The Cutting Methods Demonstration Study at Fraser Experimental Forest

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Abstract—*Efficiency of harvest, overstory regrowth, and regeneration establishment are compared among 12 even- and uneven-aged regeneration cuttings installed in 1984 in subalpine Engelmann spruce and lodgepole pine forests on the Fraser Experimental Forest in central Colorado. Individual tree selection and overstory removal prescriptions were much less efficient to log than two- or three-step shelterwood cuts, clearcuts, or group selection cuts. Considerable overstory growth has occurred in all treatments, but most noticeably in the spruce-fir shelterwood and lodgepole pine uneven-aged treatments. Abundant regeneration was present in all treatments, but subalpine fir dominated in partial harvest treatments, illustrating the need for precommercial thinning in subalpine forests.*

Background

The complexities of finding ways to manage subalpine forests to satisfy the variety of challenging resource issues in special places requires a full suite of silviculture tools and techniques. A study was established on the Fraser Experimental Forest in 1983 to provide on-the-ground examples of all even- and uneven-aged cutting methods applicable to spruce-fir (Engelmann spruce [*Picea engelmanii*] and subalpine fir [*Abies lasiocarpa*]) and lodgepole pine (*Pinus contorta*) forests in the central Rocky Mountains. It also served as a case study to compare the relative efficiency of harvesting these silviculture prescriptions under controlled conditions and continues to provide valuable information on subsequent tree survival, growth, and regeneration.

Twelve plots were established in mature spruce-fir and lodgepole pine stands (six plots in each forest type) on the Fraser Experimental Forest in Central Colorado. All plots were located on slopes less than 15 percent that adjoined existing roads, and all but one were one acre in size (because of existing stand structure, the lodgepole pine group selection plot was 4 acres in size). Silvicultural prescriptions based on recommended practice (Alexander 1987, Shepperd and Alexander 1983) were developed for each plot based on existing stand conditions and included both even-aged and uneven-aged management goals. Pre-harvest stand structure varied from plot to plot and was strongly influenced by settlement-era logging that occurred in the early 20th century. Overstory trees left after the initial harvests were generally from 12 to 20+ inches DBH and from 120-300+ years of age prior to this study. Some plots were relatively undisturbed by the earlier harvests and others contained understories of smaller trees that had been initiated by the earlier harvests.

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Treatments

Even-aged treatments were clearcutting (CC), the first entry of a two- and three-step shelterwood (SW2 and SW3), and overstory removal (OR). The latter treatment consisted of the removal of a mature overstory growing over a fully stocked sapling and pole-sized understory. Uneven-aged harvests were individual tree and group selection. Each treatment was duplicated in spruce-fir and lodgepole pine forest types. The BDQ method (Alexander and Edminster 1977) was used to regulate stocking in the uneven-aged prescriptions. A Q factor (the ratio of stem/acre in one DBH class to that of the next smaller class) of 1.3 (using 1-inch DBH classes) was used in spruce-fir with DBH classes ranging from 4 to 24 inches, the maximum retained diameter. Residual basal area targets after cutting were 80 ft^2/acre in the uneven-aged treatments. The same Q factor BDQ prescription was chosen for the uneven-aged lodgepole pine treatments, except the upper DBH limit was 18 inches. These uneven-aged configurations were selected because they (1) closely matched the distribution of growing stock on the sites, (2) removed sufficient growing stock to expect new regeneration, and (3) allowed the residual forest to remain at low risk to windthrow.

All areas were logged during one season by the same contract logger using chainsaw felling and bucking and a rubber tired cable skidder to remove and deck logs. The logger was free to log the plots as he saw fit but had to remove all marked stems, use designated skid trails, and not damage residual stems. Researchers observed all logging and kept detailed notes on the amount of time spent in felling, skidding, decking, and cleanup of each harvest unit. Every log was scaled and the number of pieces removed in each skidder turn was recorded.

Logging efficiencies for each one-acre harvest treatment unit were estimated by calculating the cubic feet of wood removed divided by the total hours of effort required by all members of the logging crew to complete the unit, resulting in a person-hour/ft^3 production rate. Data for the four-acre lodgepole pine group selection unit were adjusted to a per-acre basis.

