Shrub-Steppe Vegetation Trend, Middle Fork Salmon River, Idaho

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Abstract—The Middle Fork Salmon River drainage of the Frank Church River-Of-No-Return Wilderness has a history of livetock grazing from 1890 to1950, and changes in grazing pressure from native ungulates. High mule deer (*Odocoileus hemionus*) populations occurred between 1940 and 1960, and high elk (*Cervus elaphus*) populations occurred in the 1990s. This paper describes the shrub-steppe communities inside and adjacent to exclosures in the Middle Fork. Also presented is the current vegetative appearance at sites photographed in 1925, 1968, and 1988. Comparisons of plant species composition and characteristics, plus knowledge of grazing history, provide a basis for interpreting vegetation change and relationships to herbivore populations.

The Frank Church River-of-No-Return Wilderness has an extensive history of grazing along the Middle Fork of the Salmon River and its major tributaries, dating back to the late 1800s. At Cabin Creek, a tributary to Big Creek approximately 15 miles west of its confluence with the Middle Fork, grazing was initiated in the early 1890s. Cattle were ranched from 1902 to the early 1950s. Saddle and pack stock were grazed from the early 1950s until 1973, when the USDA Forest Service acquired it (Hartung 1978). Sheep, cattle and horses were grazed in the Thomas Creek area beginning in the 1920s, until the Idaho Department of Fish and Game bought the homesteads in the early 1940s (Hamilton 1990).

Obvious evidence of the effects of past grazing on vegetation exists in areas such as at Cabin Creek, where wormwood (*Artemisia dracunculus)*, an increaser, is prevalent on south-facing slopes next to abandoned hayfields and pastures that were created in the riparian zones. Exotic species such as spotted knapweed (*Centaurea maculosa*) have invaded some areas that have not been grazed appreciably in the last half-century, but thus far the presence of these aggressive invaders is localized. Currently, grazing of pack and saddle stock is concentrated around inholdings, and effects on plant communities are considered in management.

The FCRNRW has a history similar to most of the intermountain west, wherein fire suppression became effective in the 1940s (Wellner 1970). Current fire management policies allowing fires to burn under most circumstances in the FCRNRW (USDA Forest Service draft environmental impact statement, Frank Church River-Of-No-Return Wilderness, 1998) may eventually reduce the influences of past fire suppression.

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A series of exclosures were established in the FCRNRW in the late 1940s and early 1950s to assist in determining the effects of grazing by livestock and wildlife (mainly mule deer, *Odocoileus hemionus*) on vegetation. These exclosures were examined at intervals through the 1960s and then largely abandoned. Some of the fences were removed, while others were left intact.

Examinations of exclosure sites at Hood Ranch, Little Loon Creek, Cow Creek, Brush Creek, Reservoir Creek, and Cave Creek in the Middle Fork of the Salmon River drainage were completed between June 1988 and July 1992 (figure 1). The descriptions provide comparisons of vegetative composition inside and outside of exclosures that were established to exclude livestock and big game at least 30 years ago. Additionally, sites that were photographed in 1925, 1968, and 1988 in Brush Creek and across from Reservoir Creek provided some comparisons of shrub cover through time.

Methods

We randomly established a transect of twenty, 2 x 5 dm plots on representative sites inside exclosures and on similar adjacent sites. Plots were 1 m apart. When more than one

