The Effects of Plant Competition on the Growth and Survival of Bitterbrush Seedlings[1]

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Many winter deer ranges throughout the West have been steadily deteriorating as a result of overgrazing, fire, and insect depredations. Lack of winter forage has caused heavy mortality of deer. The problem has become so acute that some of the western states have started research to determine what can be done to rehabilitate these ranges, if and when the causes of deterioration can be controlled.

The California program was started in the deer winter range area east of the Sierra Nevada mountains. This area extends from Oregon to the Owens Valley in Inyo County. Special attention has been given to studies of bitterbrush (*Purshia tridentata*), the most important winter deer browse species in the eastside region.

This paper reports on a study of the effects of plant competition on bitterbrush seedlings. The work was done in Modoc County on the winter range of the California-Oregon Interstate deer herd. Here, the predominant vegetation is a transition type between ponderosa pine and the sagebrush-juniper complex. Big sagebrush (*Artemisia tridentata*), juniper (*Juniperus occidentalis*), rabbitbrush (*Chrysothamnus spp.*), and bitterbrush make up the bulk of the brush cover. The understory is composed of perennial grasses and annual and perennial forbs. A few scattered ponderosa pine (*Pinus ponderosa*) are also present. The annual precipitation averages between 12 and 14 inches, much of it falling as snow.

Methods

In areas of relatively low precipitation, such as the Modoc County study area, the most important, if not the limiting factor, in seedling establishment is soil moisture. It may be impractical in a range seeding program to improve soil moisture conditions by irrigation, but it is feasible to prepare seedbeds and control the vegetation that competes with seeded species for available soil moisture.

For this study of the effects of competition, three areas were selected inside a deer-livestock exclosure. One area was drilled with bitterbrush seed without soil preparation or removal of the stand of native plants. The other two were plowed, harrowed, and dragged with a rail. One of these was drilled with bitterbrush seed alone and the other with a mixture of bitterbrush and crested wheatgrass seed. Plots on the area prepared and drilled with bitterbrush alone were segregated for three different treatments. Some were kept weeded during three growing seasons, others were weeded only during the first growing season, and some were not weeded at all. The weeded plots represented negligible competition and those weeded only the first year were considered to represent light competition. The native and crested wheatgrass areas offered heavy competition. The crested wheatgrass probably did not use as much soil moisture as the established native vegetation during the first growing season. During the second and third season, however, the crested wheat-

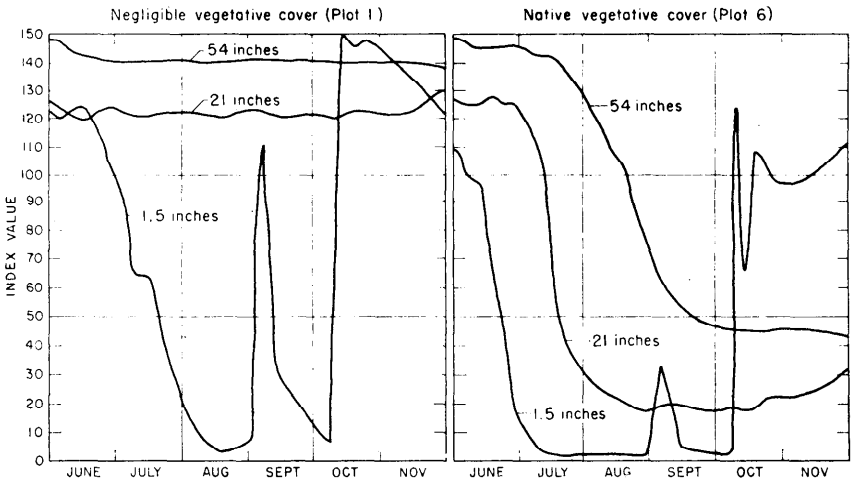

FIGURE 1. Trends of soil moisture indices at three soil depths— 1.5, 21, and 54 inches—under negligible and native vegetative cover during the first growing season (1953). Indices of 120 to 150 are in the range of high soil moisture; 0 to 30, in the range of low soil moisture.

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2 *The Experiment Station is maintained at Berkeley in cooperation with the University of California.*

grass competed at least as heavily as native plants for available soil moisture.