Results

Post-Harvest

Specific pre- and post-treatment stocking data are listed in table 1. The seed cuts removed 60 percent and 65 percent of the pretreatment growing stock from the spruce-fir and lodgepole two-step shelterwood plots, respectively. The preparatory three-step shelterwood cuts removed 40 percent and 30 percent of the stocking from the spruce-fir and lodgepole pine plots, respectively. All of the growing stock above 3.5 inches DBH was removed from the overstory removal and clearcut treatments. The individual tree and group selection treatments removed 28 to 55 percent of the pretreatment growing stock distributed as closely as possible to the target diameter class stocking curves. All visible pre-existing seedlings and saplings were removed from shelterwood and clearcut treatments to facilitate observation of the regeneration response to these treatments. Some windthrow occurred in both the spruce and lodgepole shelterwood treatments, as might be expected (Alexander 1987, Shepperd and Alexander 1983).

Table 1—Conditions existing pre- and post-treatment and in 2003 by forest type and harvest treatment: overstory basal area per acre (BA); trees per acre (TPA); and quadratic average stand diameter (DQ). Treatment codes: SW3 = three-step shelterwood. SW2 = two-step shelterwood. ITS = individual tree selection. CC = clearcut. OR = overstory removal. GS = group selection.

Engelmann Spruce – Subalpine Fir

Treat-ment	Pre BA	Pre TPA	Pre DQ	BA cut	% BA cut	TPA cut	Post BA	Post TPA	Post DQ	2003 BA	2003 TPA	2003 DQ	BA change
SW3	205	229	12.8	82	40	85	102	78	15.4	77.1	46	17.5	► -24.1
SW2	220	160	15.8	132	60	185	88	65	11.8	97.6	57	17.7	► 9.6
ITS	176	285	10.6	97	55	229	* 79	199	8.5	136.2	347	8.5	57.2
CC	136	200	11.2	136	100	241	0	0	0	0	0	0	0
OR	160	341	9.3	160	100	426	+ 0	0	0	40.4	268	5.3	40.4
GS	165	223	11.6	69	31	53	95.7	155	10.6	124.6	199	7.7	28.9

Lodgepole Pine

Treat-ment	Pre BA	Pre TPA	Pre DQ	BA cut	% BA cut	TPA cut	Post BA	Post TPA	Post DQ	2003 BA	2003 TPA	2003 DQ	BA change
SW3	156	232	11.1	47	30	151	110.6	147	11.7	94.6	112	12.4	► -16.0
SW2	220	285	11.9	143	65	95	75.3	100	11.8	68.8	74	13.0	► -1.3
ITS	145	481	7.4	65	45	86	79.0	252	7.6	136.2	432	7.2	57.2
CC	180	241	11.7	180	100	200	0	0	0	0	0	0	0
OR	98	426	7.1	97	100	341	0	0	0	4.4	32	5.0	4.4
GS	100	334	7.4	28	28	68	67.5	281	6.7	108.4	364	7.3	40.9

* Marked to 80 BA, 5 stems lost due to logging.
+ Understory not included.
► Reduced due to windthrow losses.

Efficiency of Harvest

Logging activities are presented on a person-hour and cubic volume basis in table 2. Harvest efficiency expressed in terms of person-hours/ft^3 is compared by prescription and species in figure 1. Production rates did not vary substantially, except that individual tree selection and overstory removal prescriptions were much less efficient to log, due to the necessity of avoiding existing seedlings and saplings in these treatments. Pieces of all sizes were removed from all plots (table 2), reflecting the irregular structure of the pre-existing forest. However, the larger piece sizes in group selection treatments was a consequence of harvesting predominately mature groups of trees in those stands.