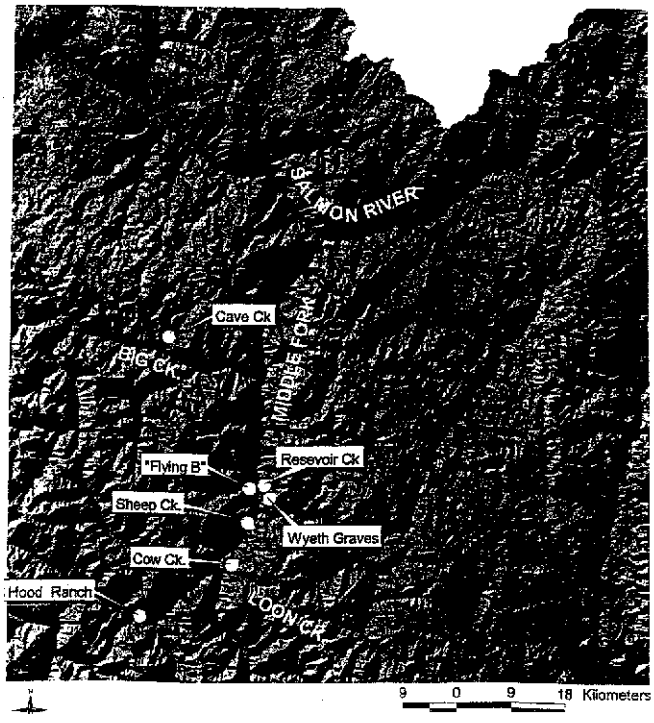

Figure 1—Middle Fork of the Salmon River exclosure locations.

vegetative type or topographical situation was present in an exclosure, paired plots were established inside and outside for each type where possible. We examined vegetation to determine if the fences appeared to influence composition and avoided locations immediately adjacent to fences.

Canopy coverage of each species in each plot was estimated to be in one of six standard categories: 1) 0-5%; 2) 5-25%; 3) 26-50%; 4) 51-75%; 5) 76-95%; 6) 96-100%. Canopy coverage is defined as the vertical projection to ground level of the maximum aerial canopy of the species within the sample plot (Daubenmire 1959).

Woody plant density was measured in 20, $4m^2$ circular plots (1.13 m radius) adjacent to the herbaceous transects. Counts of stems were made at ground level inside plots. Where individual plants had crowns with stems rising just below or at ground level and were obviously one plant, one plant was recorded. This occurred with antelope bitterbrush *(Purshia tridentata*), curl-leaf mountain mahogany (*Cercocarpus ledifolius*), big sagebrush (*Artemisia tridentata var. vaseyana*), currants (*Ribes cereum*, *R. viscossimum*), heath goldenrod (*Ericameria nauseosa)*, green rabbitbrush (*Chrysothamnus viscidiflorus*) and mallow ninebark (*Physocarpus malvaceus)* in this area. Height of a representative plant of each species in the plot was recorded. Dead plants were recorded when present, and percentage of decadent growth on each shrub was estimated.

Twigs, representing current annual growth (CAG) over 1 cm long, were counted for each species inside each plot. The plot was envisioned as a cylinder, and twigs within that cylinder were counted whether they originated from stems that occurred inside or not. A twig density was calculated to serve as a partial measure of productivity. Lengths of 50 or more randomly selected twigs were measured, air-dried and individually weighed. The entire collection was then weighed and oven-dried at 70° C for 24 hours and reweighed. The ratio of oven-dried weight to air-dried weight was multiplied for each twig weight to convert to the oven dried weight for each individual twig. Photographs were taken of all stands, and a description of the location of each transect was recorded. Plant nomenclature follows Hitchcock and Cronquist (1973) and the U.S. Department of Agriculture Natural Resource Conservation Service National Plant Database (1998 website: plants.usda.gov/plantproj/plants/index).

Data analysis used midpoints of the coverage estimation classes, and standard descriptive statistics for each species on the site were obtained using SAS-PC or STATISTIX. T-tests were used to determine significant differences (P=0.05) for selected vegetative parameters inside and outside of the exclosures. Coverage and density data were transformed using log (number + 1) to account for non-normal distributions. A Wilcoxon test was also used to compare with the t-tests, but no changes in conclusions resulted from the t-test comparisons.

Results

Cave Creek Exclosure

This site included a formerly exclosed area and adjacent areas that were unprotected. The site was a gently sloping, west-facing exposure. The major difference between the formerly exclosed portion and adjacent site was in the shrub component (table 1). Big sagebrush density was approximately 2.5 times greater on the formerly exclosed site. Dead sagebrush stem density was also greater The height of big sagebrush plants on the formerly exclosed site was double that of plants on unprotected areas.

Antelope bitterbrush heights were significantly greater on the formerly exclosed site, but stem densities were nearly

Table 1—Vegetative characteristics of the Cave Creek exclosure site.

