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ABSTRACT: A combination of factors are responsible for mortality in conifer plantations. Ponderosa pine (Pinus ponderosa) were planted on 3 transitory ranges in northern and central Idaho. These plantations were followed closely (sampling up to 7 times per year) for 6 years recording the causes of mortality and damage to the tree seedlings. Pocket gophers (Thomomys spp.) killed the most trees (71%) while nonanimal causes killed 21%. Elk (Cervus elaphus) and deer (Odocoileus spp.) killed a maximum of 9%, and cattle (Bovine spp.) killed a maximum of 4%. Pocket gophers caused the most reduction in height growth. The combination of factors caused excessive damage and mortality at all study locations, completely destroying one plantation.

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INTRODUCTION

Transitory ranges are an important resource of the Mountain West. Transitory range is land suitable for grazing of a temporary nature (Schwartz et al. 1976). Forestland transitory range occurs on land where the potential natural vegetation is forest, but because of timber harvest, wildfire, or other disturbance, the tree overstory has been substantially reduced or removed and is temporarily producing greater amounts of grasses, forbs, and shrubs than undisturbed conditions. Forage available on these ranges is an important food source for wildlife and domestic animals.

A variety of uses available on these lands create the potential for conflict, especially between timber and domestic livestock. Often the better lands for producing timber also produce large amounts of forage (Kingery 1985). The moist and mesic sites are dominated by the western redcedar (Thuja plicata) and grand fir (Abies grandis) habitat types (Cooper et al. 1987), and the drier sites are dominated by Douglas-fir (Pseudotsuga menziesii var. glauca) habitat types. Timber productivity ranges from 3.5 to 8.5 m^3/ha/yr, and forage production ranges from 900 to 3000 kg/ha/yr, (Pfister et al. 1977, Hardman 1979).

Because of the high amount of forage available on transitory ranges, they are excellent habitat for elk (Cervus elaphus) and deer (Odocoileus spp.). These animals occupy transitory ranges during all or parts of the year depending on the location and on the availability of hiding and thermal cover. In addition to game animals, these ranges provide habitat for small animals such as hares (Lepus spp.), porcupines (Erethizon dorsatum), mice (Peromyscus spp.), and pocket gophers (Thomomys spp.).

Where conflict between uses occurs, livestock can do considerable tree damage and are often attributed to causing plantation failures (Eissenstat et al. 1982). There may be several other causes of damage and mortality to plantations. Because of uncertainty as to why plantations fail, we established this study to identify the causes of damage and mortality to conifer plantations on transitory ranges.

METHODS

In 1982 we chose 3 sites in northern and central Idaho for the study. Because the sites have high value for both timber and domestic livestock production, there was potential for conflict between the uses.

Hume Study Site

The Hume study site was on the Idaho Panhandle National Forests in northern Idaho at an elevation of 872 m. Slopes of the area are moderate (10 to 30%) with aspects generally east to northeast. Soils of the area are fine-silty, mixed Typic Fragiboralfs. A fragipan causes a perched water table between 45 and 90 cm in the area from February to March. Available water capacity is low and rooting depth is shallow. Annual precipitation on the study area averaged 69 cm with the greatest proportion as snow. Snow depths reached over 2 m during the winter.

The Hume site was in two 16-ha clearcuts harvested in 1982. Before harvesting the area was occupied by western white pine (Pinus monticola), Douglas-fir, western larch (Larix occidentalis), grand fir, and ponderosa pine (P. ponderosa). Logging debris was machine piled and burned in the fall after harvesting, leaving little woody debris except where the piles partially burned.

The habitat type was western redcedar/clintonia uniflora (Cooper et al. 1987). The predominant species in the plant community were western yarrow (Achillea millefolium), thistle (Cirsium spp.), wild strawberry (Fragaria spp.), clover (Trifolium spp.), orchardgrass (Dactylis glomerata), and bluegrass (Poa spp.).

