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Grazing on Regeneration Sites Encourages Pine Seedling Growth

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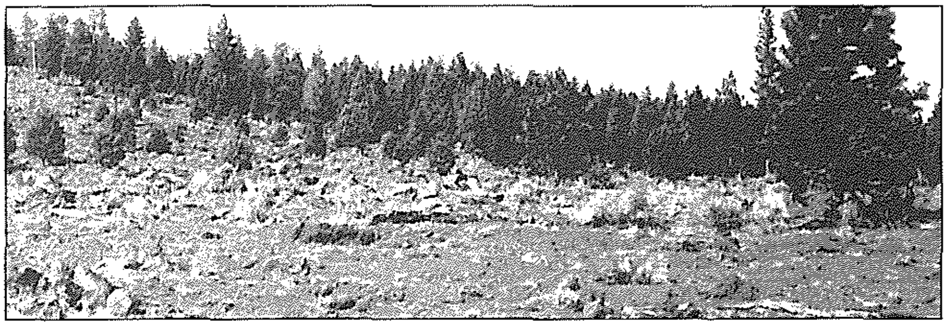

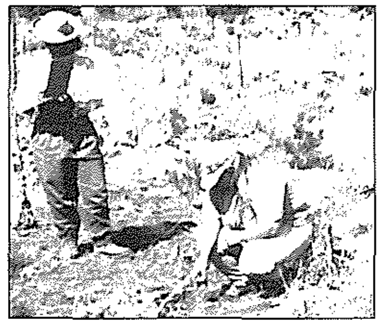

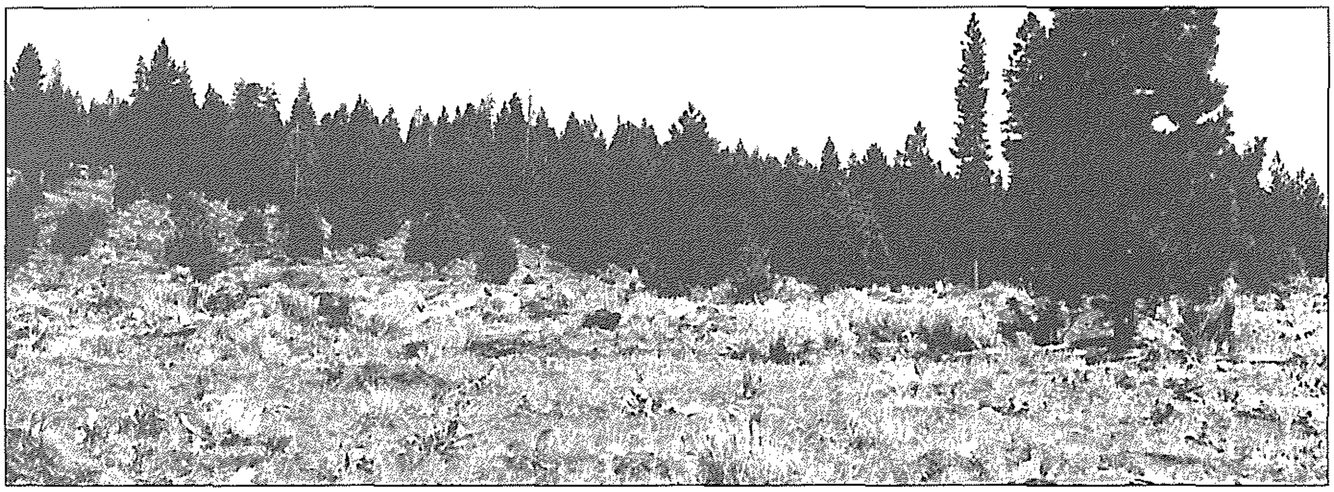

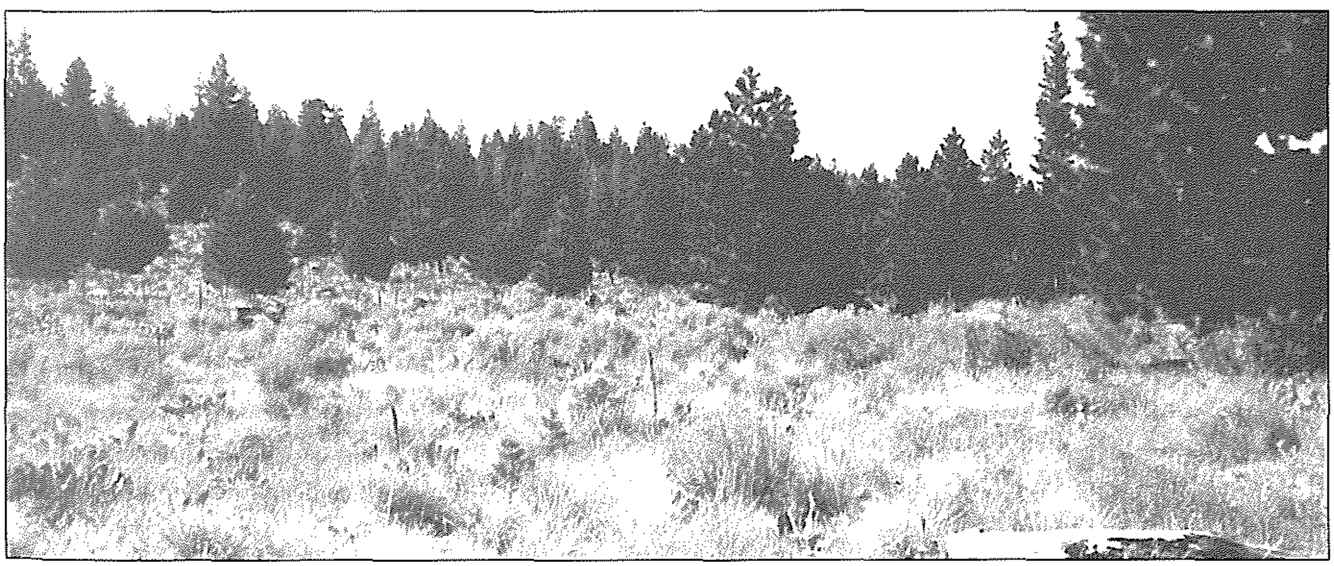

Abstract

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Effects of season-long, deferred-rotation, and rest-rotation grazing, on ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) seedling growth and herbaceous vegetation control were studied in regeneration sites at Boyd Hill, Modoc National Forest, California. Seedlings were planted in 1989. Pine seedling survival and damage did not differ, but the seedlings were significantly taller, with longer leaders with season-long grazing than without grazing. Treatment comparisons for plant group and non-plant percent cover differed only for litter and bare soil, but cover and composition of bottlebrush squirreltail (*Elymus elymoides* [Raf.] Swezey) were greater without grazing.

Retrieval Terms: Ponderosa pine, *Pinus ponderosa*, survival and damage, range condition, cattle, plantation

The Authors

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In Brief

Cattle grazing can be a useful tool for managing regeneration sites. The effects of season-long, deferred-rotation, and rest-rotation grazing, on conifer seedling growth and herbaceous vegetation control were studied at Boyd Hill, Modoc National Forest, in northern California. Wildfire burned the area in 1978, regeneration sites were prepared in 1988, and ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) seedlings were planted in 1989. Take-down fences were used to simulate deferred-rotation and rest-rotation grazing in a randomized complete block design on five sites. Pine seedling survival and damage did not differ, but the seedlings were significantly taller, with longer leaders with season-long grazing than without grazing. Improved range conditions (1989 to 1993) reflected natural recovery from site disturbance. Treatment comparisons (1993) of plant group and non-plant percent cover differed only for litter and bare soil, but the differences were not between season-long grazing and no grazing. Cover and percent composition of bottlebrush squirreltail (*Elymus elymoides* [Raf.] Swezey) were greater without grazing than with season-long grazing. Soil surface movement (except in the first year) and residual herbage amounts did not differ between treatments.

Introduction

Traditionally, a forester's job has been to grow trees. After a wildfire on commercial forest land, the primary objective is to obtain a vegetative cover that will conserve soil, protect water quality, and reestablish the forest. Seeding of grass species may be necessary, but grass (seeded or natural) competes strongly with conifer seedlings (Larson and Schubert 1969, Roy 1953). Competition is mostly for soil moisture (Embry 1971, Larson and Schubert 1969). Control of competing vegetation on regeneration sites (plantations) helps assure a new stand of ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) (McDonald and Fiddler 1989, Tackle and Roy 1953).