Herbaceous species (coverage >5%)	Inside (Canopy cover ± S.D.)	Outside (Canopy cover ± S.D.)	T-test T	T-test P
Arrowleaf balsamroot *Balsamorhiza sagittata*	6.4 ± 14.5	4.6 ± 11.7	0.48	.631
Bluebunch wheatgrass *Pseudoroegneria spicata*	19.8 ± 27.7	14.8 ± 27.9	0.45	.656
Cheatgrass *Bromus tectorum*	0.3 ± 0.8	20.0 ± 23.6	6.60	.0001
Letterman's needlegrass *Stipa lettermani*	6.5 ± 13.8	8.8 ± 15.1	0.77	.443
Western yarrow *Achillea millifolium*	2.1 ± 4.5	5.0 ± 6.8	1.51	.142
Shrubs				
Big sagebrush (*Artemisia tridentata*)				
Height (cm)	160.5 ± 25.5	47.8 ± 16.0	8.33	.0001
Stems/m^2	0.63 ± 1.00	0.25 ± 0.40	4.00	.0003
Dead stems/m^2	0.33 ± 0.23	0.01 ± 005	6.02	.0001
Twigs/m^2	104.6 ± 84.9	21.6 ± 34.7	4.78	.0001
Antelope bitterbrush (*Purshia tridentata*)				
Height (cm)	134.8 ± 35.8	85.3 ± 24.8	4.99	.0001
Stems/m^2	0.05 ± 0.1	0.05 ± 0.10	.47	.6430
Dead stems/m^2	0.01 ± 05	0		
Twigs/m^2	2.72 ± 8.3	7.2 ± 14.9	1.11	.2792

identical. Twig density was greater outside than on the formerly exclosed site, but the difference was not significant. Dead stem density was negligible outside and very low inside for this species.

The major difference in the herbaceous union was the high coverage of cheatgrass (*Bromus tectorum*) outside of the formerly exclosed area, and the very low coverage inside. The high standard deviation outside reflected the patchy distribution of this species. Coverage of other species was not appreciably different, but green weight production of bluebunch wheatgrass (*Pseudoroegneria spicata*) was 16.7 gm/m^2 inside the exclosure and 29.5 gm/m^2 outside of the exclosure at the time of measurement, indicating a more vigorous grass community outside.

The differences between the formerly exclosed site and the unprotected site adjacent strongly suggest that the area had been disturbed. The consistency of bitterbrush density suggested this species was a dominant, and with the high coverage of bluebunch wheatgrass, indicated an antelope bitterbrush/bluebunch wheatgrass habitat type (Hironaka et al. 1983, Mueggler and Stewart 1980). The high amount of big sagebrush in the formerly excluded area suggested that grazing disturbance in past periods allowed the increase of this species, which was then protected from game browsing by fencing; this in turn essentially retarded succession by allowing retention of the sagebrush. Big sagebrush was still undergoing substantial mortality inside the formerly exclosed area, but mortality appeared to persist at a low level outside. The greater coverage of cheatgrass outside of the exclosure may be explained by the disturbance of both past livestock and perhaps by ongoing wildlife grazing, and this species may diminish in coverage on this site over time. The Housley Ranch, started in the early 1900s in Cave Creek, was abandoned about 1919 (Hartung 1978). The long history of livestock grazing in the Cabin Creek area immediately downstream from Cave Creek suggests that livestock grazing was an important influence on vegetation trends in the Cave Creek area as well.

"Flying B" Exclosure

The exclosure was established on an east-facing site in 1949. Bitterbrush was planted inside the exclosure. The outside transect was established north of the exclosure, which occurred on the ridge above the airstrip owned by the "Flying B". This area received extensive use by mule deer and is also grazed by horses.

The most striking aspect of the site was the dominance of balsam root (*Balsamorhiza sagittata*), both inside and outside the exclosure (table 2). The low coverage of bluebunch wheatgrass, lesser spikemoss (*Selaginella densa*), Idaho fescue and needle-and-thread outside of the exclosure reflected responses to grazing pressure when compared with vegetation inside the exclosure. Threetip sagebrush

Table 2—Vegetative characteristics of the "Flying B" exclosure site.