To obtain indices of stored soil moisture, fiberglas soil-moisture units (Colman, 1947) were installed at 1.5, 21, and 54 inches below the surface in both the plowed and weeded and the undisturbed areas. These units measure soil moisture in terms of electrical resistance. It is possible to calibrate the resistance readings with actual soil moisture percent. However, this was not done in this study. Instead, indices derived directly from weekly resistance readings were plotted to show soil moisture depletion.

Results

During the first growing season, soil moisture on the undisturbed, native area was depleted rather rapidly (Fig. 1). Moisture to a depth of 1.5 inches was largely used during June, and by late July most of it was taken to a soil depth of 21 inches. Even at the 54-inch depth soil moisture was heavily drained during August and September. Where plant competition was negligible, soil moisture was reasonably stable at 21 and 54 inches throughout the growing season. Even at the 1.5 inch depth, soil moisture was not depleted until mid-August, a full month later than on the undisturbed area.

The earlier and more complete depletion of soil moisture under heavy competition was reflected in bitterbrush seedling mortality and growth. Seedling mortality under heavy competition was between 57 and 60 percent during three growing seasons (Table 1). Under light competition, mortality was only 21 percent. Mortality under negligible competition was essentially the same as under light competition; apparently the invading annual weeds used relatively little of the stored soil moisture.

Table 1. Mortality through three growing seasons of bitterbrush seedlings emerging in the spring of 1953 under different levels of competition.

Level of competition	July 13 1953	At end of first growing season	At end of second growing season	At end of third growing season
		Percent		
Negligible	17.1	21.0	22.4	22.4
Light:				
Weeded during first growing season	17.1	21.0	21.0	21.0
No weeding	17.1	20.5	20.8	20.8
Heavy:				
Crested wheatgrass	20.5	31.2	46.5	60.0
Native vegetation	17.8	45.0	55.0	56.6

From the time of bitterbrush seedling emergence until July 13 of the first growing season (Table 1), seedling mortality was essentially equal at all competition levels. Soil moisture below 1.5 inches held up well until about this date under both clear-cultivated and undisturbed conditions. Mortality before July 13 can probably be attributed, at least in part, to cutworms and other insects. After that date, the bulk of the die-off was probably due to the lack of soil moisture. It was during the latter period that the big differences in mortality began to show up between the plots with negligible and heavy competition. Considerable mortality occurred during the second year in the undisturbed and crested wheatgrass areas, and the third year in the crested wheatgrass area. Under negligible and light competition few seedlings died in the second year and none in the third.

The most striking contrast, however, was in the size of bitterbrush seedlings under the different levels of competition (Table 2, Fig. 2). Bitterbrush seedlings under heavy competition grew only during a relatively short time in the spring.

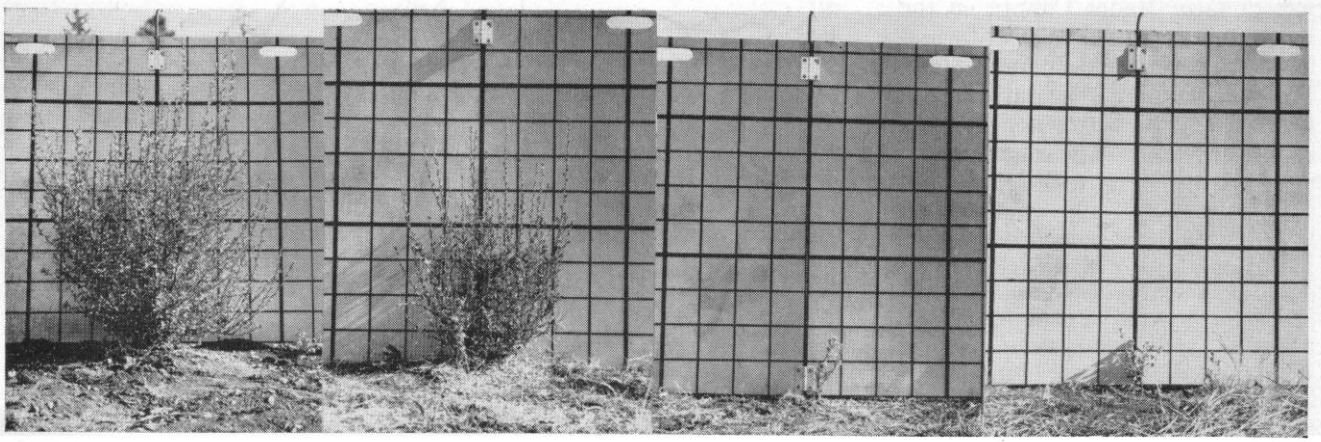

FIGURE 2. Three-year-old bitterbrush seedlings under four levels of plant competition at the Flukey Spring experiment area. *Left*: Negligible competition. *Next*: Light competition. *Third*: Heavy competition, crested wheatgrass. *Fourth*: Heavy competition, native vegetation. (Small squares on the backboard are 3 inches across.)

