1968

U.S. FOREST SERVICE
RESEARCH NOTE RM - 101

FOREST SERVICE
U.S. DEPARTMENT OF AGRICULTURE

ROCKY MOUNTAIN FOREST AND RANGE EXPERIMENT STATION

Natural Reproduction of Spruce-Fir After Clearcutting in Strips, Fraser Experimental Forest

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Numbers and stocking of seedlings and saplings on 1-, 2-, 3-, and 6-chain-wide clearcut strips were determined after logging in 1956, and in 1966. Reproduction in 1966 will provide a satisfactory replacement stand on all strip widths tested, but it is largely advanced growth that survived logging. Both advanced and subsequent reproduction is predominantly subalpine fir, but there is enough Engelmann spruce to provide an adequate representation of this more valuable species in the replacement stand on all strip widths.

In the central Rocky Mountains, some pattern of clearcutting has generally been the initial step in converting old-growth stands of Engelmann spruce (Picea engelmannii Parry)-subalpine fir (Abies lasiocarpa (Hook.) Nutt.) into manageable stands of young growing stock. Low stumpage values coupled with the difficulty of establishing artificial regeneration have made restocking clearcut areas with natural regeneration a fundamental objective in spruce-fir management.

Past research on the Fraser Experimental Forest has shown that spruce reproduces slowly but ultimately well after clearcutting small openings.[2] Elsewhere in Colorado, the establishment of natural reproduction of spruce after clearcutting has been variable, with stocking generally better on small than large openings.[3] Although advanced growth was predominately subalpine fir, it contributed substantially to total stocking on both large and small clearcut openings. Furthermore, those trees helped maintain an environment favorable to the establishment of new reproduction.[4]

The Study

This paper reports the 10-year results of a study to test the effect of clearcutting on (1) the establishment of new reproduction, and (2) the development of residual advanced growth left after logging in 1956 in the spruce-fir type on the Fool Creek drainage of the Fraser Experimental Forest.

Description of Area

The study area was located on north- and northwest-facing slopes at 10,500 to 11,000 feet

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[2] *Alexander, Robert R. Harvest cutting old-growth mountain spruce-fir in Colorado. J. Forest. 61: 115-119, illus. 1963.*

[3] *Alexander, Robert R. Stocking of reproduction on spruce-fir clearcuttings in Colorado. U. S. Forest Serv. Res. Note RM-72, 8 pp., illus. 1966. Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colo.*

[4] *Ronco, Frank. Lessons from artificial regeneration studies in a cutover beetle-killed spruce stand in western Colorado. U. S. Forest Serv. Res. Note RM-90, 8 pp., illus. 1967. Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colo.*

elevation. Slope gradients ranged from 10 percent on the north slope to 30 percent on the northwest slope. Soils are gravelly, sandy loams of the Darling series, developed in place from gneisses and schists, interspersed with bogs and wet places.[5]

The original forest overstory was a mature to overmature stand of 250- to 350-year-old Engelmann spruce and subalpine fir, intermixed with various amounts of old-growth lodgepole pine (Pinus contorta Dougl.). The understory was composed of spruce and fir seedlings, saplings, and poles.

Ground vegetation on the Darling soils—predominately grouse whortleberry (Vaccinium scoparium Leiberg)—did not increase after cutting. Ground vegetation in the bogs and wet places—principally grasses, sedges (Carex spp.), mountain bluebell (Mertensia ciliata G. Don), arrowleaf groundsel (Senecio triangularis Hook.), bittercress (Cardamine cardifolia A. Grey), brook saxifrage (Saxifraga arugta D. Don), cranesbill (Geranium richardsonii Frisch and Trautv.), Rocky Mountain parmissia (Parmissia fimbrata Koenig), fleabane (Erigeron speciosus (Lindl.) DC), and alpine pyrola (Pyrola asorifolia Michx.),—increased considerably after cutting.