Herbaceous species (coverage >5%)	Inside S	Inside N	Outside N	T-test	
	(Canopy cover ± S.D.)			T	P
Arrowleaf balsamroot *Balsamorhiza sagittata*	12.6 ± 26.8	34.8 ± 39.3	21.6 ± 20.3	0.98	.329
Bluebunch wheatgrass *Pseudoroegneria spicata*	12.5 ± 23.2	12.9 ± 22.3	0.4 ± 0.9	3.51	.0017
Cheatgrass *Bromus tectorum*	32.4 ± 31.1	16.0 ± 26.4	4.5 ± 9.2	.582	.563
Field chickweed *Cerastium arvense*	0	10.1 ± 21.6	4.7 ± 6.4	.046	.963
Idaho fescue *Festuca idahoensis*	14.0 ± 26.6	7.1 ± 13.8	0.3 ± 0.8	14.96	.056
Longleaf phlox *Phlox longifolia*	3.4 ± 6.0	1.3 ± 3.4	0.5 ± 1.1	.686	.497
Lesser spikemoss *Selaginella densa*	26.3 ± 39.2	22.6 ± 38.6	0		
Needle-and threadgrass *Hesperochloa comata*	2.3 ± 8.4	10.8 ± 28.7	0		
Sandberg bluegrass *Poa secunda*	0.1 ± 0.6	3.0 ± 8.8	0		
Shrubs					
Antelope bitterbrush (*Purshia tridentata*)					
Height (cm)	0	168.8 ± 32.0	119.0 ± 53.8	2.64	.012
% decadence	0	24.5 ± 16.4	59.5 ± 15.4	6.97	.0001
Twig lengths (cm)	0	1.25[1]	4.75 ± 2.1	8.237	.0001
Threetip sagebrush (*Artemisia tripartita)*					
Height (cm)	0	64.3 ± 14.8	19.5 ± 7.8	10.56	.0001
% decadence	0	20.7 ± 16.2	20.0 ± 16.9	0.11	.907
Twig lengths (cm)	0	40.8 ± 5.0	8.0 ± 3.5	5.93	.0001

[1]No twigs over 1.25 cm long. One plant, 35 cm high with a 10 cm leader, was established on bare soil inside the exclosure.

(*Artemisia tripartita*), a palatable deer forage, outside of the exclosure was 30% of the height inside the exclosure, and twig lengths were 47% as long outside as they were inside.

Antelope bitterbrush plants inside the exclosure were tall, contained moderate amounts of dead stems and were essentially unproductive. No current annual growth was over 1 cm. In contrast, antelope bitterbrush plants outside were lower and contained large amounts of dead stems, and CAG averaged 4.8 cm long, the converse of threetip sagebrush, which was shorter and less productive outside than inside.

The site showed evidence of extensive current and past grazing. I hypothesize that this site is a threetip sagebrush/ Idaho fescue habitat type, with antelope bitterbrush being seral or existing at low density in the undisturbed state. Antelope bitterbrush was essentially not reproducing on the site (one plant 35 cm tall had established on bare soil inside the exclosure). Deer use was probably responsible for the lower heights and shorter twig lengths of threetip sagebrush and for the lower heights and longer twig lengths of bitterbrush outside the exclosure when compared with plants located inside. This suggests that threetip sagebrush was more sensitive to grazing pressure than antelope bitterbrush. An alternative explanation for the low heights and vigor of threetip sagebrush is that both deer and horses were grazing it, while only deer used the antelope bitterbrush. Herbaceous conditions outside the exclosure were attributed to grazing by horses. This raises questions about the conditions that allowed for the prevalence of antelope bitterbrush on this site which may be attributable to past grazing history. The antelope bitterbrush may have been planted in areas where that species is not especially suited, as the antelope bitterbrush inside the exclosure was obviously not vigorous and had not been so for years.

Sheep Creek Exclosures

The small exclosure (20 X 20 feet) inside the major exclosure was established in 1930, while the larger exclosure was established in 1961, thereby allowing comparisons of 59 and 27 years of protection with unprotected conditions. Crested wheatgrass (*Agropyron cristatum)* was planted inside the small exclosure, and 15 plants remained (table 3). There were 10 live and four dead antelope bitterbrush plants in the small exclosure, and they averaged 226.5 cm tall, as compared with the 165.8 cm height of seven antelope bitterbrush plants immediately adjacent on an unexclosed site. Three heath goldenrod plants occurred in the exclosure, 95, 95 and 125 cm tall.

Perhaps the most striking difference in the herbaceous union inside and outside the small exclosure was the dominance of needle-and-thread outside and the higher coverage of harryseed lomatium (*Lomatium foeniculatum*), longleaf phlox (*Phlox longifolia*) and tall tumble mustard (*Sisymbrium altissimum*) inside. Just what this was attributable to is unclear, but different grazing regimes, past and present, and the relatively small size of the exclosure, which may enhance moisture retention, may be responsible.