But how much grass is too much after seedling establishment? Fiske (1984) hypothesized that grass maintained at less than 50 percent of full site occupancy would permit adequate stand development to meet typical wood production objectives in California forests. Depending upon location, others consider any amounts of grasses, forbs, or shrubs undesirable at least until regeneration sites are 3- to 5-years-old (McDonald and Fiddler 1986). Adequate levels of grass control can be efficiently obtained by application of herbicides. But herbicides cause concern for effects beyond the target area. Alternate methods of controlling grass on regeneration sites are, therefore, desirable.

Livestock grazing can be regarded as a tool for use in forestry (Hatton 1924). At critical phenologic stages of important herbaceous species, grazing should alter the plant community and soil properties to favor conifer seedling growth by regulating belowground as well as aboveground competition (Karl and Doescher 1993). Timing and degree of herbage use will largely govern grazing effectiveness.

To be effective, grazing must damage the competing vegetation. Time of grazing should take advantage of natural lows in plant carbohydrate reserves, and reserves of carbohydrates generally decrease with early spring growth (Smith 1972). Early spring grazing by livestock on regeneration sites is a key to grass control (Fulgham 1985, Monfore 1983). Controlling livestock so they will not browse the pine seedlings is a critical consideration (McDonald and Fiddler 1989).

Stocking must be at a rate that will use 60 to 80 percent of current forage production (Fulgham 1985, McDonald and Fiddler 1989). Grazing can reduce water stress of seedlings by reducing understory use of soil moisture (Carlson and others 1994, Doescher and others 1989). Nevertheless, over time, an effective treatment (while good for forest regeneration) may produce an overgrazed range with undesirable consequences to other vegetation and soil resources (Leopold 1924, Sampson 1925).

"Grazing use should be based upon as complete utilization of the forage resources as is consistent with forest production, water-shed protection, permanency of forage production, game propagation and recreation" (Smith 1926: 139-140).

Kingery and others (1987) observed less damage to conifer seedlings where rotation grazing was practiced, and Karl and Doescher (1993) concluded that prescribed grazing by cattle benefits the physiological status of seedlings. However, those and other studies of livestock grazing in regeneration sites did not determine whether some form of rotation grazing would benefit conifer seedling growth.

This paper reports the results of our studies on pine regeneration sites at Boyd Hill on the West Bieber Grazing Allotment, Big Valley Ranger District, Modoc National Forest, California from 1989 to 1993.

Methods and Materials

Objective

Our objective was to determine the relative effectiveness of season-long grazing, specialized grazing management, and no grazing for promoting seedling ponderosa pine growth and controlling herbaceous vegetation. Also, we hoped to learn whether better range conditions would result with managed grazing of regeneration sites than with season-long grazing or no grazing.

Study Area

Wildfire burned the Boyd Hill area in 1978. Soils there are in the Lawyer and Elmore families (Luckow 1985). Both families have loam to stony loam surface textures and clay loam to cobbly clay loam subsoil textures. They are well-drained, and permeability is moderately slow–0.5 to 1.5 centimeters (cm) water/hour. Effective rooting depths range from 50 cm to more than 100 cm over basalt bedrock. Hydrogen ion concentrations are in the slightly acid range–pH 6.1 to 6.5. The forest site class is 5, with potential productivity in the range of 3.5 cubic meters (m^3) to 5.9 m^3 per hectare per year.