Conditions in 2003

Nineteen years after the 1984 harvests, all of the 12 treatment plots are fully stocked and remain in healthy condition. Considerable overstory basal area growth has occurred in group and individual-tree selection treatments, but windthrow losses have affected growth in shelterwood treatments (table 1). However, Scribner volumes (board feet/acre) increased most noticeably in the spruce-fir shelterwood (figure 2) and in lodgepole pine uneven-aged treatments (figure 3). Scribner volumes in the latter treatments have nearly grown back to pre-harvest levels (figure 3). Current diameter distributions of all uneven-aged treatments (figures 4, 5) show stocking surpluses are greatest in the smaller diameter classes. Sufficient surpluses exist in larger diameter classes in both spruce-fir and lodgepole individual tree selection treatments (figure 5) to currently support another commercial entry cycle (figure 3).

All treatment plots are currently stocked with regeneration well in excess of regional guidelines (USDA Forest Service, Rocky Mountain Region

Table 2—Comparison of harvest activities by silviculture treatment.

Treatment	Felling and bucking Hours	Felling and bucking ft^3/hour	Skidding Hours	Skidding No. turns	Skidding Logs/turn	Skidding ft^3/piece	Skidding ft^3/hour	Cleanup hours	Other *	Total hours	ft^3/hour	Total ft^3
Engelmann Spruce												
SW3	51.2	178.9	34.0	86.1	4.3	25.0	269.8	24.5	0.0	109.7	83.5	9161.0
SW2	37.1	148.2	21.6	56.1	4.4	22.2	254.5	12.8	0.5	72.0	76.4	5498.0
ITS	45.4	91.5	84.7	52.1	4.0	19.9	49.1	27.0	0.0	157.1	26.4	4154.0
CC	22.3	311.4	14.6	56.1	4.4	28.4	474.9	37.5	0.0	74.4	93.3	6939.0
OR	79.7	57.3	59.1	91.1	3.9	12.7	77.3	9.5	0.0	148.3	30.8	4570.0
GS	21.2	290.3	20.2	44.0	3.8	37.0	304.4	22.8	0.8	64.9	94.6	6142.0
							Engelmann spruce averages				58.2	36464.0
Lodgepole Pine												
SW2	25.5	198.3	32.7	74.0	5.0	13.7	154.5	4.0	0.6	62.8	80.5	5056.0
SW3	19.8	235.1	24.0	56.0	4.8	17.2	194.2	5.0	0.9	49.7	93.7	4657.0
ITS	25.3	96.6	13.8	31.0	4.6	17.4	177.0	17.0	0.0	56.2	43.6	2448.0
CC	36.0	217.1	28.7	73.1	4.8	22.3	272.3	6.8	0.0	70.7	110.6	7817.0
OR	32.2	68.3	58.5	32.0	5.1	13.5	37.6	6.0	0.0	96.7	22.7	2197.0
GS	24.8	238.3	28.6	49.1	4.9	24.4	206.0	12.0	1.1	66.5	88.7	5897.0
							Lodgepole pine averages				69.7	28072.0

* Includes repair, skid trail construction, etc.

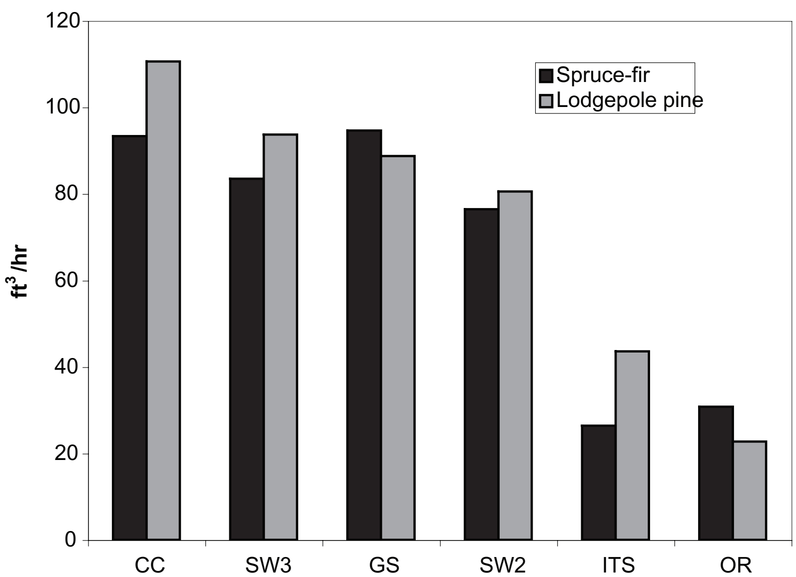


Figure 1—Harvest production rates in cubic feet per person-hour by forest type for clearcut (CC), three-step shelterwood (SW3), group selection (GS), two-step shelterwood (SW2), individual tree selection (ITS), and overstory removal (OR) cutting methods.