The harvest unit is in a 1600-ha cattle (Bovine spp.) pasture. The grazing plan for the pasture provides for season-long use beginning in early June and ending early October with 73 animal units (approximately 300 animal unit months).

Vassar Study Site

The Vassar site was on the Clearwater National Forest in northern Idaho at an elevation of 883 m. The study area is mostly level with minimal aspect changes. The soils were classified as the fragipan phase of the medial over loamy mixed Anedptic Paleboralfs. They are deep and moderately well drained with high erosion potential. Available water capacity is low and rooting depth is 51 to 77 cm because of the fragipan. Annual precipitation at Vassar was 90 cm with the majority falling during the winter months with deep snow covers possible.

The study site was clearcut in 1976 and 1977 creating a 160-ha opening. After harvesting, the logging debris was machine piled and burned, leaving little or no woody material on the site. Because of the erosion potential on the site, the area was seeded with a mixture of orchardgrass and timothy (Phleum pratense). A mixture of lodgepole pine (Pinus contorta), western white pine, and ponderosa pine were planted at a rate of 860 trees per ha. These plantings failed to provide an acceptable stand.

The habitat type was grand fir/clintonia uniflora (Cooper et al. 1987). The dominant species were orchard grass, timothy, elk sedge (Carex geyeri), strawberry, sweetscented bedstraw (Galium triflorum), starry solomonplume (Smilacina stellata), and buckbean (Thermopsis montana). The overstory before harvesting consisted of western white pine, grand fir, western larch, Douglas-fir, and ponderosa pine.

The Vassar site was in two grazing pastures with a total area of 1200 ha. The grazing plan for the pasture allowed for 470 animal units. The grazing season began in early June and ended in early October. The area averages 1125 AUM in a normal grazing year.

Slate Study Site

The Slate study site was on the Nez Perce National Forest in central Idaho. The elevation is 1,280 m. Easterly and southerly slopes of 20 to 35% prevail. The soils are Typic Argixerolls with a fine-loamy texture. Extensive mass wasting has occurred in the area, but rooting depth of soils is deep and available water capacity is high. Annual precipitation averages near 35 cm.

The habitat type was Douglas-fir/(Physocarpus malvaceus) (Cooper et al. 1987). Woody vegetation consisted of ninebark (Physocarpus malvaceus), serviceberry (Amelanchier alnifolia), and currant (Ribes spp.), with herbaceous species dominated by houndstongue (Cynoglossum spp.), buckbean, orchard grass, and pinegrass (Calamagrostis rubescens). Prior to timber harvesting the stand consisted of mature ponderosa pine and Douglas-fir. The site was harvested in 1976 leaving a seed-tree overstory of ponderosa pine followed by a minimum amount of machine piling of the logging debris. The study area was enclosed in a 95-ha timber harvest unit within 600-ha cattle grazing pasture.

The cattle stocking rate for the pasture was 314 AUM. The cattle grazing on the allotment was a rotation system, alternating between spring and fall grazing. During the study, 183 animal units grazed the study area beginning in June or September for an average of 38 days.

Experimental Methods

At each study site 3 deer, elk, and cattle exclosures 1.2-ha in size were constructed. A companion, 1.2-ha site was chosen outside each exclosure. The paired exclosures and companion sites (each pair make up a replication) were located randomly in each harvest unit within the constraints of being able to construct the exclosures.

Two-year-old bare-root ponderosa pine grown at the USDA Forest Service nursery in Coeur d'Alene, Idaho, were planted within a 30-cm square area cleared of competing vegetation. In April 1983 the Slate and Vassar study sites were planted. The Hume site was planted in April 1984. Seedlings were planted using a planting hoe. After planting, each seedling was shaded with a 30 by 36-cm paper card. Each companion area and exclosure were planted with 350 trees in 25 tree rows at 2-m spacings within the row and between the rows. To minimize edge effect, 2 rows of seedlings were planted around the study trees.

Each tree was tagged and height measured at the time of planting. At 2-week intervals beginning in April 1983 at the Vassar and Slate sites, the trees were surveyed 7 times for damage. In 1984 and 1985 beginning in mid-April, 4 observations were made at 3-week intervals. In 1986, 1987, and 1988 one observation was made in October. Tree heights were measured in October of each year.