Cutting Pattern

Timber was removed in alternate clearcut strips located at right angles to the contour. Four different widths of clearing were used: 1, 2, 3, and 6 chains. The four strip widths were repeated on each aspect. Average length of the clearings was about 600 feet, the slope distance between logging spur roads (fig. 1). All trees 4.0 inches in diameter and larger were removed from the cleared strips by horse skidding. No special precautions were taken to avoid damaging advanced growth. Cutting began in 1954 and was completed in 1956.

Measurements

Reproduction was surveyed after logging was completed in 1956, and in 1966. Measurements were made to the same standards each time. A stratified random sample of 360 milacres—10 milacres on each of 36 transect lines, 10 links wide and 100 links long—was taken in each width of clearing on each aspect. Distribution of the transects on each aspect were: six transect lines in each of six 1-chain-wide strips, 12 transect lines in each of three 2-chain-wide strips, 18 transect lines in each of two 3-chain-wide strips, and all 36 transect lines in one 6-chain-wide strip.

Numbers and stocking of seedlings and saplings from 2 years old to 4.0 inches in diameter were recorded by species for each milacre sampled. Only reproduction of good form and vigor was included. An attempt was made to record reproduction as either advanced or subsequent in the 1966 survey but that was not possible. Subsequent reproduction in this paper is therefore expressed as the increase in numbers and stocking of seedlings between 1956 and 1966.

Analysis of Data

Relationships between density and stocking of seedlings and saplings by species in 1966, and strip width and aspect were tested by covariance analyses. The 1956 data were used as a covariate in the analyses to represent initial conditions. There were no significant differences in either adjusted density or stocking of spruce and fir reproduction due to aspect, but differences between strip widths were significant for both variables of spruce reproduction. The width x aspect interaction was also significant for both species and both variables—primarily because the 1-chain-wide strips did not behave in the same manner on each aspect. However, since the differences between 1-chain-wide strips on the two slopes were associated with factors other than size of opening and aspect, the data from the two slopes were combined to show the average increase in reproduction on the different strip widths between 1956 and 1966.

Results

Numbers of Seedlings and Saplings

On Fool Creek, where stands contained abundant advanced reproduction, enough trees survived logging to restock all strip widths

[5] *Retzer, J. L. Soil survey of Fraser alpine area, Colorado. U. S. Forest Serv. and Soil Conserv. Serv., in cooperation with Colo. Agr. Exp. Sta., Series 1956, No. 20, 47 pp., illus. 1962.*

tested; numbers ranged from 4,183 per acre on the 2-chain-wide strips to 5,957 per acre on the 6-chain-wide strips (table 1). Composition of surviving advanced growth was predominately subalpine fir. Firs outnumbered the more valuable spruces by about four to one on the 2- and 6-chain-wide strips, two and one-half to one on the 1-chain-wide strips, and three to two on the 3-chain-wide strips. There were no lodgepole pines in the advanced reproduction.

Advanced reproduction, although desirable stocking in spruce-fir forests, may not be abundant in all old-growth stands. Furthermore, results from similar studies on the Fraser Experimental Forest indicated that only about one-half of the advanced growth survives logging.[7 6] Where advanced reproduction is scarce, the effectiveness of any cutting pattern for regenerating a stand must be measured in terms of new reproduction established after cutting.

Subsequent reproduction was not abundant on any of the strips 10 years after cutting. The best recovery was made on the 3-chain-wide strips where 1,365 new seedlings per acre were established. New seedlings on the 3-chain-wide strips outnumbered the increase on the 1- and 6-chain-wide strips by more than two times, and were four times greater than the increase on the 2-chain-wide strips (table 1).

Species composition was not improved by new reproduction. More new firs than new spruces were established on all strips except the 2-chain-wide, where new lodgepole pines outnumbered both spruces and firs. Lodgepole pines also established in greater numbers than spruces on the 6-chain-wide strips. Establishment of subsequent lodgepole pines was related to the amount of pine in the original overstory, however, and not to strip width.

