Successional Trends in a Ponderosa Pine/ Bitterbrush Community Related to Grazing by Livestock, Wildlife, and to Fire

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Highlight: A ponderosa pine/bitterbrush community in the South Fork of the Salmon River, Idaho, was determined to be a seral stage of a Douglasfir/snowberry habitat type. An exclosure, erected in 1959 to evaluate effects of browsing on bitterbrush by big game, contained more kinnikinnik and less Idaho fescue than did the outside area. Bitterbrush density was similar outside and inside the exclosure, but twig production was 12 times greater outside. A combination of periodic natural fire prior to effective suppression starting in the 1940's, and livestock grazing were probably initially responsible for the secondary successional vegetation on the site. Subsequently, utilization by big game of this vegetation has served to maintain the productivity of the bitterbrush and retard succession to climax.

Bitterbrush (*Purshia tridentata*) is generally recognized as a component of climax dry forest and steppe habitat types in Idaho (Daubenmire and Daubenmire 1968; Steele et al. 1975). A 0.047-ha (one acre) big game exclosure established in 1959 on a big game winter range on the Buckhorn Bar, South Fork of the Salmon River of central Idaho has provided an opportunity to evaluate successional status of bitterbrush (*Purshia tridentata*) in relation to habitat type and land use practices. Two hypotheses were tested during this study: (1) bitterbrush was a seral species within a zootic-pyrrhic disclimax of a Douglasfir (*Pseudotsuga menziesii*)/snowberry (*Symphoricarpos albus*)-kinnikinnik (*Arctostaphylos uva-ursi*) habitat type (h.t.), and (2) foraging by mule deer (*Odocoileus hemionus*) and elk (*Cervus elaphus*) was contributing to maintenance of the existing bitterbrush stand outside of the exclosure.

U.S. Forest Service records, including history of the area, standing crop and annual productivity measurements of bitterbrush, and canopy coverage/composition measurements of the understory made in July 1976, form the basis for testing the hypotheses.

Study Area

Buckhorn Bar is underlain by granitic gravel substrate, approximately 100 m above current river level at an elevation of about 1,400 m. The surrounding canyon slopes are very steep, unglaciated decomposed granite. Climate is mild and relatively dry with an average precipitation about 620 mm at a river-grade station (Krassel R.S.) 10 km south of Buckhorn Bar. Temperatures seldom go below −10°C in winter and snow is rarely over a few centimeters deep. Mid-June to mid-September is normally without effective precipitation. The South Fork Salmon River canyon is dominated by forests of ponderosa pine and Douglasfir. Dry-lightning is common during the summer drought and the evidence of high fire frequency is easily read from the trees.

A savanna-like stand of uneven-aged ponderosa pine dominates Buckhorn Bar; the great majority of trees are mature and yellow-barked. In and around the exclosure there are about 245 trees/ha. Mean diameter breast high is 24 cm with the larger trees up to 91 cm. Two Douglasfirs of about 15 cm dbh were also present in the vicinity, but they were very rare on Buckhorn Bar. The understory of the general area was dominated by bitterbrush 0.9–1.8 m tall, rather widely spaced. Average stem age of bitterbrush was 26 (15–39) years based on annual ring counts of 13 randomly selected stems. Lesser amounts of snowberry, low huckleberry (*Vaccinium caespitosum*), wild rose (*Rosa woodsi*), and white spiraea (*Spiraea betulifolia*) form a very open low-shrub layer, while a few scattered Scouler willow (*Salix scouleriana*) and serviceberry (*Amelanchier alnifolia*) plants represent the tall shrubs. Graminoids, chiefly Idaho fescue (*Festuca idahoensis*), Junegrass (*Koeleria cristata*), and pinegrass (*Calamagrostis rubescens*) dominate a widely spaced ground layer which is rich in forbs.

The area had a history of fire as evidenced by fire scars on many pine trees, and charcoal on stumps and downfalls. Human use of the area dates back over 75 years, consisting primarily of domestic livestock grazing until the 1940's. Around 1940 the river bars were described by the District Ranger as "dust beds" from sheep and horse use. Grazing was sharply reduced in the late 1940's, and excluded in early 1960. Establishment of the current bitterbrush stand dates to the initial reduction of livestock grazing. Occasional selective cutting of larger insect-infested pine ceased in the early 1960's.