Preparation for planting ponderosa pine in 1989 occurred during the summer and fall of 1988. Standing dead trees and shrubs were pushed into large piles with a brushrake-equipped bulldozer and later burned. Plant cover, non-plant factors (bare soil, gravel, rock, litter, wood, and animal waste), and soil properties (bulk density, organic matter, soil water, and water absorption) 1 year after site preparation were reported by Ratliff and Denton (1991).

Study Design

Five regeneration sites were randomly selected for establishing 64-m by 128-m study plots. To provide a randomized complete block experimental design, each plot consisted of four experimental units (EU) each 32 m by 64 m (*fig. 1*). Blocking was dictated by differences among the selected sites in slope, surface rocks, and pre-planting vegetation.

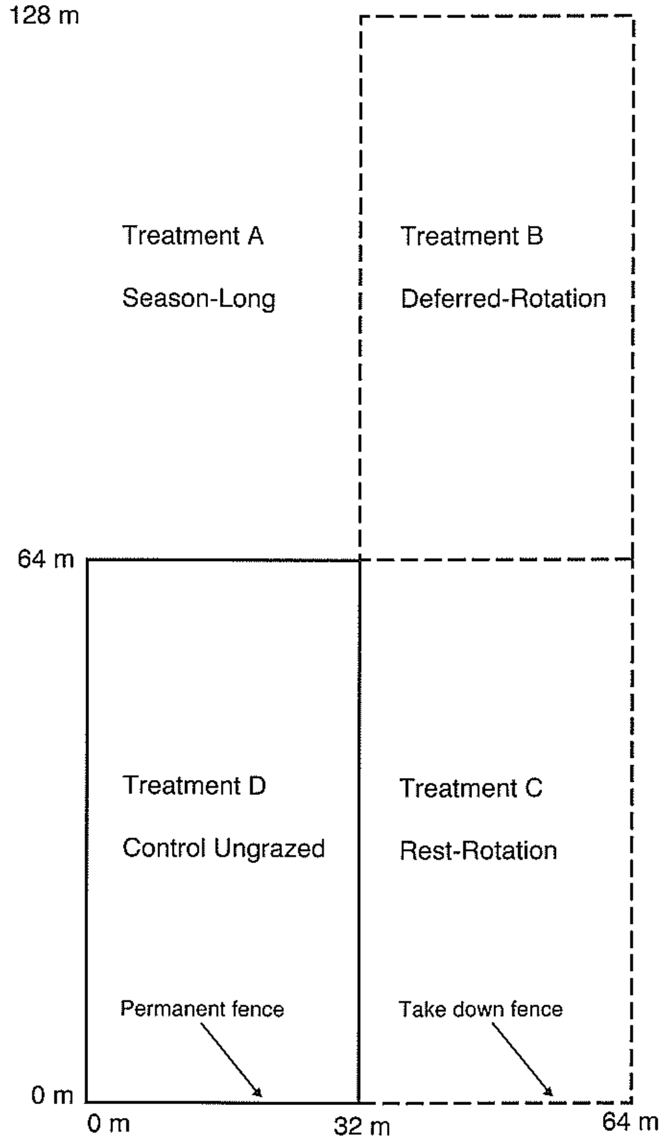

Figure 1—Generalized treatment arrangement used for plots in regeneration sites at Boyd Hill, Modoc National Forest, California.

We could not control livestock use within EUs of that size. Incident grazing (use occurring under current allotment management) was relied upon, and fencing was used to simulate specialized management and provide protected (ungrazed) controls. Treatments assigned were:

a) Unfenced, season-long grazing by livestock and wildlife.
b) Simulated one unit of a two-unit deferred-rotation grazing program, using a take down fence.
c) Simulated one unit of a 3-unit rest-rotation grazing program, using a take down fence.
d) Fenced, ungrazed by livestock but available to wildlife.

Sampling units (SU) were two 3-m by 60-m belt transects (Stoddart and others 1975) randomly located within each EU. The first 1.5 m bordering each EU formed a buffer for reducing side effects. Also, 1.5 m was the minimum distance allowed between the two transects. All responses, except pine seedlings and soil surface movement, were estimated within the belt; and sample placement was random. The SUs for conifer seedlings were 40 randomly located, healthy seedlings within each EU. The SUs for soil surface movement were 25 metal washers (1.91-cm diameter) placed 30 cm apart on a 7.5-m transect randomly located in the EU. Similar techniques had been used successfully for measuring erosion (Gleason 1957).

Response units (RU) for plant groups (grasses, grasslike plants, forbs, shrubs, and pine seedlings) and non-plant factors (bare soil, gravel, etc.) were composed of 100 meter-long sub-transects. Perpendicular to the center line of the SU, sub-transects were randomized in the left-hand, center, or right-hand meter of the belt transect. Because of time constraints, the RU were composed of 50 randomly selected sub-transects in 1993.

Plants and non-plant factors intercepted by each sub-transect were measured to the nearest millimeter. Projected crown intercepts were recorded for tree seedlings and shrubs. Actual basal intercepts were recorded for all other characteristics. The sum of all intercepts equaled 100 percent cover. Plant intercepts were recorded by species, but analyzed by groups. Gravel, litter, and bare soil were measured individually on about a fifth of the sub-transects, and together as surface on all other sub-transects.

Conifer seedlings were identified by numbered tags and plotted on a map of the EU to facilitate finding them. Growth and survival were assessed each summer. Growth was assessed as stem height and leader length and diameter at 30 cm height. An RU was an individual seedling. Four damage classes were recognized: dead, not apparent, lateral, and terminal. Observed damage was assumed to result from cattle or deer browsing or both. Survival and damage classes were assessed as percentages of the original 40 seedlings.