The failure of species composition to improve after cutting is in disagreement with past work on the Fraser Experimental Forest and elsewhere in Colorado.[2 7] In those studies, new spruces greatly outnumbered the increase in new first on both narrow and wide clearcut strips.

[6] *Alexander, Robert R. Damage to advanced reproduction in clearcutting spruce-fir. U. S. Forest Serv., Rocky Mountain Forest and Range Exp. Sta., Res. Note 27, 3 pp., 1957. Fort Collins, Colo.*

[7] *Alexander, Robert R. Unpublished data on file, Rocky Mountain Forest and Range Exp. Sta., Fort Collins, Colo.*

Figure 1.--Aerial view of Fool Creek, showing pattern of cleared strips and road network.

Stocking

All strips were well stocked after logging; stocking ranged from 76 percent on the milacres sampled on the 1-chain-wide strips to 83 percent on the 6-chain-wide strips. Although advanced reproduction that survived logging was predominately subalpine fir, Engelmann spruce was adequately distributed on all strips; 54 percent of the milacres sampled were stocked to spruce on the 3-chain-wide strips, 48 percent on the 1- and 6-chain-wide strips, and 37 percent on the 2-chain-wide strips (table 1).

Total stocking increased at about the same rate as new reproduction established after logging, but the increase in stocking was propor-

Table 1.--Numbers and stocking of seedlings and saplings, Fool Creek, Fraser Experimental Forest, Colorado -- 1956, 1966

Width of openings and species	Trees			Stocking		
	1956	1966	Increase	1956	1966	Increase
	- - Number per acre - -			- - Percent per acre - -		
1-chain-wide openings:						
Engelmann spruce	1,360	1,453	93	47	52	5
Subalpine fir	3,036	3,557	521	68	70	2
Lodgepole pine	0	26	26	0	1	1
All	4,396	5,036	640	76	78	2
2-chain-wide openings:						
Engelmann spruce	894	988	94	37	46	9
Subalpine fir	3,289	3,378	89	75	77	4
Lodgepole pine	0	162	162	0	10	10
All	4,183	4,521	345	78	86	8
3-chain-wide openings:						
Engelmann spruce	2,017	2,386	369	54	68	14
Subalpine fir	3,186	4,176	990	70	80	10
Lodgepole pine	0	6	6	0	1	1
All	5,204	6,568	1,365	78	86	8
6-chain-wide openings:						
Engelmann spruce	1,182	1,208	26	48	52	4
Subalpine fir	4,775	5,306	531	79	82	3
Lodgepole pine	0	132	132	0	6	6
All	5,957	6,646	689	83	88	5

tionally greater for spruces and pines than for firs. By 1966, from 78 to 88 percent of the milacres sampled were stocked, and spruce was present on 46 to 64 percent of the milacres (table 1).

Conclusions

Reproduction on Fool Creek in 1966 will provide a satisfactory replacement stand on all strip widths tested, but it is largely advanced growth that survived logging. Both advanced and subsequent reproduction is predominately subalpine fir, but there is enough spruce on all strip widths to provide a good representation of the more valuable species in the replacement stands. Although the increase in both numbers and stocking of new seedlings differed between strip widths, there was no apparent relationship between size of opening and new reproduction established after logging.

The scarcity of subsequent reproduction can be attributed in part to seed supply, and competition from ground vegetation. Seedfall studies on Fool Creek show that seed crops of both spruce and fir during the period 1956-65 were fair to moderate in 3 years, poor in 3 years, and nearly complete failures in the other 4 years.[7] On those strips located wholly or in part in wet places, grasses and other ground vegetation increased so rapidly after cutting that they created an effective barrier to the establishment of new reproduction, especially of spruces, which have more exacting seedbed requirements than first. On some individual strips, the density of herbaceous vegetation was so great that competition reduced the numbers of seedlings and saplings surviving in 1966 to less than the number alive in 1956.