The larger exclosure provided similar comparisons and included more species (table 4), but harryseed lomatium was less prevalent in the large exclosure than in the smaller one. Bushy blazingstar (*Mentzelia dispersa),* was common on this site and was not observed elsewhere in the Middle Fork exclosures. If grazing is to be considered the major factor influencing differences between excluded and unprotected areas in this canyon, why should parsnip-flowered buckwheat (*Eriogonum heracleoides)* and longleaf phlox, both relatively unpalatable half-shrubs, be more prevalent inside

Table 3—Vegetative characteristics of the small Sheep Creek exclosure site.

Herbaceous species (coverage >5%)	Inside (Canopy cover ± S.D.)	Outside (Canopy cover ± S.D.)	T-test T	T-test P
Bluebunch wheatgrass *Pseudoroegneria spicata*	3.4 ± 9.3	0.8 ± 3.3	1.18	.248
Cheatgrass *Bromus tectorum*	4.4 ± 9.5	1.4 ± 3.4	0.96	.3509
Fennel-leaved desert parsley *Lomatium foeniculatum*	6.3 ± 11.9 .	.03 ± 0.8	2.384	.0255
Lesser spikemoss *Selaginella densa*	54.5 ± 39.9	31.6 ± 38.1	1.103	.2771
Longleaf phlox *Phlox longifolia*	20.8 ± 30.2	0		
Needle-and-Thread *Hesperochloa comata*	3.8 ± 6.7	26.3 ± 28.3	3.32	.0019
Shrubs				
Antelope Bitterbrush (*Purshia tridentata*)				
Height (cm)	226.5 ± 88.3	165.8 ± 66.3	1.134	.2748
Number of live plants	10	0		
Number of dead plants	4	0		

Table 4—Vegetative characteristics of the large Sheep Creek exclosure site.

Herbaceous species (coverage >5%)	Inside (Canopy cover ± S.D.)	Outside (Canopy cover ± S.D.)	T-test T	T-test P
Bluebunch wheatgrass *Pseudoroegneria spicata*	4.4 ± 19.6	0.8 ± 3.4	0.32	.748
Bushy blazingstar *Mentzelia dispersa*	6.4 ± 13.8	4.1 ± 14.1	.791	.4348
Cheatgrass *Bromus tectorum*	4.4 ± 9.5	1.4 ± 3.4	0.96	.3509
Fennel-leaved desert parsley *Lomatium foeniculatum*	0	0.3 ± 0.77		
Lesser spikemoss *Selaginella densa*	45.9 ± 38.3	21.1 ± 29.0	2.097	.0427
Longleaf phlox *Phlox longifolia*	6.4 ± 9.6	0.1 ± 0.6	3.962	.0005
Needle-and-Thread *Hesperochloa comata*	16.6 ± 23.9	29.8 ± 27.7	.9575	.3444
Parsnipflower buckwheat *Eriogonum heracleoides*	4.9 ± 21.8	0		
Shrubs				
Antelope bitterbrush (*Purshia tridentata)*				
Height (cm)	209.8 ± 80.3	195 ± 86.8	.833	.4084
Number of live plants	43			
Number of dead plants	13			

the exclosures than outside? Other factors, including competition for moisture between plant species, successional patterns of vegetation following protection from different kinds of disturbances, different soil and moisture regimes among the various exclosures (this site is the highest and is located on a ridgetop) and climatic change from periods of relative drought to periods of high precipitation were probably involved.

Forty-three live antelope bitterbrush plants occurred inside the large exclosure and were comparable in height to plants inside the small exclosure. Dead plants constituted 23% of the standing antelope bitterbrush stems. Needle-and- thread characterized the understory inside the exclosure, while a large variety of species constituted relatively equivalent proportions of the vegetative cover outside. Cheatgrass occurred primarily beneath bitterbrush plants, while needle-and-thread occurred in openings between shrubs, where effects of shade and perhaps moisture competition were less. The higher coverage of lesser spikemoss inside this exclosure was again considered a reflection of the lack of disturbance of the soil surface. This site was considered primarily a bitterbrush/bluebunch wheatgrass habitat type. This may be the most severe site enclosed in the general area.

