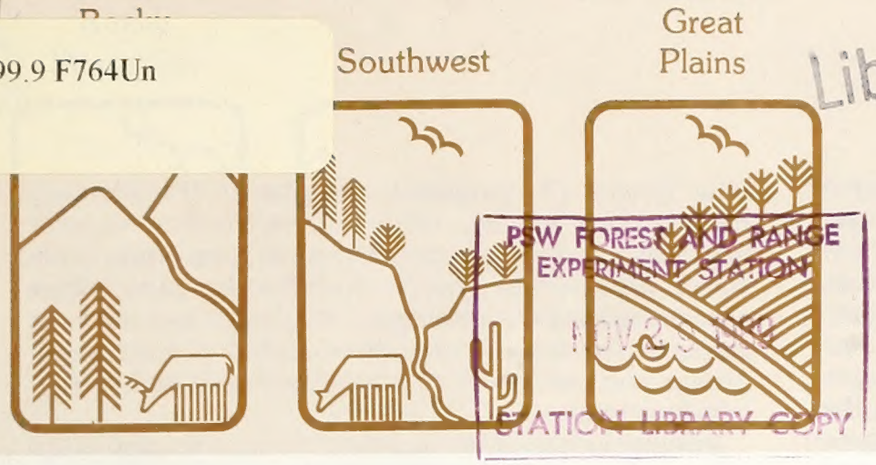

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Production and Utilization of Herbaceous Plants in Small Clearcuts in an Arizona Mixed Conifer Forest

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Small patch clearcutting has been recommended for managing a variety of resources from southwestern mixed conifer forests. In this study, herbage production and utilization were higher in small clearcuts (0.3-1.6 acres) than in adjacent, partially harvested forest stands. Production in the openings ranged from 208 to 355 pounds per acre, while production in the harvested forest ranged from 39 to 92 pounds per acre. Utilization of herbaceous plants was significantly higher in the clearcuts for two of the three measurement dates. Small patch clearcuts should thus benefit livestock, deer, and elk.

Keywords: Herbage production, herbage utilization, patch clearcutting, mixed conifers

The southwestern mixed conifer and associated aspen and spruce-fir forests cover about 2.5 million acres in Arizona and New Mexico (Jones 1974). These moist, high elevation forests produce a wide range of commercial and noncommercial products. Small dispersed clearcut patches have been advocated as a means of increasing water yields and, concurrently, of enhancing other resources. Periodic harvesting of trees in small groups and clearcuts is compatible with silvicultural recommendations for uneven-aged, clumpy mixed conifer stands (Jones 1974).

Small clearcuts should also be beneficial for big game and livestock. Neff et al. (1979) recommended patch clearcuts in overmature and mature mixed conifer stands. The patches should blend with the terrain and provide maximum benefits in deer and elk forage production. For an opening to be used, it not only must provide feed but must be surrounded by a forest stand that will provide the animals with security and thermal cover. Elk (*Cervus elaphus*) tend to use clearcuts more consistently than do mule deer (*Odocoileus hemionus*), but deer will use these openings when the surrounding stands are dense, extensive, and stagnant (Severson and Medina 1983).

Cattle will also benefit, since dense stands produce little herbaceous cover (Thill et al. 1983). Brown (1976), in an economic alternative analysis for multiple use management on a 562-acre watershed, estimated that a prescription that included patches of between 2 to 10 acres would eventually produce an average of 36 animal-unit months (AUM) of forage utilization annually. The plan called for 59 acres to be harvested every 20 years over the 120-year rotation. This schedule would provide an increase of 24 AUM over virgin conditions. Brown indicated that the prescription would benefit deer, elk, Merriam's turkey (*Meleagris gallopavo*), and several species of nongame birds.

Although small clearcuts of various sizes have been recommended for increasing herbage production for wildlife and livestock, the effects of the prescription on the production and utilization of herbaceous plants has not been evaluated in southwestern mixed conifer forests. However, previous studies in Arizona ponderosa pine (*Pinus ponderosa*) forests (Ffolliott et al. 1977, Patton 1974) have demonstrated increased herbage production and/or utilization in small clearcuts, as have studies in the spruce-fir forests of Arizona (Reynolds 1966) and Colorado (Crouch 1985).