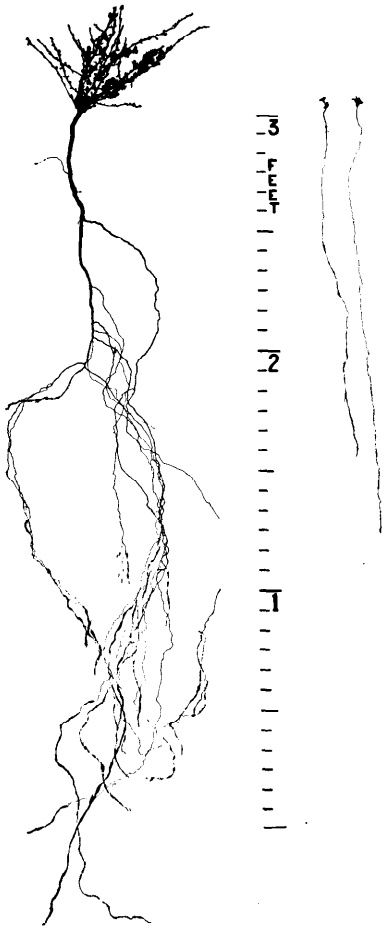

FIGURE 3. Root development of bitterbrush seedlings grown under two degrees of plant competition. *Left*: Negligible competition. *Right*: Heavy competition.

Those on the plowed area continued to grow throughout the summer. After three growing seasons seedling heights varied from 4.5 inches on the undisturbed native area, and 5.5 inches on the crested wheatgrass area, to 26 inches on the plowed and weeded plots.

The difference in the vigor of the plants was also reflected in development of their root systems. Under light and negligible competition the roots penetrated to 42 inches during the first growing season and were extensively branched. Under heavy competition they penetrated only 20 to 30 inches and generally were unbranched, thin taproots (Fig. 3).

Table 2. Average height through three growing seasons of bitterbrush seedlings emerging in the spring of 1953 under different levels of competition.

Level of competition	End of first growing season	End of second growing season	End of third growing season
	Inches	Inches	Inches
Negligible	6.0	13.8	26.0
Light:			
Weeded during first growing season	6.0	12.8	21.4
No weeding	4.7	9.5	18.0
Heavy:			
Crested wheatgrass	1.9	2.8	5.5
Native vegetation	1.3	2.6	4.5

Conclusion and Summary

Seedbed preparation, alone and with subsequent weeding, permitted greatly increased seedling growth of bitterbrush and reduced seedling mortality. Even though some of the seedlings growing under heavy competition from native plants may survive many years, there is little chance that they will break free of the competition and become dominant plants. This study was conducted under favorable site and precipitation conditions. Preliminary results from another study indicate that complete mortality of emerged bitterbrush seedlings may occur under less favorable conditions on native, untreated areas.

Weeding after seedbed preparation increased the growth rate of bitterbrush seedlings over soil preparation without follow-up weeding, but the increase was not enough to warrant the extra expense. Weeding could not be justified in an extensive range seeding program.

Planted crested wheatgrass provided about the same level of competition as native vegetation, judging from growth performance of bitterbrush seedlings. It may sometimes be desirable to seed both bitterbrush and crested wheatgrass to provide additional forage, reduce livestock use of bitterbrush, or aid fire protection. Seeding of this type was done (U. S. Forest Service, 1950) in Oregon with the two species sown in alternate drill rows. Seeding alternating drill widths might be another feasible method. Mixing the two species, as in the present study, seems unlikely to give satisfactory results.

Many areas suitable for bitterbrush reseeding would be expensive to cultivate; some would be impossible, but other methods of removing competing vegetation, such as burning and chemical spraying, can sometimes be used. It would be advisable to study other sites and other levels of competition to determine the maximum level of competition by sites under which satisfactory establishment and growth of bitterbrush seedlings can be obtained. Economical methods of reducing existing vegetation must then be developed.

Acknowledgement

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