Reforestation Handbook) for spruce-fir and lodgepole pine forests (table 3). The abundance of small seedlings indicates that new trees are still being recruited into these areas. The predominance of subalpine fir in all spruce-fir treatments is also noteworthy. Fir will obviously dominate the future stocking in all of the spruce-fir treatment plots, but especially so in the individual tree selection and three-step shelterwood treatments.

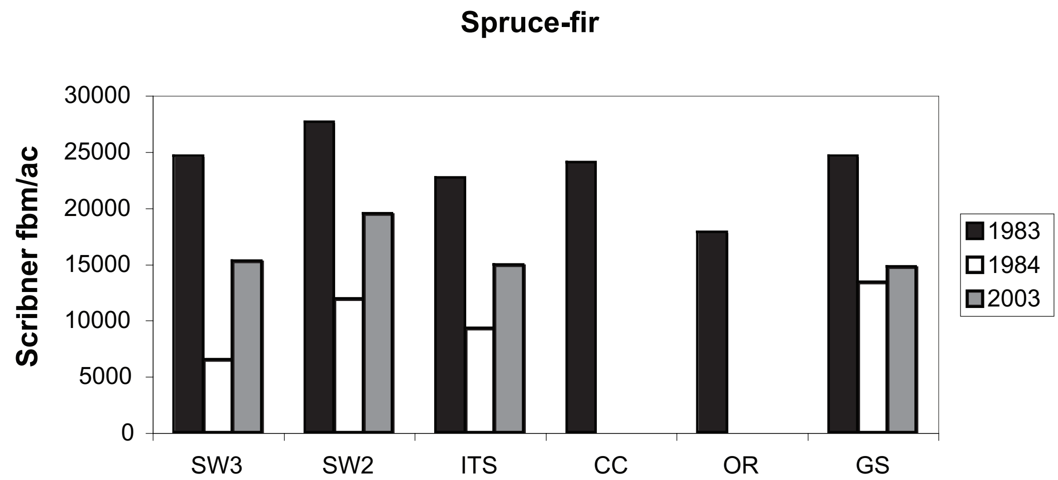


Figure 2—Pre-harvest, post-harvest, and 2003 board foot Scribner volumes in spruce-fir units by silviculture treatment.

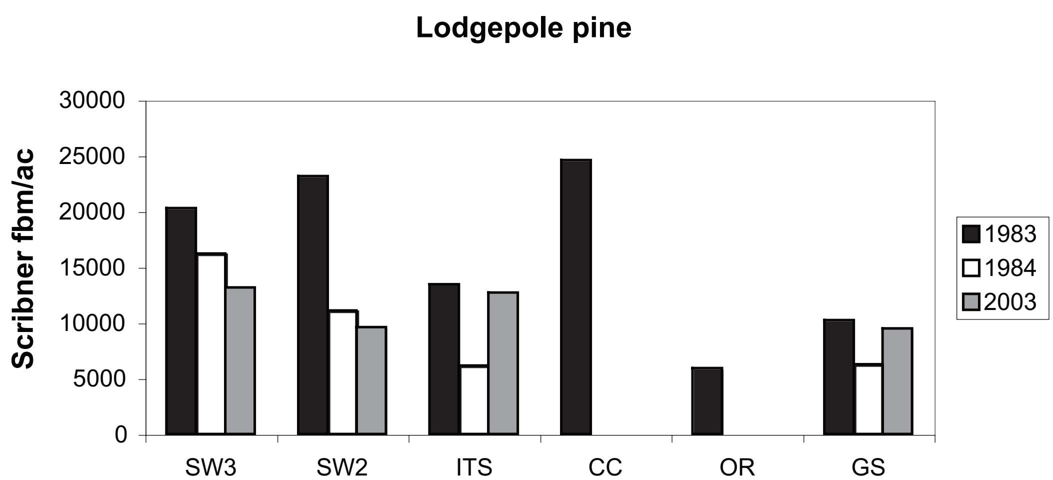


Figure 3—Pre-harvest, post-harvest, and 2003 board foot Scribner volumes in lodgepole pine units by silviculture treatment.