Method

Vegetation Sampling

Vegetation was sampled with a series of micro- and macroplots taken inside and immediately outside of the exclosure. Four lines were placed perpendicular to the sides of the exclosure at estimated mid-points from the corners. Ten 2 × 5-dm (0.2 m^2) plots were taken on each line both inside and outside with a plot interval of about 1.5 m between plots. A 2-m distance from the fence was maintained to prevent bias associated with the edge. A road-trail over 15 years old was by-passed by doubling the plot interval. Cover was estimated as outlined by Daubenmire (1959) using six cover classes, on plants rooted in the plots. This method is most reliable for low plants of relatively discrete habit. Taller shrubs, such as bitterbrush, often go unsampled, while cover estimates of rhizomatous grasses, such a pinegrass, are very inaccurate. To add depth to the vegetational

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description, cover was also estimated on two circular macro-plots of 375 m^2 inside and outside the exclosure. This system follows Daubenmire and Daubenmire (1968) as modified by Steele et al. (1975) and allows direct comparison with plot data published for most of the forest habitat types of Idaho and western Montana. The northern plot pair was chosen to represent medium bitterbrush density with typical ponderosa pine overstory dominance. The southern plot pair was judged typical of open areas with virtually no overstory shade and higher coverage of bitterbrush. Habitat types were determined using Steele et al. (1975). Voucher specimens of most plants were deposited in the Research Herbarium, College of Forestry, Wildlife and Range Sciences, University of Idaho (IDF). Scientific and common plant names follow Hitchcock and Cronquist (1973).

Parker 3-step transects (Parker 1951) were measured inside and outside the exclosure in 1959, 1964, and 1975. These provide direct estimates of vegetation change when grazing by big game is excluded.

Bitterbrush Sampling

Production of current year twig growth of bitterbrush was used as the index to productivity. Twigs were counted within 35 4-m^2 circular plots, inside and outside adjacent to the exclosure, following Shafer (1963). A regression equation of twig weight as a function of length was determined by clipping, measuring the length, oven-drying at 70°C for 24 hours, and weighing 68 twigs representing the range of lengths encountered on the site. Lengths of 100 unbrowsed twigs inside and outside of the exclosure were measured to nearest 0.5 cm. A mean weight per twig was obtained from mean leader lengths inside and outside the exclosure and multiplied by the mean number of twigs per m^2 to arrive at weight estimates for twig growth.

Standing crop of aerial shoots of bitterbrush was estimated by counting individual plants within the 4-m^2 plots. A crown cover estimate was made by measuring two diameters at right angles to each other across the canopy of each plant; and canopy area was determined using the formula

$$\alpha = \frac{\pi}{4} d_1 d_2$$

where α equals canopy area and d equals one diameter (cm) across the canopy of the plant. Ten whole plants representative of the variation in plants within the stand were measured, clipped at ground level, and weighed. A regression equation of weight of plant on its canopy area was calculated following Peek (1970). Calculation of standing crop was made by determining a mean canopy area for plants inside and outside the exclosure, converting to weight using the regression equation, and multiplying by stem density/ha. A significance level of $P = 0.10$ is used in all statistical tests unless otherwise specified.

Heights of all bitterbrush plants within the plots and percent of crown covered by the arboreal black lichen *Bryoria fremontii* Tuck, and number of dead plants were also determined.

Results

Present Vegetation

Table 1 summarizes micro- and macro-plot data and compares with the Douglasfir/snowberry habitat type-kinnikinnik phase and the ponderosa pine/bitterbrush habitat type-Idaho fescue phase from Steele et al. (1975). Steele et al. (1975) sampled 11 Douglasfir/snowberry stands and three ponderosa pine/bitterbrush stands in the central Idaho area. Both microplot and macroplot data reveal several remarkable differences in the vegetation outside and inside the exclosure. Idaho fescue, Junegrass, and intermediate oatgrass (*Danthonia intermedia*) declined dramatically inside. Pinegrass declined substantially in macroplots while remaining about the same in microplots. Other graminoids showed but small differences outside to inside. Figure 1, taken in July 1976, compares vegetation inside and outside the exclosure.

There were 31 species of forbs, most low in both cover and frequency in microplots and cover in macroplots both outside

Table 1. Summarization of species cover values and frequencies in microplots (0.1 m^2) and macroplots (375 m^2) inside and outside the Buckhorn Bar exclosure, and comparison with cover values for Douglasfir/snowberry and Ponderosa pine/bitterbrush habitat types.