For residual herbage amounts, the RU was a m^2 quadrat (a 1/2 m^2 quadrat was used in 1993). RUs were randomly located (without replacement) within the SU in the same way as the sub-transects. In addition, heights and densities of one to three forage species were recorded for each RU on each block.

Herbage was defined as herbaceous, non-woody, plant material, and was inclusive of forage and non-forage species (e.g., grasses and thistles, respectively). Grazing use estimates were based on amounts of residual herbage: ungrazed EUs estimated total production, and treatment EUs estimated amounts left.

Surface soil movement was assessed as a volume calculated from the average vertical, horizontal, and depth displacements of washers.

Statistical Analyses

The generalized hypothesis (H_0) to be tested was that seedling, herbaceous plant, or soil responses do not differ between grazing treatments. The alternate hypothesis (H_a) was that some responses differ due to grazing treatment.

We used four treatments in five blocks of a randomized complete block design. Treatment and block effects both were fixed, and analysis of variance for that experimental design was used.

For cover (species groups and non-plant factors), conifer seedling survival and damage types, and soil surface movement, statistically there was one measure per EU. The appropriate analysis of variance had r = 5 blocks, t = 4 treatments, s = 1 observation/block and treatment. Assuming the block-treatment interaction is zero, the experimental error mean square was the proper testing term. The arcsine transformation was used for analyses of seedling damage counts (expressed as percentages) (Steel and Torrie 1960). Tukey's honestly significant difference (hsd) test was used to separate treatment means. Alpha-level was set at 0.05, but 0.10 was used for soil surface movement, because of expected variation.

Observations per EU were 4 and 40 for residual dry matter and seedling growth responses, respectively. The number of dead seedlings varied. Variation among observations (sampling error) was accounted for in the analysis. The variance of the data measurements was assumed to be constant. The appropriate analysis of variance for residual dry matter had r = 5 blocks, t = 4 treatments, s = 5 observation/block and treatment. The ANOVA model included the block by treatment interaction. Separation of treatment means for residual dry matter was by Tukey's hsd. Because the numbers of seedlings and quadrats in which a forage species was found varied, growth response means were separated by contrasts, giving a Bonferoni "t" test with a family alpha of 0.05.

Paired samples "t" ($\alpha = 0.05$) was used to test for plant species groups and non-plant factor percentage cover differences between 1989 and 1993.

Results and Discussion

Seedling Growth and Survival

Early researchers agreed that managed grazing by cattle had little detrimental effect on regeneration (Stickel and Hawley 1924), and damage to regeneration by cattle was usually confined to overgrazed areas (Pearson 1927). Proper grazing by cattle did not harm trees on conifer regeneration sites at Blodgett Forest Research Station, California; and the extent of damage to trees was the same by cattle and deer as by deer alone (Kosco and Bartolome 1983). Where cattle, deer, and elk were allowed to forage, seedling loss was 44 percent compared with 25 percent where they were not allowed (Kingery and Graham 1991). Cattle damaged ponderosa pine seedlings by trampling them, but most damage was done by deer and elk browsing. Sheep grazing significantly increased diameter growth of ponderosa pine and reduced cover of competing vegetation without damaging the trees near Klamath Falls, Oregon (Senter and Kelly 1987). But in another study, in the Sierra Nevada of California, 10 years of sheep grazing did not enhance pine growth (McDonald and Fiddler 1993).

In this study, grazing did not affect seedling survival. All blocks and treatments showed that 72 percent of the tagged seedlings survived (*table 1*). We found no differences because of grazing treatment, but block effects were significant. Blocks with the best survival were those that were nearly level, while those with the poorest survival were those with moderate to high degrees of slope. No relationships between seedling survival and non-plant factor or plant group covers were found.

Grazing did affect seedling growth. Seedlings were taller with season-long grazing than those that were protected

Table 1—*Average Ponderosa pine seedling survival, heights, leader lengths, and diameters by grazing treatment in plantations at Boyd Hill, Modoc National Forest, California, 1993.*

Treatment	Survival (pct.)	Height (m)	Leader (cm)	Diameter (cm)
Season-long	74.0a[1]	0.497 ± 0.190[2]a	19.750 ± 8.615a	1.257 ± 0.540a
Deferred-rotation	73.0a	0.450 ± 0.170ab	16.808 ± 7.161b	1.102 ± 0.402a
Rest-rotation	71.5a	0.468 ± 0.194ab	17.601 ± 7.804b	1.171 ± 0.483a
Ungrazed	69.5a	0.446 ± 0.186b	16.101 ± 8.191b	1.079 ± 0.429a

[1] Column values followed by the same letter do not differ significantly at a family $\alpha = 0.05$ by Bonferoni "t."
[2] Average ± standard deviation based on the numbers of observations for all blocks.

from cattle. Similarly, leaders were longer with season-long grazing than with the other treatments. Differences in diameter were not statistically significant; nevertheless, the average diameter was largest with season-long grazing and smallest without grazing.

Cattle grazing did not increase damage to the seedlings, and class of damage did not differ significantly between treatments. Among the surviving seedlings, 64.8 percent had no apparent damage, 4.9 percent had lateral branch damage, and 30.4 percent had terminal bud damage.

Plant Cover and Composition

Increases in total plant and litter cover with decreases in bare soil suggest lowered erosion potential, and hence, improved watershed values. Increases in shrub cover suggest greater hiding or escape potential, yielding improved wildlife habitat values. Increases in perennial grasses without increases in annual grasses or forbs suggest a higher forage potential, and improved grazing values. These changes in cover and composition suggest better ecosystem health, and improved range resource values.