Reservoir Creek Game Exclosures

The Reservoir Creek exclosures were established in 1949. The "game" exclosure was located on the west and southerly exposed slopes south of Reservoir Creek and contained a variety of sites and at least two habitat types. Outside replications on comparable adjacent sites were difficult to locate; finally, one outside replicate of the bitterbrush stand in the exclosure was located on an adjacent slope north of the exclosure.

The crest of the ridge inside the exclosure was considered a threetip sagebrush/Idaho fescue habitat type (table 5). No replicates were available for this community adjacent to the exclosure. The aspect was northwest. The community consisted of a vigorous stand of Idaho fescue, with bluebunch wheatgrass, Sandberg bluegrass (*Poa secunda*), hawksbeard (*Crepis atrabarba*), threetip sagebrush, and antelope bitterbrush all comprising between 3% and 10% canopy coverage.

The rest of the exclosure faced south to southwest and probably contained an antelope bitterbrush/bluebunch wheatgrass habitat type on the more xeric sites. The higher canopy coverage values of bluebunch wheatgrass and antelope bitterbrush outside the exclosure were from the adjacent slope and may reflect less severe growing conditions there. Antelope bitterbrush plants in the exclosure were most decadent on sites with the highest grass coverage. The youngest and thriftiest plants inside this exclosure occurred on the most severe sites, where grass cover was lowest. There were few plants less than 30 cm tall, which indicated seedling establishment, but antelope bitterbrush plants were more commonly reproducing by layering. Plants outside the exclosure showed three to four times the leader growth of those inside and were intensively browsed. Dead and decadent antelope bitterbrush was significantly greater inside than outside the exclosure, with the difference being related to associated grass cover. Mule deer were the major users of this site, and a few pellet groups were found inside the exclosure.

Reservoir Creek Stock Exclosure

This exclosure was on a gentle slope below the game exclosure and further south. It appeared to be an antelope bitterbrush/bluebunch wheatgrass habitat type. There was

Table 5—Vegetative characteristics of the Reservoir Creek game exclosure site.

East end of exclosure Herbaceous species (coverage >5%)	Inside	Outside	T-test	
	(Canopy cover ± S.D.)		T	P
Bluebunch wheatgrass *Pseudoroegneria spicata*	23.0 ± 31.7	15.6 ± 22.4	0.31	.759
Cheatgrass *Bromus tectorum*	4.4 ± 9.5	5.4 ± 6.6	0.77	.452
Heath goldenrod *Ericameria nauseosa*	1.0 ± 28.5	0.8 ± 3.4	1.14	.269
Lesser spikemoss *Selaginella densa*	15.0 ± 30.9	2.6 ± 8.9	1.91	.0716
Needle-and-Thread *Hesperochloa comata*	0.8 ± 3.4	12.0 ± 24.9	2.02	.058
Sandberg bluegrass *Poa secunda*	3.4 ± 6.0	0.1 ± 0.6	1.94	.067
Shrubs				
Antelope bitterbrush (*Purshia tridentata*)				
Height (cm)	167.0	130.5	2.72	.0135
% decadent	22.5	28.0	1.00	.3299
Twig length (cm)	1.25	5.24	3.83	.0004

North and west side of exclosure Herbaceous species (coverage >5%)	Inside S	Inside N	Outside N	T-test	
	(Canopy cover ± S.D.)			T	P
Bluebunch wheatgrass *Pseudoroegneria spicata*	10.5 ± 16.9	7.3 ± 20.8	23.9 ± 26.2	2.13	.0468
Heath goldenrod *Ericameria nauseosa*	0	4.6 ± 14.	4.7 ± 20.1	0	1.00
Slender hawksbeard *Crepis atrobarba*	6.5 ± 14.5	0	0		
Idaho fescue *Festuca idahoensis*	47.9 ± 27.7	0	0		
Sandberg bluebrass *Poa secunda*	6.8 ± 6.9	0.1 ± 0.6		4.65	.0002
Shrubs					
Antelope bitterbrush (*Purshia tridentata*)					
Height (cm)	104.5[1]	123.2[2]	104.5	.46	.6513
% decadent	16[1]	36[1]	21	2.54	.020
Twig length (cm)	1.25	1.25	5.75	7.61	.0001