At each observation, damaged seedlings were examined to determine the probable source of injury. Dead trees were excavated and examined to determine cause of mortality. Damage or mortality was classified as cattle, big game (deer or elk), pocket gophers, or other rodents. Animal damage was indicated by removal of stem, branch, or root parts through feeding or trampling indicated by hoof prints on and around the tree. Cattle damage was distinguished from deer or elk by the presence of tracks and other sign, plus big game and cattle did not always occupy the study areas simultaneously. Nonanimal causes of damage and mortality (drought, frost, sun scald, snow, poor planting, unknown) were indicated by needle loss, desiccation, deformed roots, and bud loss that could not be attributed to animals. Because of the frequent observations all damages and causes of mortality were classified.

Forage utilization was determined by comparing ten 1-m square exclosures to 1-m square grazed plots located within the companion areas following procedures established by Brown (1954). At the end of the growing season, forage utilization was determined by clipping and weighing forage from the grazed and nongrazed plots. Percentage of utilization was determined by comparing the oven-dry forage weights of the nongrazed plots to the grazed plots.

For analysis we combined the damages into 5 groups: cattle, big game (deer or elk), pocket gophers, other rodents, and nonanimal. We calculated percentages of dead and damaged trees for each replication (exclosure and companion area), and we computed means and standard errors for the damage classifications. Mean year-end heights and standard errors were computed. Analysis of variance for a randomized complete block design was used to detect differences among causes of damage. Each pair of exclosures and companion areas were used as replications (3 at each study area). A T test was used to compare the grazed and nongrazed areas. Percentage data were transformed (square root arcsine) before analysis (Steel and Torrie I960). We ranked the means according to procedures outlined by Mize and Schultz (1985).

RESULTS

Forage utilization at Vassar, the grand fir/clintonia uniflora habitat type, was 50 to 60% (Table 1). Only 8% of the seedlings were alive after the 3rd season in the grazed area, and after 4 seasons entire replications were missing in the grazed areas. The majority of the mortality was caused by pocket gophers (71%) (Table 2). Nonanimal agents caused 12% mortality. Cattle caused 1.5% mortality, and game caused 4% mortality. After 3 years 61% of the trees died from pocket gophers in the nongrazed area and 71% in the grazed exclosure. In the nongrazed area 7% of the seedlings that survived were damaged, and 4% were damaged in the grazed area (Table 3). Browsing by pocket gophers caused the most reduction in height growth (Table 4).

Table 1. Forage utilization in the 3 plantations.

	Age of plantation (years)					
	1	2	3	4	5	6
	Percent					
	Slate					
Mean	46.0	48.0	52.7	53.0	52.7	50.3
SE	12.0	13.5	11.3	11.8	9.8	10.8
	Vassar					
Mean	58.3	54.0	50.0			
SE	10.6	10.5	9.7			
	Hume					
Mean	43.7	44.0	47.3	45.7	43.0	
SE	10.9	10.7	10.2	12.8	12.7	

Forage utilization at the Hume site, the western redcedar/Clintonia uniflora habitat type, ranged from 43 to 47% (Table 1). After 5 years 62% of the trees survived in the nongrazed area, and 49% survived in the grazed area (Table 2). The greatest mortality at the Hume site was from nonanimal causes. Cattle caused 3% mortality, and game caused 9% mortality (Table 3).

Game damaged 6% of the seedlings at the Hume site (Table 3). These trees and those damaged by rodents were growing at an annual rate of 13 cm (Table 4). Of the trees damaged by cattle, 3% had a growth rate of 5 cm less than nondamaged trees.

Forage utilization at the Slate site, the Douglas-fir/Physocarpus malvaceus habitat type, ranged from 46 to 53% (Table 1). In the nongrazed area 10% of the seedlings were killed by pocket gophers, and 12% succumbed to nonanimal causes (Table 2). In the grazed area nonanimal causes killed 20% of the trees, with 10% killed by gophers and 9% by game.