	Macroplots Avg. cover % (+ = < 1%)				Microplots % cover • % frequency (+ = < 0.9%)	
	Two plots Psme/Syal-Aruv		All plots[1] Avg. cover			
Vascular plants	Outside	Inside	Psme/Syal-Aruv	Pipo/Putr-Feid[3]	Outside	Inside
Graminoids						
*Agropyron repens	+	+	•	•	•	+ • 3
Calamagrostis rubescens	20	9	15	•	4 • 60	6 • 70
Carex geyeri	2	+	3	3	+ • 3	•
Carex rossii	+	•	•	1	+ • 8	1 • 5
Carex sp.					+ • 3	+ • 3
Danthonia intermedia	9	2	•	•	2 • 25	+ • 18
Festuca idahoensis	15	2	1	22	4 • 45	+ • 3
Koeleria cristata	2	+	1	1	1 • 23	+ • 8
Luzula campestris	•	+	•	•	•	
Poa sp.	+	+	•	•	+ • 15	+ • 10
Unknown grass					+ • 3	
Forbs						
Achillea millefolium	+	+	1	3	1 • 65	1 • 48
Antennaria microphylla	+	+	•	1	+ • 15	+ • 20
A. neglecta	+	+	•	•	2 • 23	+ • 5
A. stenophylla	•	+	•	•	•	•
Arenaria congesta	•	+	•	•	+ • 10	+ • 5
A. macrophylla	+	+	•	•	+ • 8	+ • 13
Calochortus eurycarpus	+	•	•	•	•	•
Campanula rotundifolia	•	+	•	•	•	•
Castilleja spp.	+	•	•	•	+ • 3	•
**Collinsia parviflora* (A)	+	•	•	•	+ • 10	•
Collomia tinctoria (A)	+	•	•	•	+ • 8	•
Epilobium angustifolium	+	+	•	•	+ • 8	+ • 8
E. paniculatum (A)	•	•	•	•	+ • 3	•
Fragaria virginiana	+	+	1	3	2 • 48	+ • 38
Gayophytum (A)	+	+	•		+ • 25	•
Gentiana affinis	•	+	•	•	+ • 5	•
Geum triflorum	+	+	•	•	+ • 3	+ • 3
Hieracium albertinum	15	3	•	•	3 • 63	1 • 28
Lotus purshiana (A)	+	•	•	•	+ • 20	•
Lupinus sericeus	+	+	•	•	+ • 3	+ • 3
Madia exiqua (A)	+	•	•	•	+ • 5	•
Microsteris gracilis (A)	•	•	•	•	+ • 8	•
Montia perfoliata (A)	•	•	•	•	+ • 3	•
Orthocarpus tenuifolius (A)	+	•	•	•	+ • 13	•
Penstemon procerus	+	+	•	•	+ • 15	+ • 8
Potentilla glandulosa	+	+	•	•	•	•
P. gracilis	+	+	1	•	•	•
Sedum stenophyllum	•	•	•	•	+ • 5	•
Solidago missouriensis	+	+	•	•	+ • 15	•
Trifolium longipes	+	•	•	•	+ • 3	+ • 3
Zig adenus venenosus	+	•	•	•	•	•
Shrubs						
Amelanchier alnifolia	+	+	1	0	•	•
Arctostaphylos uva-ursi	9	50	56	•	2 • 15	46 • 80
Physocarpus malvaceus	•	+	•	•	•	•
Purshia tridentata	50	38	15	22	+ • 3	+ • 3
Ribes irriguum	•	+	•	•	•	•
Rosa woodsii	3	3	•	•	+ • 10	2 • 25
Salix scouleriana	+	2	•	•	•	•
Shepherdia canadensis	+	+	•	•	•	•
Spiraea betulifolia	+	•	15	•	+ • 8	+ • 10
Symphoricarpos albus	3	9	26	3	1 • 28	3 • 45
Vaccinium caespitosum	2	+	•	•	1 • 18	1 • 13

* = Alien taxa.
(A) = annual.
[1] Steele et al. 1975.
[2] Psme/Syal-Aruv = Douglasfir/snowberry habitat types (Steele 1975).
[3] Pipo/Putr-Feid = Ponderosa pine/bitterbrush habitat types (Steele 1975).