Discussion

These demonstration areas on the Fraser Experimental Forest provide an opportunity to view and compare a variety of management options in one readily accessible location. All of these treatments have been successful in that they resulted in the establishment of new regeneration, successfully prepared the forest for subsequent entries without excessive windthrow, or have demonstrated the applicability of both even-aged and especially uneven-aged regeneration methods in both spruce-fir and lodgepole pine forest types.

The production data collected during the 1984 harvests clearly show that conventional handfelling and tractor skidding was possible in all treatments. Although the overstory removals in the overstory removal treatments were least efficient, performing these operations while regeneration was still in the seedling stage would lessen damage from equipment and tree falling and substantially increase harvest efficiency. Using new mechanical harvesting equipment available since this study was harvested would probably increase

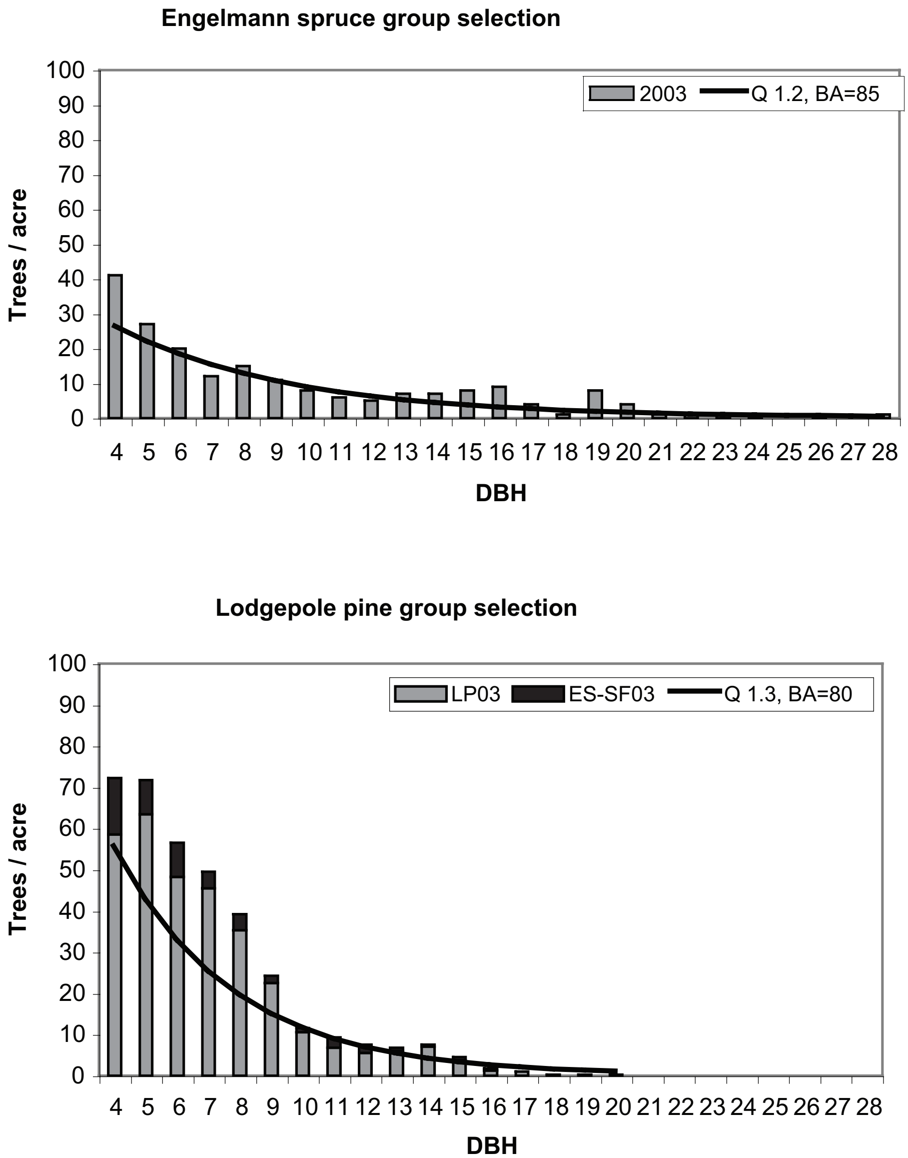
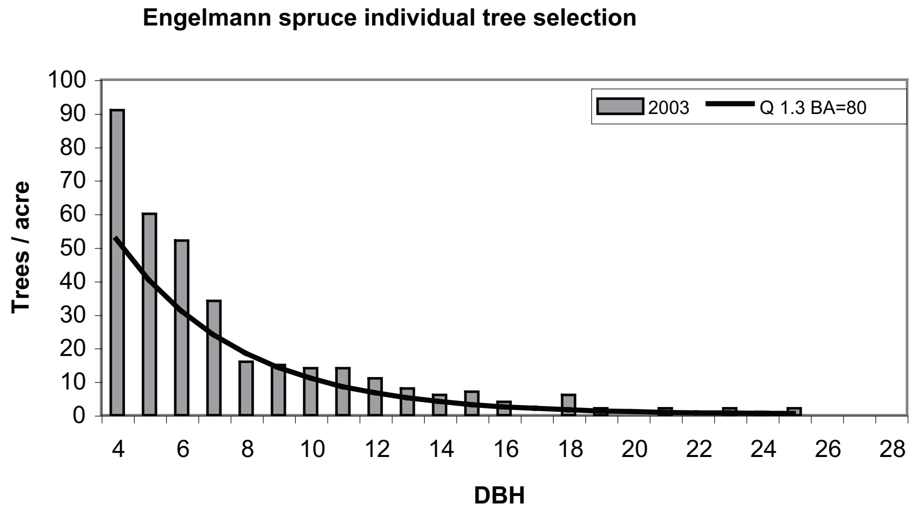