Damage at Slate in the nongrazed area ranged from 19% by nonanimal causes to 3% caused by rodents (Table 3). In the grazed area game caused the most damage at 18%. Trees damaged by game were growing at 17 cm per year and trees damaged by cattle were growing at 14 cm per year. This compared to nondamaged trees growing at 19 cm per year (Table 4).

DISCUSSION

Livestock grazing can be compatible with timber production. It has been shown to be an alternative for managing competing vegetation (Doescher et al. 1987, Allen and Bartolome 1989). Grazing of transitory ranges may not result in excessive direct damage to conifer plantations as shown by this study and those by Leininger and Sharrow (1989) and Krueger (1983). Even with acceptable levels of direct damage by livestock, higher mortality on grazed areas than nongrazed areas can occur as shown in this study (Table 2). Cattle use appears to create site conditions that favor other causes of seedling damage and mortality.

Table 2. Mortality of ponderosa pine by different causes at the 3 study locations.

Cause of mortality	Location and age of plantation					
	Hume 5-yr		Vassar 3-yr		Slate 6-yr	
	Mean	SE	Mean	SE	Mean	SE
	Percent					
	Nongrazed					
Living	61.5[a]	3.3	28.9[a]	18.8	75.2[a]	5.8
Cattle	--	--	--	--	--	--
Game	--	--	--	--	--	--
Gopher	9.0[b]	1.4	60.6[b]	19.0	10.1[b]	5.0
Rodent	7.0	2.5	1.0	0.4	2.6	0.8
Nonanimal	22.8	0.9	9.5	1.1	12.3	0.9
Total mortality	38.7	3.1	71.1	18.8	25.0	5.9
	Grazed					
Living	49.3	10.1	7.9	3.3	59.4	7.1
Cattle	2.7[b]	0.7[b]	1.5[b]	0.9[b]	3.6[b]	0.3[b]
Game	8.6	0.5	3.6	1.6	8.8	0.5
Gopher	10.5	0.7	70.9	7.4	9.8	2.3
Rodent	2.3	0.4	3.2	2.0	2.6	0.9
Nonanimal	26.6	10.0	11.8	3.0	19.4	1.5
Total mortality	50.6	10.1	92.1	3.3	40.6	4.7

[a]Significant ($P \leq .05$) differences between the grazed and nongrazed areas.
[b]Significant ($P \leq .05$) differences among causes of mortality.

Site disturbance by cattle appears to be sufficient to maintain gopher densities because gophers usually prefer disturbed lands (Teipner et al. 1983). Moreover, the severe site treatments such as those used at Vassar (machine yarding and machine piling of logging debris) along with grass seeding provide vigorous communities of grasses and forbs favoring pocket gophers. The conditions at Vassar caused a complete plantation failure in the grazed area predominantly caused by gophers. This was similar to the results found by Crouch (1971) attempting to reforest a 7-year-old burned-over area in south-central Oregon. In contrast, the month-long grazing season at the Slate site and the moderate site treatment did not create conditions that favored large pocket gopher populations, and gopher damage and mortality were within acceptable limits. The best control of pocket gophers is to recognize the problem and modify the habitat to reduce populations (Teipner et al. 1983). Grazing may be useful for reducing competing vegetation (Doescher et al. 1987), but it does not appear to be useful in reducing pocket gopher populations through habitat modification.

Table 3. Damage of ponderosa pine by different causes at the 3 study locations.