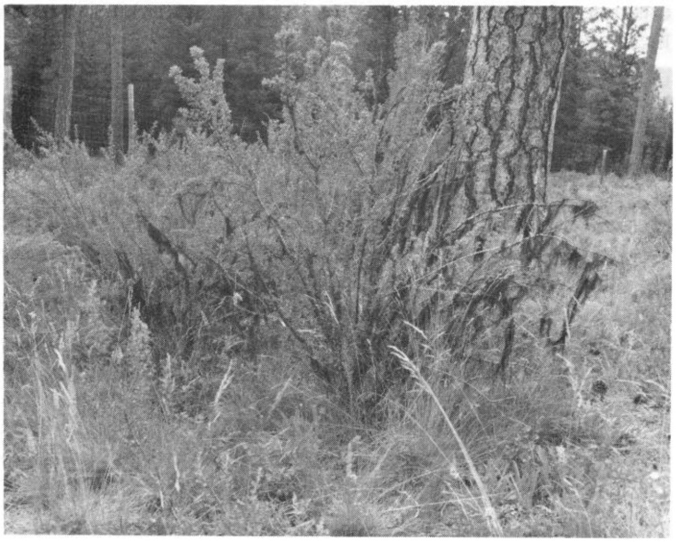

Fig. 1. *Comparisons of bitterbrush plants inside (left) and outside (right) of the Buckhorn Bar exclosure illustrating differences in black lichen occurrence.*

and inside. Most significant was the decline of hawkweed (*Hieracium albertinum*) inside, substantiating the seral role of this common forb in this habitat type.

Nine species of annuals occurred in plots outside of this exclosure, none with significant cover or frequency. Only one species, *Lotus purshiana*, appeared in plots inside the exclosure, testifying to the trend toward climax of the vegetation inside.

The most obvious difference in the outside/inside vegetation comparison occurred with kinnikinnik. Outside, kinnikinnik had a microplot frequency of 15% and a cover of 2%, while inside frequency and cover increased to 80% and 46%, respectively. Cover of this species in macroplots outside and inside were 9% and 50%, respectively. The average cover of bitterbrush remained about the same inside and outside the macroplots, while a few scattered tall and midsize shrubs including serviceberry, Scouler willow, and buffaloberry (*Shepherdia canadensis*) appear in small amounts. The trend toward snowberry domination at climax was shown by slight increases in its macroplot cover and larger increases in microplot cover and frequency. Low huckleberry (*Vaccinnium caespitosum*) may be a seral increaser on this habitat type, but it shows little change after 17 years of protection from browsing, suggesting a long-term role in the successional process.

Successional Trends

Parker 3-step data indicated downward trends of Idaho fescue and yarrow and upward trends of snowberry and kinnikinnik inside the exclosure (Table 2). Pinegrass declined both outside and inside, indicating a seral role following fire.

Bitterbrush showed similar trends in cover inside and outside of the exclosure, with highest coverage occurring in 1975. Alberta hawkweed, the most abundant forb in our outside plots, showed a strong upward trend outside in the Parker 3-step data. The 3-step data strongly imply that hawkweed was not an important early seral species but achieved an important role more recently.

Bitterbrush Standing Crop

The coefficient of determination for the regression weight of arboreal stems of bitterbrush on canopy area was 0.85, and the regression was significant at the 0.01 level of probability (Fig. 2). Regression coefficient derived separately from plants inside and outside the exclosure were not significantly different. Mean canopy area of 48 plants measured inside the exclosure was $3{,}956 \pm 737$ cm^2, and of 76 plants measured outside, $4{,}729 \pm 1{,}005$ cm^2. Standing crop of plants outside the exclosure was 157 ± 6.8 g/m^2, and inside 115 ± 7.5 g/m^2, or 73% of the weight of the outside crop (Table 3).