Figure 4—Comparison of 2003 stocking by diameter class with target stocking guidelines for spruce-fir and lodgepole pine group selection treatments. The LP03 and ES-SF03 labels indicate 2003 stocking of lodgepole pine, spruce, and fir in the lodgepole group selection treatment.

the harvest efficiency in all treatments, but the ranking of treatments would likely not change, since it was closely related to the number of pieces that needed to be moved.

Both the appearance and the current stocking of these plots indicate that additional silviculture activities are needed in all of these treatments. Sufficient growth and regeneration have occurred in the two-step shelterwood plots that overstory removals could now be done. Adequate wind firmness and advanced regeneration exist in the three-step shelterwood treatments so that seed cuts could now be completed. Stocking has increased in the uneven-aged treatments to the point that growing stock should once again be reduced to desired levels by another cutting cycle harvest.

A more critical concern with regard to the future composition of these forests would be the need to precommercially thin excessive subalpine fir stocking from both the spruce-fir and lodgepole pine plots. Subalpine fir comprises the majority of seedling and sapling stocking in the spruce-fir individual tree selection, group selection, overstory removal, and three-step shelterwood treatments. Subalpine fir also accounts for over 30 percent of the regeneration in the lodgepole pine individual tree selection and over-



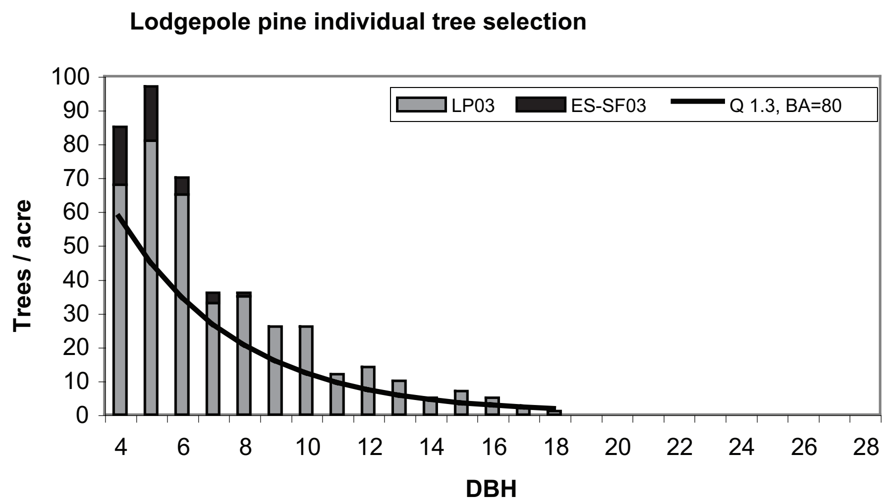


Figure 5—Comparison of 2003 stocking by diameter class with target stocking guidelines for spruce-fir and lodgepole pine individual tree selection treatments. The LP03 and ES-SF03 labels indicate 2003 stocking of lodgepole pine, spruce, and fir in the lodgepole individual-tree selection treatment.

story removal treatments. Subalpine fir is much more shade tolerant than either spruce or lodgepole pine and can persist very well under these other species. As the fir trees grow larger, the dense shade cast by their full crowns will strongly inhibit the ability of lodgepole pine and spruce to successfully establish. The result will be a type-shift to fir dominated forests rather than the spruce and lodgepole forests that we intended to regenerate.