A current study at Thomas Creek, in the White Mountains of east-central Arizona, is evaluating the effects of

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a silvicultural prescription, which includes the clearing of small openings, on a number of mixed conifer forest resources. Responses being evaluated included water yields, tree growth and regeneration, herbaceous cover, and wildlife species. A lack of adequate herbage production would limit the usefulness of the small clearcuts for multiresource management objectives. The objective of the current study, therefore, was to determine the effects of small clearcuts within a mixed conifer stand on production and utilization of herbaceous plants, and to compare them with conditions in the surrounding partially harvested forest.

Study Area

This study was part of a multiresource study being conducted within the South Fork of Thomas Creek. The 562-acre watershed is within the Apache-Sitgreaves National Forests about 15 miles south of Alpine, Arizona. Elevations on South Fork watershed range from 8,350 to 9,150 feet. The soils are primarily sandy loams derived from basaltic parent material and are classified as Mollic Eutroboralfs loamy-skeletal mixed. Average annual precipitation is above 30 inches, with 56% occurring from October through May, mostly as snow. However, July and August receive the most monthly precipitation, with respective means of 4.5 and 4.4 inches (table 1). Mean temperature and precipitation values for the May through September growing season are presented in tables 1 and 2.

Thomas Creek originally supported an old-growth, uneven-aged mixed conifer forest consisting of eight main species: Engelmann spruce (*Picea engelmannii*), blue spruce (*P. pungens*), Douglas-fir (*Pseudotsuga menziesii* var. *glauca*), white fir (*Abies concolor*), corkbark fir (*A. lasiocarpa* var. *arizonica*), ponderosa pine, southwestern white pine (*P. strobiformis*), and quaking aspen (*Populus tremuloides*). Douglas-fir was the most common species. The stands consisted of a mosaic of groups and patches of varying size classes and species compositions.

Principal graminoids include Arizona fescue (*Festuca arizonica*), mountain muhly (*Muhlenbergia montana*), mutton bluegrass (*Poa fendleriana*), bottlebrush squirreltail (*Sitanion hystrix*), and prairie junegrass (*Koeleria cristata*) (Thill et al. 1983). Among the forb species are western yarrow (*Achillea lanulosa*), leafybract aster (*Aster foliaceus*), trailing fleabane (*Erigeron flagellaris*), American vetch (*Vicia americana*), deer-ears swertia (*Swertia radiata*), silvery lupine (*Lupinus argenteus*), and showy goldeneye (*Viguiera multiflora*). Commonly found woody plants are Fendler ceanothus (*Ceanothus fendleri*), Arizona rose (*Rosa arizonica*), New Mexico locust (*Robinia neomexicana*), and mountain snowberry (*Symphoricarpos oreophilus*).

Thomas Creek is part of a pasture that is usually grazed from the middle of May through August, although occasionally grazing extends into October.

A prescription was prepared for the upper 422 acres of forest on South Fork; the lower areas were withdrawn from the sale because of locally steep slopes. It called for group selection on 233 acres, patch clearcutting and individual tree selection on 159 acres, and individual tree selection on the 28 acres adjacent to the stream channel. Two acres of meadow were left undisturbed. The harvest, from May 1978 through January 1979, removed 3.4 million board feet of volume (Scribner C) after

Table 1.—Precipitation for the May through September growing season for the three sampling years and for the period of record.

Precipitation month	1982	1983	1986	24-year mean	±	std. error
May	3.13	0.39	0.75	0.86	±	0.18
June	0.62	0.39	3.04	1.20	±	0.22
July	3.22	5.76	4.45	4.47	±	0.29
August	5.11	3.06	4.34	4.41	±	0.36
September	2.47	6.33	2.21	3.22	±	0.38
Period total	14.55	15.93	14.79	14.16	±	0.44

Table 2.—Mean daily temperatures for the May through September growing season for the three sampling years and for the period of record.

Mean daily temperature month	1982		1983		1986		13-year monthly means ± std. error	
	max (°F)	min (°F)	max (°F)	min (°F)	max (°F)	min (°F)	max (°F)	min (°F)
May	57.4	30.5	61.0	31.3	63.9	32.0	63.2 ± 1.0	32.7 ± 0.7
June	72.8	38.7	68.2	38.7	69.9	41.1	74.4 ± 1.1	41.7 ± 0.6
July	71.8	46.6	71.8	47.1	69.3	45.1	73.0 ± 0.9	47.1 ± 0.4
August	68.5	48.1	71.4	46.8	70.5	46.8	70.9 ± 0.5	45.6 ± 0.6
September	61.2	42.2	65.4	44.7	63.8	36.4	65.3 ± 0.7	41.0 ± 0.6

allowing for defect. Stand basal area for the entire cutting unit was reduced 34%, from 200 to 132 square feet per acre. The harvest resulted in 63 patch clearcut and group selection openings. The average opening was 1.2 ± 0.1 acres; the range was from less than 0.5 to 4.1 acres. The total area in these clearings was 75.4 acres, approximately 13% of the watershed. Efforts were made to protect poles and advance regeneration in the clearings. Large logging slash was piled in landings, and all slash was piled along logging roads and in the perimeter fuelbreak. Slash piles were burned.