Stem densities per m^2 were similar inside (0.336 ± 0.022) and outside (0.325 ± 0.014) the exclosure. Plant heights averaged 88.37 ± 6.7 cm inside the exclosure and 80.95 ± 7.6

Table 2. Comparisons of vegetation (% cover) inside and outside the Buckhorn Bar exclosure in 1959, 1964, and 1975.[1]

	1959		1964		1975	
Vegetative cover	Inside	Outside	Inside	Outside	Inside	Outside
Graminoids						
Calamagrostis rubescens	38	45	32.5	35.7	2	5.9
Carex geyeri	–	–	5	–	–	–
Festuca idahoensis	5.5	25	7	25	–	11.8
Koeleria cristata	–	–	–	7	–	–
Poa spp.	–	–	–	7	–	–
Forbs						
Achillea millefolium	2.8	–	–	–	–	–
Anemone sp.	2.8	–	–	–	–	–
Antennaria spp.	5.5	5	7	10.7	3.5	–
Eriogonum spp.	–	5	–	–	–	–
Fragaria virginiana	–	–	–	–	3.5	–
Heuchera sp.	2.8	–	–	–	–	–
Hieracium albertinum	–	–	2	–	4.5	29.4
Potentilla spp.	–		5		–	
Shrubs						
Arctostaphylos uva-ursi	2.8	5	23	3.6	33	–
Purshia tridentata	23	10	14	10.7	38	35.3
Rosa woodsii	11	–	2	–	2	–
Spiraea betulifolia	–	5	–	–	–	5.9
Symphoricarpos albus	7	–	2	–	13	5.9
Vaccinium caespitosum	–	–	–	–	–	5.9
Total plant cover	37	20	43	28	56	17
Moss	8	7	9	5	1	0
Bare soil	3	15	0	7	0	0
Litter	52	58	48	60	43	83

[1] Data are percentage cover values taken from Parker 3-step transects by U.S. Forest Service personnel. Records are on file at Krassel Ranger Station, Payette National Forest.

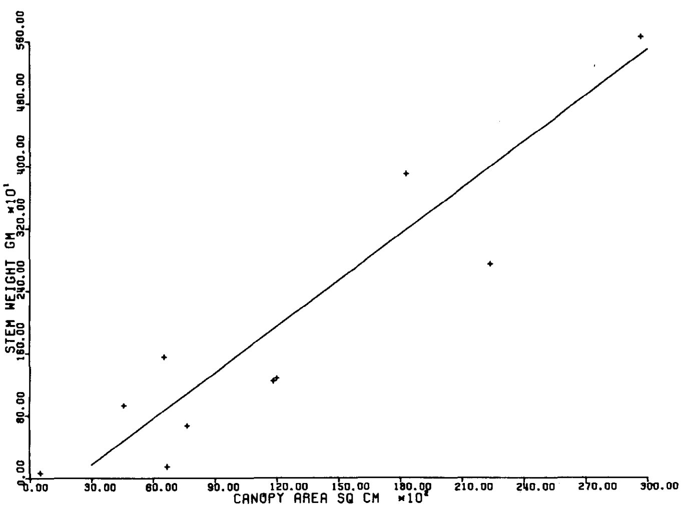

Fig. 2. *Regression of aerial stem weight of bitterbrush on canopy area. The regression equation is* $Y = -383.47 + 0.1834X$. $r^2 = 0.85$. *Data were collected in July 1976.*

outside the exclosure. In addition, an average of 16 ± 6% of the crown canopies of bitterbrush within the exclosure were covered with the common black tree lichen, while this palatable species was completely absent from bitterbrush outside (Table 3).

Dead stem densities averaged four times greater inside the exclosure than outside (Table 3). Thus the bitterbrush stand inside the exclosure was similar in density to that outside, but was uniformly taller, with more dead stems, greater black lichen coverage, and smaller canopy area. These factors indicated that bitterbrush vigor was deteriorating within the exclosure when compared with that existing outside.

Bitterbrush Production

Twig production was much greater outside than inside the exclosure, probably reflecting the stimulating effect of moderate browsing (Table 3). Approximately 12 times more twigs per m² were produced outside than inside, accounting for a similar disparity in weight production. Regression coefficients of twig weight on length derived separately for twigs inside and outside the exclosure were not significantly different. Twig lengths were significantly greater outside the exclosure (5.36 ± 0.65 cm) than inside (3.39 ± 0.56 cm). However, twig weights did not differ significantly. The regression of twig weight on length was significant ($P = 0.001$) and had a coefficient of determination of 0.889 (Fig. 3). The regression equations of Basile and Hutchings (1966), developed from twigs collected during plant dormancy, estimated twig weight at 62% of the estimates derived from collection during the growing season on the study area.