Cause of damage	Hume 5-yr Mean	Hume 5-yr SE	Vassar-3 yr Mean	Vassar-3 yr SE	Slate 6-yr Mean	Slate 6-yr SE
	Percent					
	Nongrazed					
None	49.9[a]	7.3	21.9[a]	16.0	43.5[a]	6.6
Cattle	--	--	--	--	--	--
Game	--	--	--	--	--	--
Gopher	0.3[b]	0.1	1.5[b]	0.5	9.5[b]	3.9
Rodent	3.9	1.4	--	--	2.7	0.8
Nonanimal	7.4	3.1	5.5	2.6	19.3	3.4
Total damaged	11.6	4.7	6.9	3.1	31.4	8.1
	Grazed					
None	34.2	9.0	4.2	1.1	26.2	6.4
Cattle	3.1[b]	0.2	0.8	0.2	1.9[b]	0.5
Game	6.3	2.1	0.9	0.5	18.0	4.2
Gopher	0.3	0.1	0.8	0.5	2.1	1.0
Rodent	2.1	1.2	0.3	0.1	2.5	1.4
Nonanimal	3.8	0.9	1.3	1.0	8.6	3.2
Total damaged	15.6	4.5	4.2	2.3	33.2	10.2

[a]Significant (P≤.05) differences between the grazed and nongrazed areas.
[b]Significant (P≤.05) differences among causes of mortality.

Nonanimal causes of damage and mortality were greater in the grazed areas than in the nongrazed areas at the 3 study sites. Even though strictly controlled grazing has been shown to improve the availability of soil moisture to seedlings and improve tree growth and vigor (Doescher et al. 1989), this study with operational grazing did not show similar results. Month-long or season-long grazing by cattle apparently created less favorable conditions for tree growth than in the nongrazed areas. Soil displacement, soil compaction, and shade removal could all contribute to more damage and mortality from nonanimal causes on the grazed areas compared to the nongrazed areas. In our study at the most controlled grazing situation (Slate) there was more seedling mortality from nonanimal causes in the grazed area than the nongrazed area.

Table 4. Annual height growth of ponderosa pine by damage classification for the 3 study locations.

Cause of damage	Hume 5-yr Mean	Hume 5-yr SE	Vassar 3-yr Mean	Vassar 3-yr SE	Slate 6-yr Mean	Slate 6-yr SE
	cm					
	Nongrazed					
None	19.0	0.9	14.4[a]	1.8	18.1	0.2
Cattle	--	--	--	--	--	--
Game	--	--	--	--	--	--
Gopher	18.8[b]	1.1	10.4	2.1	17.1	.4
Rodent	13.9	.7	--	--	16.0	1.5
Nonanimal	15.2	2.0	11.7	1.3	16.9	0.3
	Grazed					
None	20.7	1.5	19.9[a]	1.2	18.9	1.4
Cattle	15.8[b]	1.0	21.6[b]	1.2	14.0[b]	2.0
Game	13.1	1.2	20.9	1.4	16.7	2.1
Gopher	18.4	1.2	9.8	.8	15.6	2.3
Rodent	12.8	.9	12.0	3.0	16.0	1.0
Nonanimal	16.8	.5	13.0	.7	16.6	1.9

[a]Significant (P≤.05) differences between the grazed and nongrazed areas.
[b]Significant (P≤.05) differences among causes of mortality.

To prevent plantation failures, a complete and proper silvicultural system including grazing plans should be developed to meet common objectives. In our study the Vassar site was treated far too harshly in regards to opening size, surface soil disturbance, and the seeding of nonnative grasses to protect the site after harvesting. The Hume site also was excessively disturbed after harvesting beyond the present guidelines for site preparation in the Northern Rocky Mountains. A combination of factors including poor silvicultural practices and poor grazing practices lead to plantation failures. To minimize the conflict between livestock and timber production in new plantations, we recommend less than season-long grazing, less than 50% utilization of available forage, and timing of grazing after seedlings become "hardened" and established.

Timber production and cattle grazing are two important uses of public lands in the Mountain West. Several studies, Krueger 1983, Currie 1988, Allen and Bartolome 1989, have shown that livestock grazing and reforestation can be compatible. This study has shown that a combination of factors can be responsible for poor plantation performance. What appears to be missing is an integrated approach of livestock grazing, silvicultural practices, and plantation protection on many forest lands. If transitory ranges are going to be managed for all forest uses, many of the administrative constraints either real or perceived, need to be overcome.

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