Methods

Nine representative patch clearcuts were selected for intensive evaluation of herbage production and utilization. The clearcuts were dispersed throughout the unit and varied in size from 0.3 to 1.6 acres. Two transects were established that intersected at right angles in the center of each opening. Along the transects, permanent plots were established at an interval equal to the average height approximately 50 feet of the dominant trees surrounding the clearcut. Transects extended 150 feet into the harvested forest adjacent to the clearcuts.

Herbage production was determined by the weight-estimate method (Pechanec and Pickford 1937) on circular 9.6 square-foot plots centered at the sample plot locations. Utilization of the herbaceous plants by cattle and wildlife was ocularly estimated in terms of the proportion of the plant weight apparently eaten by cattle and wildlife. Production and utilization were measured in late summer of 1982, 1983, and 1986, about 4, 5, and 8 years after the creation of the small clearcuts. Production and utilization of individual species were not evaluated during the study; however, a recent study (Crouch 1985) found that logging had little effect on the presence or absence of plant species.

The total basal area of the forest overstory adjacent to each plot was estimated following the harvest by point sampling techniques using a 25 basal area factor wedge. Basal areas varied from 96 to 165 square feet per acre, and averaged 122 ± 7 square feet per acre.

Data from plots within each clearing or forested area were pooled. Comparisons between the production and utilization of herbaceous plants in the nine small clearcuts and under the adjacent forest overstories were evaluated by paired t-tests. Changes over time were analyzed using repeated measures procedures. Mean values are presented here with their standard errors. Statements referring to increases or decreases, and greater or lesser, indicate that the differences were statistically significant at the 5% level, except where noted by another probability level.

Results

Production

In all 3 years of measurements, production of herbaceous plants in the small clearcuts was greater than that in the adjacent forests (fig. 1). Herbage production in the

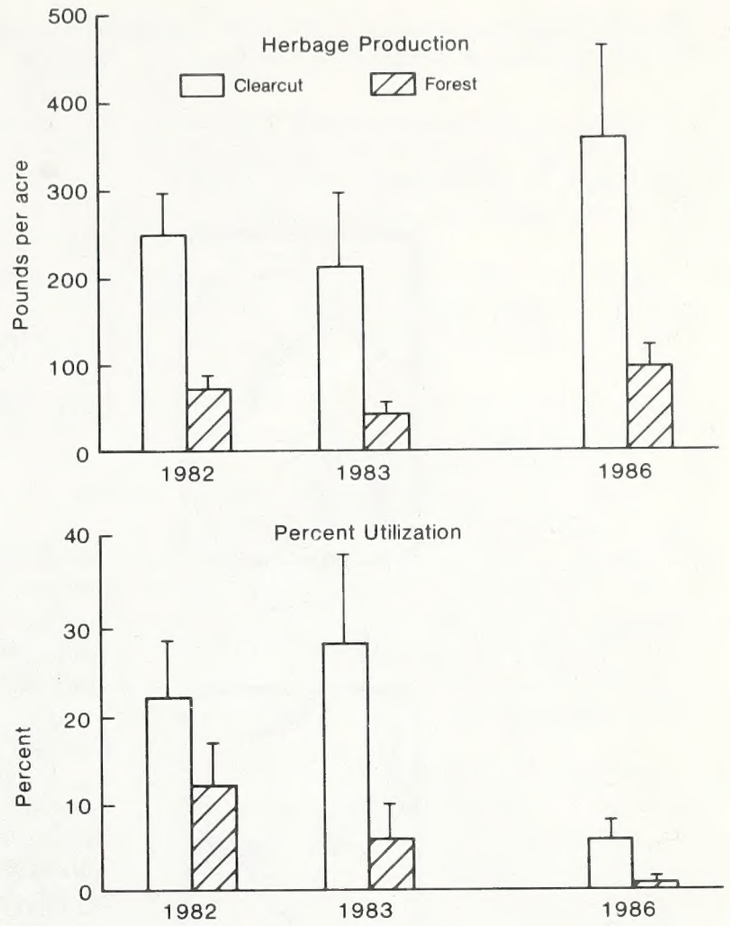

Figure 1.—Average herbage production and utilization in nine small clearcuts in Thomas Creek (with standard errors).

clearcuts averaged 248 ± 48 pounds per acre in 1982, compared to 71 ± 14 pounds per acre in the forest (fig. 1). Production decreased on both the clearcut and the forest sites in 1983, but the difference between sites was still significant. Production recovered in 1986. There was no significant "time trend" in the production of herbaceous plants after the creation of the small clearcuts, nor were there any time x site interactions.