Table 3. Standing crop, productivity, height, dead stem density, and lichen coverage on bitterbrush inside and adjacent to the Buckhorn Bar exclosure, South Fork Salmon River, in July 1976. Confidence interval (CI) is 90%.

	Outside		Inside	
Cover	X̄	CI	X̄	CI
Stems/m²	0.325	± 0.014	0.336	± 0.022
Canopy area per plant (cm²)	4,729	± 1,005	3,956	± 737
Stem weight/m² (g)	157	± 6.8	115	± 7.5
Plant height (cm)	80.9	± 7.6	88.4	± 6.7
% canopy covered by lichen	0		16	± 5.7
Dead stems/m²	0.075	± 0.032	0.279	± 0.085
Current year's twigs/m²	224.8	± 20	19	± 1.5
Twig weight/m² (g)	14.36	± 1.28	1.21	± 0.96

Discussion

To most observers, Buckhorn Bar appears to be an undisturbed area. Based on keys and descriptions provided by Steele et al. (1975), plus the insight of over 20 years' experience in forest typing, Buckhorn Bar was determined to be a Douglasfir/snowberry h.t.-kinnikinnik phase. However, this area will not key directly due to the paucity of Douglasfir, which could be considered accidental. Thus, the vegetation here could easily be taken to represent the ponderosa pine/bitterbrush h.t., Idaho fescue phase. The description of this habitat type (Steele et al. 1975, p. 32) and the occurrence map (p. 31) all support this conclusion. Only the constancy table (p. 173–174) provides insight to the discrepancy between the Buckhorn Bar vegetation and a ponderosa pine/bitterbrush climax.

In the climax condition, bitterbrush and Idaho fescue can be expected to disappear from Buckhorn Bar. Both are important winter forage species for big game in this area. Yarrow, Alberta hawkweed, the three species of *Antennaria*, and most small annual forbs, all are either seral or disturbance increasers in this type. Lack of low huckleberry in the Steele et al. (1975) data helps to establish the seral role of this shrub in this habitat type,

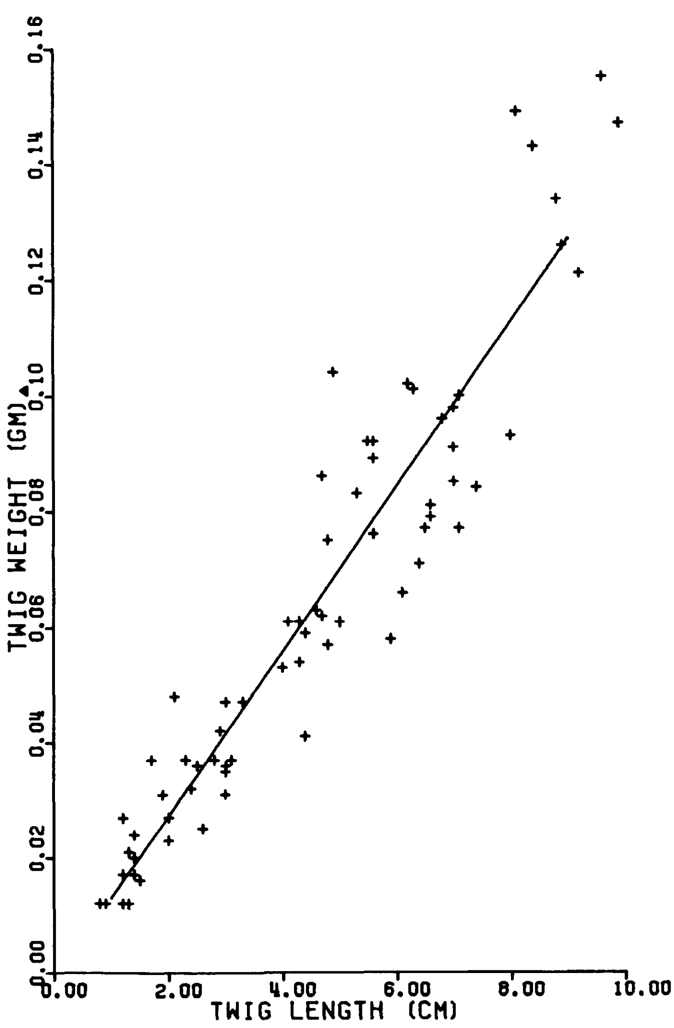

Fig. 3. *Regression of twig weight on length of bitterbrush. The regression equation is* $Y = -0.001 + 0.014X$. $r^2 = 0.89$. *Data were collected in July 1976.*

while our data show it to be slow in yielding to the advancing succession.

