose (*Rosa* sp.) serviceberry (*Amelanchier* sp.), and quaking aspen (*Populus tremuloides*). Bitterbrush was the only woody species that contributed measurable yields; judging from its increase on older thinnings near the study plots, one can expect a much greater increase in future years.

Discussion

The present findings show that pine thinning produces significant increases in understory vegetation. Before thinning can make a practical contribution to the range resource, however, more economical slash disposal methods must be developed. Even then, thinning will generally be impractical as a range improvement technique. But when considered as an adjunct to timber stand improvement, increased forage production could be an important aspect of local farm forestry programs. Thinning pines for forage production may also be justified on selected key range areas; e.g., big-game winter ranges where there are acute shortages of forage.

Unfortunately, despite significant advances in knowledge, no comprehensive and balanced picture of the forest ecosystem is currently available. Thus, timber stand manipulation and the accompanying changes in environment and associated vegetation presents problems, as well as opportunities, for both range and timber managers. Numerous examples are available which show dramatic increases in understory vegetation when dense pine overstories are thinned. On the other hand, substantial increases in wood fiber production also occur when understory vegetation is greatly reduced (Barrett, 1965; Barrett and Youngberg, 1965). Consequently, some foresters, e.g., Gordon (1962), question the use of wide pine spacings because anticipated growth increments may be adversely affected by increases in understory vegetation.

Other workers feel that the effects of understory vegetation are not all bad. For example, Wollum and Youngberg (1964), Russel and Evans (1966), and Webster et al. (1967) report improvement of soil fertility due to nitrogen fixation by such common understory plants as bitterbrush and snowbrush ceanothus. Shrubby species can also provide mechanical protection of pine seedlings from grazing and trampling (Youngberg, 1966). There may even be some important indirect relationships such as the decline of forest stands due to changes in microbiological activities in the soil. Florence and Crocker (1965) discuss this problem and indicate the role of "brush and weed species" in revitalizing such sites in the redwoods of California. Dyrness (1960), Youngberg (1966), Wahlenberg (1930), and others report that soil moisture and temperature are more favorable for pine seedlings under shrubs than under grasses or on open ground.

There is definitely a trend toward wider spacings in pine silviculture; and this, of course, means more potential forage for game and livestock. But if this resource is grazed, it will have to be managed to minimize possible conflict with timber production. Sometimes it may even be possible to manipulate grazing to benefit silviculture programs. For example, Pearson (1923) observed that pine seedlings were more vigorous where herbaceous plants were grazed than where grass was thick. He concluded that very heavy grazing during a good cone year and the year thereafter could be an effective silvicultural tool. In a later study, Pearson (1942) simulated grazing by clipping grasses at different intensities and intervals and reported that managed grazing could definitely aid pine reproduction. Many other studies have also been conducted, but relatively few have considered the silvicultural aspects of grazing in depth; most have emphasized the damage aspects of grazing. There is still a definite need for coordinated research by range, wildlife, and timber managers.

It is also important to realize that there will be some situations where the needs of wildlife or livestock will be more important than timber production. For example, big-game animals tend to winter at low elevations, and in many areas they rely heavily on the lower fringe of the pine zone. Where this occurs, south- and west-facing slopes often become key wintering areas. Fortunately, most of these areas are low quality pine sites, and thinning beyond silvicultural standards is a justifiable way to increase winter forage. At the same time, however, it should be realized that these stands must not be thinned indiscriminately because dense patches of young pines are also important resting areas for big game. On the study area, for example, there were three times as many deer beds in unthinned thickets as there were in thinned stands. Thus number, size, and dispersion of thinned areas is also important from a game management standpoint. Considerations like these are commonplace and simply emphasize the importance of close coordination between sometimes divergent interests to maintain a responsible integration of forest uses.

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