[1]Severe site without significant grass understory.
[2]Less severe site with moderate grass understory
[3]Inside(n) is near ridge, more mesic site than inside(w) which is on a steep facing south slope.

abundant deer use in this exclosure and some horse use; it was apparently used as a corral by hunters at some time in the recent past. On the east side, bluebunch wheatgrass exhibited the highest coverage values, both on a representative site that was replicated outside and on an unreplicated severe site inside (table 6). Cheatgrass was present on the severe site but not on the replicated sites. Needle-and-thread coverage was higher on the unprotected site than inside, while heath goldenrod showed higher coverage inside than outside. The more severe site had lower coverage values of antelope bitterbrush, and big sage was present, suggesting a big sagebrush/bluebunch wheatgrass habitat type. Needle-and-thread grass may be a high seral dominant, which ultimately would be replaced by bluebunch wheatgrass on this site.

The south side of this exclosure and the adjacent unprotected site were dominated by needle-and-thread, with antelope bitterbrush and big sagebrush in the overstory. Although big sage was not recorded in the plots, it occurred on the site and was taller, less decadent and exhibited longer leader growth inside the exclosure than outside. The plants outside the exclosure were extensively browsed.

Wyeth Burial Site

This burial site, excluded from grazing by a low pole fence, is on a flat bench across from the "Flying B" on Idaho Fish and Game Department land and is approximately 3.3 by 6.6 m in size. It was surrounded by a big sagebrush community, but only one small sagebrush plant occurred inside the

Table 6—Vegetative characteristics of the Reservoir Creek stock exclosure site.

Herbaceous species (coverage >5%)	Inside (low)	Inside (high)	Outside (high)	T-test	
	(Canopy cover ± S.D.)			T	P
Ballhead sandwort *Arenaria congesta*	0	7.1 ± 9.7	11.0 ± 14.7	.26	.8008
Bluebunch wheatgrass *Pseudoroegneria spicata*	18.3 ± 30.5	0	0		
Cheatgrass *Bromus tectorum*	6.6 ± 23.8	0	0		
Needle-and-Thread *Hesperochloa comata*	0	42.6 ± 25.4	57.1 ± 25.6	1.94	.0676
Sixweeks fescue *Vulpia octoflora*	0	15.5 ± 21.1	7.9 ± 6.7	1.82	.0842
Shrubs					
Big sagebrush (*Artemisia tridentata*)					
Height (cm)	129.0 ± 23.8	110.3 ± 47.3	0	2.35	.0296
% decadent	36.0 ± 20.4	46.5 ± 17.2	0	1.69	.1077
Twig length (cm)	13.0 ± 5.3	9.3 ± 3.0	0	4.64	.0001

fence. Needle-and-thread was dominant, with coverage estimated at over 80%. Cheatgrass was present, with coverage estimated at 10%. Some bluebunch wheatgrass was present at 5% coverage. One small big sagebrush plant was present. Three dead heath goldenrod plants occurred on this site. There were no forbs present. This greatly disturbed site provided evidence that needle-and-thread was seral to bluebunch wheatgrass on these benches. If this is the case, at least some of the benches along the river were probably a big sagebrush/bluebunch wheatgrass habitat type, to which this site would presumably succeed if left undisturbed.

Sunflower Creek (Hood Ranch) exclosure

The fence at this site was torn down in the mid-1980s, but the outline of the exclosure was readily apparent from a line of bluebunch wheatgrass along one side, wire laying on the ground near one corner and trails along other sides. It was 0.4 ha in size. An 0.4 ha plot was established adjacent to the exclosure site for comparisons.

The herbaceous union did not show significant differences in coverage of bluebunch wheatgrass, cheatgrass or arrowleaf balsamroot, the three major plant species (table 7). The slightly higher coverage of cheatgrass, and presence of field chickweed (*Cerastium arvense*) outside of the exclosure, were offset by the slightly higher coverage of annual cruciferae inside. A significant difference in bluebunch wheatgrass seed stalk heights was apparent on the exclosure site (mean 75.7 cm) and the adjacent site (mean 69.2 cam, T= 2.9734, P=.0039).