Total plant cover increased from 2.5 percent in 1989 to 8.1 percent in 1993. The largest increase was contributed by shrubs (*table* 2). Percentage increases in cover were: tree seedlings (495 percent), shrubs (355 percent), perennial grasses (192 percent), and litter (44.6 percent). Bare soil decreased by 36.4 percent and gravel by 23.3 percent. Although their presence was observed in 1989, grasslike plants were first intercepted in 1993. Surprisingly cover of annual grasses and perennial or annual forbs were unchanged.

Grasses declined in their relative contribution to the plant cover, but perennials made up 83 percent of the grass cover in 1993 compared to 48 percent in 1989. Composition of the plant cover (relative cover) in 1993 included pine seedlings, 3.2 percent; shrubs, 80.9 percent; grasses, 9.2 percent (7.7 percent perennials and 1.5 percent annuals); grasslike plants, 0.2 percent; and forbs, 6.4 percent (4.6 percent perennials and 1.8 percent annuals). These compare with 1.7 percent, 56.9 percent, 17.6 percent, 0.0 percent, and 23.9 percent, respectively in 1989.

Increases in plant species on or around the study plots between 1989 and 1993 suggest improved diversity (*table*

Table 2—*Means, standard errors (SE), and 95 percent confidence intervals (CI) for 1989 and 1993; and mean difference (1989-1993), "t" values (T), and probability of the difference (P) for plant cover[1] by species group and non-plant factors, Boyd Hill, Modoc National Forest.*

	1989			1993			1989-1993		
Group/factor	Mean	SE	CI	Mean	SE	CI	Mean	T	P
	percent cover								
Tree seedlings	0.043	0.014	0.005-0.081	0.256	0.081	0.087-0.425	-0.213	-2.814	0.011
Shrubs	1.445	0.593	-0.202-3.091	6.575	1.150	4.168-8.982	-5.130	-5.680	0.000
Perennial grasses	0.214	0.058	0.054-0.375	0.625	0.099	0.445-0.859	-0.410	-3.555	0.002
Annual grasses	0.232	0.054	0.081-0.383	0.125	0.021	0.080-0.170	0.107	1.708	0.104
Grasslike plants	--	--	--	0.020	0.006	0.006-0.034	-0.020	-3.015	0.007
Perennial forbs	0.443	0.072	0.244-0.641	0.373	0.049	0.270-0.476	0.070	0.939	0.360
Annual forbs	0.164	0.039	0.055-0.272	0.151	0.180	0.067-0.235	0.013	0.257	0.800
Non-plant	97.454	0.697	95.519-99.389	91.879	1.112	89.552-94.206	5.576	6.137	0.000
Animal waste	0.193	0.059	0.029-0.356	0.249	0.059	0.126-0.372	-0.056	-0.652	0.522
Rock	3.181	1.562	-1.154-7.516	3.166	0.832	1.425-4.907	0.016	0.049	0.961
Wood	3.633	0.685	1.730-5.535	3.679	0.503	2.626-4.732	-0.047	-0.123	0.904
Surface[2]	90.449	2.373	83.861-97.037	84.785	1.594	81.448-88.122	5.664	5.171	0.000
Gravel	3.718	0.658	1.890-5.546	2.853	0.230	2.372-3.334	0.866	2.164	0.043
Litter	33.777	2.239	27.560-39.994	48.852	2.127	44.401-53.303	-15.075	-5.972	0.000
Bare soil	52.990	4.179	41.390-64.590	33.698	2.377	28.724-38.672	19.293	7.789	0.000

[1]Cover values for tree seedlings and shrubs were based on projected crown intercepts.
[2]Surface = (gravel + litter + bare soil). The difference between the mean value of "Surface" and the sum of the mean values of gravel, litter, and bare soil is due to sampling intensity--N for surface is five times that for the components.

3). Eight species (two exotic perennial grasses, an exotic biennial forb, and five endemic perennial forbs) not found in 1989 were found in 1993. Among the 57 species found (conifers not included), 72 percent were endemics, 65 percent perennials, 70 percent forbs, 23 percent grasses, 2 percent grasslike plants, and 5 percent shrubs.

Increased species evenness (percent composition) between 1989 and 1993 suggests lowered diversity. Although not all the same, in 1993 and 1989 seven species had cover values of 0.1 percent or more. Those from 1989 comprised 87.3 percent of the plant cover (Ratliff and Denton 1991), while those from 1993 comprised 90.6 percent (*table 3*). The species in 1993 were: western needlegrass (*Achnatherum occidentalis* [Thurber] Barkworth), cheatgrass brome (*Bromus tectorum* L.), mahala mat (*Ceanothus prostratus* Benth.), rubber rabbitbrush (*Chrysothamnus nauseosus* [Pallas] Britton), yellow rabbitbrush (*C. viscidiflorus* [Hook.] Nutt.), bottlebrush squirreltail (*Elymus elymoides* [Raf.] Swezey), and mountain mule-ears (*Wyethia mollis* A. Gray).

Among fourteen species common to all blocks in 1993, only yellow rabbitbrush and bottlebrush squirreltail differed among treatments (*table 4*). Yellow rabbitbrush composition was greater under season-long grazing than under deferred-rotation, but we found no differences in its cover percentages. Percentage composition and percentage cover of bottlebrush squirreltail were both greater without grazing than under season-long grazing. The averages

Table 3—*Names, habits, and percent compositions of understory plants on pine plantations at Boyd Hill, Modoc National Forest, 1989 and 1993.*