U.S. Forest Service utilization estimates for bitterbrush outside the exclosure from 1959 to 1975 averaged 60% of current growth removed (range 33–84%). The average fell within the maximum allowable annual utilization for bitterbrush as determined from clipping (Garrison 1953). It also appeared that this level of use had maintained bitterbrush in vigorous condition on Buckhorn Bar, while after 17 years of protection from browsing, the plants within the exclosure were less productive. These observations were the reverse of often anticipated results, since exclosures were often established as public relation tools to demonstrate detrimental effects of heavy browsing on preferred forage by big game.

A "browse line" was evident on black tree lichens outside the exclosure, where no lichens were present below 2.5 m, indicating the high palatability of this species. Also, the few ponderosa pine and Douglasfir seedlings available to big game in the vicinity showed heavy browsing and some mortality. Ponderosa pine regeneration was present inside the exclosure.

We hypothesize that the combination of periodic natural fire prior to effective suppression dating from the 1940's and livestock grazing were initially responsible for the secondary successional vegetation present on this site. Subsequently, utilization by big game has served to maintain the productivity of the bitterbrush, prevent establishment of conifer regeneration, and retain the seral community. Thus, we conclude that this is an example where browsing by a big game population has perpetuated a favorable food source.

Management alternatives to retain this situation must be considered if the balance between big game and the winter range is altered to allow succession to continue. Experimental burning may be considered to determine response of bitterbrush, usually a nonsprouter following fire (McKell et al. 1972). Selective logging to retain the savanna-like qualities of the site is a less-risky alternative (Stuth and Winward 1976). Livestock grazing at a controlled level of use on herbaceous forage, when use of winter game forage would be minimal, is also to be considered. The current population and mix of elk and mule deer should also be maintained through judicious regulation of harvest, with utilization of bitterbrush as one guide to adjusting seasons. If successional trends toward the climax Douglasfir/snowberry habitat type progress, the area will eventually become much less valuable as winter big game range. Heavier ground fuel a better fuel continuity will also develop with the more me vegetation and thus forest fires will be both hotter and m difficult to control.

Bitterbrush is seral on this habitat type, with its seral positi being effectively maintained by moderate browsing by deer a elk. Also, the ponderosa pine/bitterbrush community represe one successional stage of a Douglasfir/snowberry habitat ty The following plants appear to be important seral species on t Douglasfir/snowberry habitat type: Idaho fescue, intermedi oatgrass, three species of *Antennaria*, Alberta hawkwe lupine, wild rose, low huckleberry, and bitterbrush.

Caution must be exercised by field crews, and particula those training them for habitat-type work. In habitat-typi observations beyond the obvious indicator (or key) plants often needed. Crews should be able to read and interp constancy tables. In this instance, the numbers of mesic fo present is a positive, though subtle, indicator that the fo depauperate ponderosa pine/bitterbrush climax is an inappro ate choice for classification.

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THESIS: NEW MEXICO STATE UNIVERSITY

Effects of Type and Rates of Nitrogen Fertilizers on Blue Grama (*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.) Rangeland Production, by Kenneth Owen Fulgham, MS, Animal, Range, and Wildlife Science. 1972.

A study was conducted on the Fort Stanton Experimental Research Station in Lincoln County, New Mexico, to determine the effects of four types of nitrogen fertilizers applied at two rates on production of a blue grama rangeland.

Ammonium nitrate, ammonium sulfate, sulfur coated urea and urea were applied at rates of 40 lb of nitrogen per acre annually and 80 lb nitrogen per acre biennially.

Fertilization increased production for carruth sagewort, grasses and other forbs ($P < .01$) during the study. The drouth experienced during the study influenced plant composition and production. Production of other forbs increased from 1970 to 1971 while the carruth sagew and grass production decreased. This was a result of the decrea precipitation. Urea was the most effective nitrogen source over th years. The 80 lb nitrogen per acre rate was more effective the first y while the inverse was true the second year.

Inflorescence production was not significantly influenced by fert zation except that there was a significant response to the low rate urea in 1970 on blue grama culm heights. Crude protein was increa almost 1% for all fertilizer treatments combined when compared to control.