Utilization

The utilization of herbaceous species did not differ significantly between patch clearcuts and adjacent forest in 1982 (fig. 1). Average utilization was greater in the openings in 1983 ($P = 0.06$) by approximately 22%. Some openings showed no utilization, while several, in a relatively flat area, had up to 89% utilization. Five of the forested sites also showed no animal use in 1983. In 1986, utilization dropped to 6.1% ± 1.6% in the clearings and to 1.0% ± 0.3% in the forest. This difference was statistically different.

An analysis of changes over time showed that 1982 and 1983 utilization values were similar, but that the 1986 values were significantly lower (fig. 1). One possible reason for the lower utilization in 1986 is that the Thomas Creek pasture had been divided and the number of cattle reduced from 224 to 124 head. Another reason may be that the abundance of forage throughout the

general area may have dispersed the cattle and wildlife. There were no time x site interactions for the percent utilization data.

Discussion

Patch clearcutting has been recommended as a way to increase water yields and tree regeneration within southwestern mixed conifer forests (Brown 1976, Gottfried 1989). This prescription also has been recommended as a method to increase herbage production for livestock and wildlife. Most mixed conifer stands, unless heavily logged, are fairly dense and do not support a well developed herbaceous cover. Although herbaceous production was not measured prior to treatment, it was estimated (using the regression equations of Thill et al. 1983) that a stand with a basal area of 200 square feet per acre will produce about 48 pounds per acre of graminoids and forbs. This is lower than the 100 pounds per acre measured in a neighboring undisturbed watershed by Patton (1976), but that survey included 24 acres of streamside meadows where production normally is higher.

Average herbage production in the nine intensively monitored patch clearcuts ranged from 355 pounds per acre in 1986 to 208 pounds per acre in 1983 (fig. 1). The clearcuts produced significantly more herbage than did adjacent, partially harvested stands. Most clearcuts showed a decline between 1982 and 1983, but three demonstrated increases. The decline is probably related to the relatively low precipitation in May, June, and August (table 1), and to cooler temperatures in May and June (table 2). An evaluation of species composition might have helped explain these differences. The increases in production in the clearcuts are related to the modified microclimate, especially the radiation balance, resulting from the removal of the dense coniferous overstory, and to the increased soil moisture because of augmented snowpack accumulations (Plasencia et al. 1984) and reduced evapotranspiration (Gottfried 1989).

The average production for the three sampling dates was 270 pounds per acre in the clearcuts, an increase of 222 pounds per acre over the estimated preharvest value. It is difficult to compare the Thomas Creek results with those from other patch clearcutting evaluations for several reasons (differences in general and yearly weather conditions, site factors, herbaceous species compositions, slash accumulations, competition with conifer regeneration and deciduous trees and shrubs, as well as in clearcut shapes and sizes). However, the Thomas Creek values are within the range reported for openings in Arizona and Colorado. Crouch (1985) indicated average increases of 97 pounds per acre, over preharvest conditions, on twelve 3-acre circular clearcuts in a Colorado subalpine forest. Two pounds per acre were measured prior to harvest. However, a single moist-site clearcut produced 1,595 pounds per acre of graminoids and forbs, an increase of 1,103 pounds. Patton (1974) reported that maximum forage production in the open areas within an eastern Arizona ponderosa pine stand was between 500 and 600 pounds per acre.

Herbage production in the forested areas harvested by the individual-tree selection method surrounding the nine clearings averaged 68 pounds per acre for the three measurement periods, an estimated 20-pound increase over undisturbed conditions. The increase would probably have been larger if forest stand basal area reductions had been greater; however, even relatively small reductions can impact production. Thill et al. (1983) found that, 4 years after harvesting, Willow Creek produced significantly greater amounts of deer and elk forage for basal areas of 50 through 175 square feet per acre than did unlogged sites. Changes in the amount of light passing through the canopy after logging may be one reason for the increases. Patton (1976) measured an average increase of 51 pounds per acre on Willow Creek. Heavy overstory removals, which stimulate forage production, may have the same effect on deer as clearcuts, provided security and thermal cover requirements are satisfied (Severson and Medina 1983). However, the increases from partial harvesting may decline in time as the residual trees grow and reoccupy the site (Severson and Medina 1983, Thill et al. 1983).