In many ways these demonstration plots represent conditions and trends that are present in many special places throughout the central and southern Rocky Mountains. This study clearly illustrates that forest conditions are not static but dynamically change over time in response to disturbance. If that disturbance is a program of silviculture treatments intended to improve the condition of the forest, we are obligated to continue management to either ultimately replace the forest or maintain it in a desired condition. The natural advantage that shade-tolerant subalpine fir has in establishing under overstory canopies ensures that management goals for any partial cutting silviculture treatment in subalpine forest types cannot be accomplished unless precommercial thinning is an integral part of the silvicultural system.

Table 3—Number of seedlings and saplings (<3.5 inches DBH) per acre in 2003 by harvest treatment, species, and size class.

Engelmann Spruce

	Tree species				**Size class**				
Treatment	Engelmann spruce	Lodgepole pine	Subalpine fir	Total	Less than 1.5 ft.	1.5 to 4.5 ft ht.	4.5 ft. to 1 in. DBH	1 to 3.5 in. DBH	Percent stocking
OR	780	180	2010	2970	750	990	750	480	100
CC	720	240	480	1440	540	240	360	300	80
SW2	1230	150	720	2100	990	540	450	120	100
SW3	330	0	930	1260	480	360	300	120	80
ITS	2053	0	3130	5183	1440	2340	900	503	100
GS[1]	429	0	2210	2639	510	900	720	509	90
Average	924	95	1580	2599	785	895	580	339	92

Lodgepole Pine

	Tree species				**Size class**				
Treatment	Engelmann spruce	Lodgepole pine	Subalpine fir	Total	Less than 1.5 ft.	1.5 to 4.5 ft ht.	4.5 ft. to 1 in. DBH	1 to 3.5 in. DBH	Percent stocking
OR	80	550	550	1180	250	150	280	500	100
CC	30	2520	120	2670	180	420	780	1290	80
SW2	150	3300	630	4080	2370	900	570	240	100
SW3	150	3660	840	4650	3090	1050	390	120	90
ITS	307	1538	1061	2906	1650	570	240	446	100
GS[1]	334	2733	429	3496	1350	870	510	766	95
Average	175	2384	605	3164	1482	660	462	560	94

[1] Group selection (GS) treatments include regeneration in group openings and intervening forest.

Literature Cited

Alexander, Robert R. 1987. Ecology, silviculture, and management of the Engelmann spruce-subalpine fir type in the central and southern Rocky Mountains. Agric. Handb. 659. Washington, D.C.: U.S. Department of Agriculture, Forest Service. 144 p.

Alexander, Robert R.; Edminster, Carleton B. 1977. Regulation and control of cut under uneven-aged management. Res. Pap. RM-182. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station.
7 p.

Shepperd, Wayne D.; Alexander, Robert R. 1983. Silviculture of lodgepole pine in the central Rocky Mountains. Publication RMTT-3. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 36 p.