Plant names[1]			Composition pct.	
Scientific name	Common name	Habit[2]	1989	1993
Achillea millefolium L.	Common yarrow	EN-PE-FO	0.146	0.014
Achnatherum occidentalis (Thurber) Barkworth	Western needlegrass	EN-PE-GR	5.588	3.595
Agoseris retrorsa (Benth.) E. Greene	Spearleaf agoseris	EN-PE-FO	--[3]	0.462
Agropyron desertorum (Fischer) Schultes	Desert crested wheatgrass	EX-PE-GR		--
Antennaria howellii E. Greene	Howell pussytoes	EN-PE-FO		--
Brassica rapa L.	Field mustard	EX-AN-FO	--	--
Briza maxima L.	Big quakinggrass	EX-AN-GR	--	--
Bromus carinatus Hook. & Arn.	California brome	EN-PE-GR	0.404	0.087
B. inermis Leysser	Smooth brome	EX-PE-GR		0.022
B. japonicus Murr	Japanese brome	EX-AN-GR	0.236	--
B. tectorum L.	Cheatgrass brome	EX-AN-GR	8.969	1.526
Calystegia occidentalis (A. Gray) Brummitt	Western morning glory	EN-PE-FO	0.072	0.311
Camelina microcarpa Andrz.	Littleseed falseflax	EX-BI-FO		0.011
Carex rossii Boott	Ross sedge	EN-PE-GL	--	0.244
Ceanothus prostratus Benth.	Mahala mat	EN-PE-SH	50.276	42.737
Chamaesyce serpyllifolia (Pers.) Small	Thymeleaf spurge	EN-AN-FO	--	--
Chrysothamnus nauseosus (Pallas) Britton	Rubber rabbitbrush	EN-PE-SH	0.822	5.357
C. viscidiflorus (Hook.) Nutt.	Yellow rabbitbrush	EN-PE-SH	5.700	32.848
Cirsium andersonii (A. Gray) Jepson	Anderson thistle	EN-PE-FO	2.023	0.815
C. occidentale (Nutt.) Jepson	Snowy thistle	EN-PE-FO	0.120	--
Crepis occidentalis Nutt.	Western hawksbeard	EN-PE-FO	--	
Cryptantha ambigua (A. Gray) E. Greene	Wilkes cryptantha	EN-AN-FO	1.004	0.169
Dactylis glomerata L.	Orchardgrass	EX-AN-FO	0.010	--

continues

Table 3—*continued*

Plant names[1]			Composition pct.	
Scientific name	Common name	Habit[2]	1989	1993
Descurainia pinnata (Walter) Britton	Pinnate tansymustard	EN-AN-FO	--	0.032
Elymus elymoides (Raf.) Swezey	Bottlebrush squirreltail	EN-PE-GR	0.642	2.655
Elytrigia intermedia (Host) Nevski	Intermediate wheatgrass	EX-PE-GR	1.723	0.389
Erigeron eatonii A. Gray	Eaton fleabane	EN-PE-FO		--
Eriophyllum lanatum (Pursh) James Forbes	Woolly eriophyllum	EN-PE-FO	0.040	0.028
Gayophytum humile A. L. Juss.	Low gayophytum	EN-AN-FO	2.955	0.308
Hieracium scouleri Hook.	Hawkweed	EN-PE-FO		0.018
Hydrophyllum capitatum Douglas	Woolenbreeches	EN-PE-FO		0.010
Lactuca serriola L.	Prickly lettuce	EX-AN-FO	0.494	0.005
Lagophylla ramosissima Nutt.	Comman hareleaf	EN-AN-FO	--	0.072
Lathyrus nevadensis S. Watson	Nevada peavine	EN-PE-FO	0.504	0.095
Lepidium nitidum Torrey & A. Gray	Tongue pepperweed	EN-AN-FO	0.058	0.128
Lupinus argenteus Pursh	Tailcup lupine	EN-PE-FO	0.014	--
Madia glomerata Hook.	Cluster tarweed	EN-AN-FO	0.174	0.021
Malva neglecta Wallr.	Common mallow	EX-BI-FO	--	--
Mentzelia gracilenta Torrey & A. Gray	Blazing star	EN-AN-FO	--	0.094
Mimulus species	Monkey flower	EN-AN-FO	--	0.039
Monardella odoratissima Benth.	Pacific monardella	EN-PE-FO	--	0.011
Montia chamissoi (Sprengel) E. Greene	Chamisso minerslettuce	EN-PE-FO	0.034	0.544
Navarretia species	Navarretia	EN-AN-FO	0.024	--
Nicotiana attenuata Torrey	Coyote tobacco	EN-AN-FO	--	0.023
Phacelia heterophylla Pursh	Varileaf phacelia	EN-PE-FO	0.644	0.212
Phlox gracilis E. Greene	Small star	EN-AN-FO	1.641	0.485
Poa bulbosa L.	Bulbous bluegrass	EX-PE-GR	0.010	--
P. compressa L.	Canadian bluegrass	EX-PE-GR	--	0.857
P secunda J. S. Presl	Sandberg bluegrass	EN-PE-GR	--	0.081
Polygonum douglasii E. Greene	Douglas knotweed	EN-AN-FO	--	0.002
Scutellaria nana A. Gray	Dwarf skullcap	EN-PE-FO	--	--
Sidalcea oregana (Torrey & A. Gray) A. Gray	Oregon checkermallow	EN-PE-FO	--	--
Taeniatherum caput-medusae (L.) Nevski	Meduesahead	EX-AN-GR	--	--
Taraxacum officinale Wigg.	Common dandelion	EX-PE-FO	--	0.016
Verbascum thapsus L.	Woolly mullein	EX-PE-FO	1.246	0.711
Viola purpurea Kellog	Pine violet	EN-PE-FO	--	0.004
Wyethia mollis A. Gray	Mountain mule-ears	EN-PE-FO	12.694	1.881

[1]Sources: scientific names, Hickman (1993); common names, Beetle (1970), Hickman (1993), Niehaus and Ripper (1976), and/or Weeden (1975).
[2]Habit: EN = endemic, EX = exotic, AN = annual, BI = biennial, PE = perennial, FO = forb, GL = grasslike, GR = grass, SH = shrub.
[3]Dashes indicate that the species was observed but not intercepted. A blank indicates that the species was not observed.

increased from season-long to deferred-rotation to rest-rotation to no grazing.