Herbage utilization appeared greater in the openings than in the adjacent forest (fig. 1). Some of the small clearcuts received greater use throughout the study period than others did. Different animal species may have been feeding in different sites. It has been found, for example, that elk use open and forested areas equally, while deer prefer to remain in the forest (Reynolds 1966). Both tend to concentrate along the borders of forest stands. Cattle prefer natural openings to clearcuts, possibly because the residual slash accumulations in clearcuts restrict their movement. Deer and elk prefer openings in ponderosa pine forests where slash has been piled and burned compared to just piled (Ffolliott et al. 1977). There was relatively little slash on the small clearcuts in the South Fork of Thomas Creek, however.

Although the creation of small clearcuts in Arizona's mixed conifer forests should benefit cattle and big game, some wildlife species, such as red squirrels (*Tamiasciurus hudsonicus*), which depend largely upon undisturbed forest conditions, may have been impacted adversely.

Conclusions

Small patch clearcuts within a mixed conifer watershed produced more herbage than adjacent, moderately harvested stands. Production has remained higher over an 8-year period since logging, which is particularly important considering the low levels of production within these normally dense stands. There also appears to be increased herbage utilization in these clearings. The results indicate that small patch clearcuts are beneficial for livestock and big game. This benefit, plus the increases in water yields and satisfactory regeneration (Gottfried 1989), should make patch clearcutting a viable management alternative for the southwestern mixed conifer forests.

Literature Cited

Brown, Thomas C. 1976. Alternatives analysis for multiple use management: a case study. Res. Pap. RM-176. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 16 p.

Crouch, Glenn L. 1985. Effects of clearcutting a subalpine forest in central Colorado on wildlife habitat. Res. Pap. RM-258. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 12 p.

Ffolliott, Peter F.; Thill, Ronald E.; Clary, Warren P.; Larson, Frederick R. 1977. Animal use of ponderosa pine forest openings. Journal of Wildlife Management. 41: 782-784.

Gottfried, Gerald J. 1989. Effects of patch clearcutting on water yield improvement and on timber production in an Arizona mixed conifer watershed. Tucson, AZ: School of Renewable Natural Resources, University of Arizona. Ph.D. dissertation. 184 p.

Jones, John R. 1974. Silviculture of southwestern mixed conifers and aspen. Res. Pap. RM-122. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 44 p.

Neff, Don J.; McCulloch, Clay Y.; Brown, David E.; Lowe, Charles H.; Barstad, Janet F. 1979. Forest, range, and watershed management for enhancement of wildlife habitat in Arizona. Arizona Water Commission Special Report No. 7. Arizona Game and Fish Department. 109 p.

Patton, David R. 1974. Patch cutting increases deer and elk use of a pine forest in Arizona. Journal of Forestry. 72: 764-766.

Patton, David R. 1976. Timber harvesting increases deer and elk use of a mixed conifer forest. Res. Note RM-329. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 3 p.

Pechanec, Joseph F.; Pickford, G. D. 1937. A weight estimate method for determination of range or pasture production. American Society of Agronomy Journal. 29: 894-904.

Plasencia, Douglas J.; Ffolliott, Peter F.; Gottfried, Gerald J. 1984. Effects of mixed conifer openings on snow. In: Hydrology and water resources of Arizona and the Southwest, vol. 14: proceedings of the symposium; 1984 April 7; Tucson, AZ. Arizona Section, American Water Resources Association and the Hydrology Section, Arizona-Nevada Academy of Science: 57-61.

Reynolds, Hudson G. 1966. Use of openings in spruce-fir forests of Arizona by elk, deer and cattle. Res. Note RM-66. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 4 p.

Severson, Kieth E.; Medina, Alvin L. 1983. Deer and elk habitat management in the Southwest. Journal of Range Management Monograph No. 2. 64 p.

Thill, Ronald E.; Ffolliott, Peter F.; Patton, David R. 1983. Deer and elk forage production in Arizona mixed conifer forests. Res. Pap. RM-248. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 13 p.

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