Plant group or surface factor covers in 1993 did not differ for the ungrazed and season-long grazing treatments (*table 5*). Nevertheless, deferred-rotation and rest-rotation had less litter cover and rest-rotation had more bare soil than the ungrazed treatment. A greater number of blocks or a longer time period or both may be necessary for effects on other species groups and factors to be manifested.

Soil Surface Movement

Soil movement was active during six observation periods (July 1989 to July 1990 to May 1991 to July 1991 to May 1992 to July 1992 to July 1993). During all periods a washer was displaced an average of 5.46 cm vertically (above or below the transect line), 3.41 cm horizontally (left or right of its initial position along the transect), and was covered by 0.41 cm of soil (*table 6*). On the basis of those averages, a washer represented 1.27 cm^3 of soil moved each period or 7.63 cm^3 during the study or 1.91 cm^3/year.

Nevertheless, we did not find treatment differences in soil surface movement, except for the first year of the study (*table 6*). That year (July 1989 to 1990) soil movement was greater for rest-rotation than either season-long or deferred-rotation grazing but no greater than without grazing. Although cattle may have helped firm the soil in some areas before fencing, the differences more likely reflect settling of the soil after site preparation.

Residual Dry Matter

Whether grazed or ungrazed the amounts of material left are apt to be the same. Amounts of residual dry matter did not differ between treatments (*table 7*). Forage and non-forage species, were not separated for analysis. Therefore, non-forage species compensated for the weight of forage species consumed by animals. Nature abhors a vacuum.

Nevertheless, from other information we found evidence that grazing affected the residual dry matter.

Season-long grazing reduced culm heights of western needlegrass by 9.8 percent, 14.6 percent, and 15.2 percent compared with the deferred-rotation, rest-rotation, and ungrazed treatments, respectively. While height/weight relationships were not available for western needlegrass, the height/weight relationships established for other grasses

Table 4—*Percentage compositions by grazing treatment, analyses of variance (ANOVA), and Tukey's honestly significant differences (hsd) at = 0.05 for plant species found on all blocks, Boyd Hill, Modoc National Forest, 1993.*

	Grazing Treatment[1]				ANOVA[2]		
Species[3]	S-L	D-R	R-R	U-G	F	P	hsd
	percent composition						
Western needlegrass	6.153	2.943	5.229	3.774	0.307	0.820	10.909
Cheatgrass brome	1.056	2.327	3.109	2.332	1.117	0.381	3.378
Ross sedge	0.213	0.421	0.625	0.140	0.778	0.528	1.042
Mahala mat	24.005	37.931	33.762	19.149	1.270	0.329	32.217
Yellow rabbitbrush	42.553	27.997	32.597	38.149	3.520	0.049	14.239
Wilkes cryptantha	0.329	0.130	0.200	0.310	0.418	0.743	0.609
Pinnate tansymustard	0.022	0.089	0.066	0.035	0.458	0.717	0.188
Bottlebrush squirreltail	1.335	1.832	3.383	8.326	4.210	0.030	6.535
Low gayophytum	0.082	0.141	0.217	2.375	1.132	0.375	4.405
Nevada peavine	0.071	0.112	0.235	0.258	0.705	0.567	0.460
Chamisso minerslettuce	0.225	1.456	0.703	0.416	0.674	0.584	2.767
Small star	0.152	0.210	0.320	3.333	0.962	0.442	6.658
Woolly mullein	0.498	0.129	1.366	0.817	0.956	0.445	2.251
Mountain mule-ears	2.340	3.353	2.516	3.513	0.140	0.934	6.608

[1]S-L = season-long grazing, D-R = deferred-rotation, R-R = rest-rotation, U-G = ungrazed (protected).
[2]F = F ratio (df = 3,12) from ANOVA, P = probability of "F" occurring by chance.
[3]Species scientific names are given in *table 3*.

Table 5—*Cover[1] percentages by grazing treatment, analyses of variance (ANOVA), and Tukey's honestly significant differences (hsd) at α = 0.05 for plant groups and non-plant factors, Boyd Hill, Modoc National Forest, 1993.*

Group/factor	Grazing Treatment[2] S-L	D-R	R-R	U-G	ANOVA[3] F	P	hsd
	-----------------------*percent cover*-----------------------						
Tree seedlings	0.302	0.250	0.154	0.318	0.142	0.933	0.825
Shrubs	6.170	9.682	4.620	5.826	0.909	0.466	9.586
Perennial grasses	0.410	0.642	0.568	0.878	1.318	0.314	0.713
Annual grasses	0.080	0.160	0.132	0.128	0.955	0.445	0.145
Grasslike plants	0.012	0.024	0.030	0.012	0.441	0.728	0.059
Perennial forbs	0.520	0.348	0.216	0.406	2.026	0.164	0.371
Annual forbs	0.072	0.170	0.096	0.264	1.072	0.397	0.351
Non-plant	92.436	88.724	94.184	92.172	1.133	0.375	9.018
Animal waste	0.258	0.272	0.318	0.146	0.355	0.787	0.514
Rock	3.296	3.776	2.542	3.048	0.363	0.781	3.580
Wood	5.614	3.288	2.342	3.472	2.558	0.104	3.629
Surface[4]	83.264	81.386	88.982	85.508	1.940	0.177	9.848
Gravel	2.818	2.986	2.950	2.656	0.096	0.960	2.023
Litter	48.350	42.538	45.258	59.262	5.838	0.011	12.750
Bare soil	31.956	35.976	39.778	27.082	3.428	0.052	12.353

[1]Cover values for trees and shrubs were based on projected crown intercepts.
[2]S-L = season-long grazing, D-R = deferred-rotation, R-R = rest-rotation, U-G = ungrazed (protected).
[3]F = F ratio (df = 3,12) from ANOVA, P = probability of "F" occurring by chance.
[4]Surface = (gravel + litter + bare soil); see explanation on *table 2*.

(USDA Forest Service, 1993) suggest that use of western needlegrass was less than 10 percent by weight.

Neither heights nor density of bottlebrush squirreltail differed due to treatment. The effect of season-long grazing relative to no grazing on bottlebrush squirreltail cover and percentage composition, therefore, resulted from a reduction in individual plant basal area. Hormay and Talbot (1961) found that clipping (defoliating) it once when its flower stalks were low-in-the-boot reduced bottlebrush squirreltail basal areas by 36 percent, and 4 years of clipping at the seed-in-milk stage reduced basal areas by 62 percent.

Animal Influences

Cattle use occurred on all blocks in all years of the study. Actual use on the West Bieber Allotment averaged 2,525 animal-months from 1988 to 1993 or about 95 percent of the allowable use (Pope 1994). With incident grazing we could not control the degree of forage use. Nevertheless, in our judgment, forage use on EUs open to season-long grazing was moderate, considering both years with low and years with ample precipitation. Within the deferred and rest-rotation EUs, time and degree of use depended on cattle being in the regeneration sites when the fences were down.

No differences were found in animal waste percentage cover (*table 5*). Nevertheless, based on the averages, animal waste covered about twice the area in the other treatments as in the ungrazed EUs where it covered an average of 3.0 m^2. That finding suggests use of the deferred and rest-rotation EUs when they were open to cattle. Even so, forage use in those treatments seldom approached levels that could be expected were the systems implemented on the allotment.

Deer were abundant in the area early in the study, but the population declined markedly by 1993. The counts on 64-kilometer-long transects (inclusive of the Boyd Hill area herd) dropped from 50 in 1992 to 36 in 1993 to 19 in 1994 (Stowers 1994). Given no treatment difference in damage to or survival of pine seedlings and the animal waste in the ungrazed EUs, we assumed that deer had an influence on the

Table 6—*Average washer displacement and soil movement for the study period, soil movement for the July 1989-90 period, and Tukey's honestly significant difference (hsd) at α = 0.10 by grazing treatment in plantations at Boyd Hill, Modoc National Forest, California.*

Treatment	Washer displacement[1]			Soil movement[2]		
	ab	bc	cd	A	B	1989-90
	(cm)			*(cm³)*		
Season-long	4.85	3.38	0.39	1.64	1.07	0.34z
Deferred-rotation	5.39	3.06	0.40	2.11	1.10	0.35z
Rest-rotation	6.34	3.75	0.54	3.20	2.14	2.74y
Ungrazed	5.29	3.46	0.33	2.75	1.01	1.09yz
hsd	2.75	1.47	0.21	2.81	--	2.20

[1] Average washer displacement. ab = vertical (above or below the transect line); bc = horizontal (along the transect line); cd = depth (covering with soil).

[2] Soil movement = volume estimated by washer displacement. A = average over all periods; B = average based on average displacements; 1989-90 = average for the period July 1989 to July 1990 (values with like letters are not significantly different).

Table 7—*Average residual herbage dry matter and heights[1] and densities for western needlegrass[2] and bottlebrush squirreltail by grazing treatment, Boyd Hill, Modoc National Forest, 1990-93.*

Factor	Grazing Treatment[3]				ANOVA[4]	
	S-L	D-R	R-R	U-G	F	P
Dry matter (gm/m²)	91.59	92.21	99.43	87.16	0.253	0.859
Western needlegrass						
height (cm)	44.41b	49.26a	52.01a	52.39a	5.000	0.002
density (plants/m²)	4.72	5.49	4.14	3.66	1.688	0.171
Bottlebrush squirreltail						
height (cm)	29.54	27.49	27.59	31.13	1.388	0.249
density (plants/m²)	3.16	3.07	2.52	3.38	1.046	0.0375

[1] Row values followed by a different letter are significant at α = 0.05 by mean differences.
[2]Species scientific names are given in *table 3*.
[3]S-L = season-long grazing, D-R = deferred-rotation, R-R = rest-rotation, U-G = ungrazed (protected).
[4]F = F ratio (df = 3,79) from ANOVA, P = probability of "F" occurring by chance.

pine seedlings. That deer had little effect on other vegetation is suggested by the animal waste to grass and forb ratio which was 1 unit to 11.5 units in the ungrazed EUs, about a third as high in the other treatments.

Conclusions

Range conditions (based on cover and composition) have improved since the regeneration sites were planted in 1989. Improvement without grazing reflects natural recovery from site disturbance (preparation for planting). No differences in cover between the season-long and ungrazed treatments in 1993 means that conditions improved using both treatments.

Seedling survival did not differ among treatments at Boyd Hill, suggesting no detrimental effect of cattle grazing. Nevertheless, season-long grazing, as it occurred at Boyd Hill, was better than no grazing for promoting conifer seedling growth. The pine seedlings were taller and leaders were longer under season-long grazing than without grazing. Differences were not found among treatments in types of damage to seedlings, suggesting that deer browsing was a major influence.

Grazing can affect species cover and percentage composition as shown by bottlebrush squirreltail. Nevertheless, season-long grazing, compared with no grazing, did not effect shrub or total perennial grass cover.

A longer period and a tightly controlled, large-scale study will be necessary to define the effects of deferred-rotation and rest-rotation grazing on pine seedling development in plantations. Such specialized grazing management should, nevertheless, produce seedling growth as good as or better than without grazing.

Forage and other herbaceous vegetation in regeneration sites increases and then decreases as the trees grow and become dominant. Ideally, forest management will coordinate grazing of regeneration sites and permanent range areas to take advantage of the positive effects on seedling growth. The problem is attaining proper stocking, distribution, and time of use. The key is attention to grazing management.

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