The shrub component showed rather dramatic differences inside and outside the exclosure site. Live antelope bitterbrush was nearly absent outside the exclosure site in its vicinity. Within the exclosure site, 47 of 90 plants were alive, while 3 of 66 were alive adjacent to the site. One of the three plants outside was 34 cm tall, while the other two were over 200 cm tall. A variety of size classes were represented inside the exclosure. Fifteen of 20 heath goldenrod plants were alive inside the exclosure site, while 28 of 42 were alive outside, an insignificant difference. These plants were all heavily browsed. Mountain sagebrush was represented by three plants inside the exclosed site and was not found on the adjacent plot. Heath goldenrod was taller inside than on the adjacent site.

This site was considered an antelope bitterbrush/bluebunch wheatgrass habitat type, based on the presence of these species on the exclosed site. The reduction in shrub components outside was attributable to the site being a major elk and mule deer wintering area. Since the shrub component was so depauperate on the sites that were consistently exposed to browsing, the trend was towards a bluebunch wheatgrass/balsamroot community. As evidence of antelope bitterbrush disappears, interpretation of the successional status in the absence of the exclosed site will become progressively more difficult.

The ridge above this exclosure site was burned in the Mortar Fire of 1981. On the most southerly exposed sites, cheatgrass and arrowleaf balsam root predominated, and antelope bitterbrush plants were all dead. However, on other sites where Idaho fescue was present, sprouting from the rootcollars of many burned antelope bitterbrush plants was observed. The whole area was traditional mule deer winter range and was probably grazed by livestock during the period when the homesteads were occupied. Bud Hamilton, a long-time Forest Service employee with extensive knowledge of this area, said that sheep, cattle and horses grazed the Thomas Creek area in the 1920s and 1930s. The Idaho Department of Fish and Game bought the Hood Ranch in the early 1940s to secure the mule deer winter range by removing the livestock. In 1966, there were hardly any elk in the area, according to Hamilton. Current elk population for the Middle Fork hunting unit 27 is estimated at 5,224+255 by Idaho Department of Fish & Game (Scott 1999).

Little Loon Creek exclosure

This one-acre site, established in 1964, was burned in 1981, but the charcoal remnants of the wooden railings of the exclosed site outlined the exclosure. It was examined in

Table 7—Vegetative characteristics of the Hood Ranch exclosure site.

Herbaceous species (coverage >5%)	Inside (Canopy cover ± S.D.)	Outside (Canopy cover ± S.D.)	T-test T	T-test P
Annual mustards *Crucifera* spp.	5.3 ± 9.3	1.01 ± 1.1	1.18	.244
Arrowleaf balsamroot *Balsamorhiza sagittata*	14.4 ± 32.4	8.5 ± 20.2	.418	.6778
Bluebunch wheatgrass *Pseudoroegneria spicata*	15.5 ± 29.3	17.0 ± 27.8	.9924	.3498
Cheatgrass *Bromus tectorum*	44.3 ± 31.5	52.4 ± 32.9	.669	.5071
Fennel-leaved desert parsley *Lomatium foeniculatum*	0.3 ± 1.11	0		
Field chickweed *Cerastium arvense*	0	0.1+1.1		
Longleaved phlox *Phlox longifolia*	2.3 ± 3.8	0		
Bluebunch wheatgrass Seedstalk heights	75.7 ± 7.9	69.2 ± 9.6	2.973	.0039
Shrubs				
Big sageb ush (Artemisia tridentata)				
No. plants	3	0		
Height (cm)	113.3 ± 4.0	0		
No. dead	0	0		
Heath goldenrod (*Ericameria nauseosa)*				
No plants	15	28		
Height (cm)	65.1 ± 18.7	57.6 ± 18.4	1.739	.0951
No. dead	5	14		
Green rabbitbrush (*Ericameria viscidiflorus)*				
No. plants	2	1		
Height (cm)	57 ± 12.7	17	one plant outside	
No. dead	0	2		
Antelope bitterbrush (*Purshia tridentata)*				
No plants	47	3	7.68	.0001
Height (cm)	143.4 ± 42.9	200	.412	.683
No. dead	43	63		

July 1990. The area was on flat ground south of the confluence of Little Loon Creek and the Middle Fork, on a mix of Douglas-fir (*Pseudotsuga menziessia*) /mallow ninebark (*Physocarpus malvaceus*), Douglas-fir/pinegrass (C*alamagrostis rubescens*), and Idaho fescue/bluebunch wheatgrass habitat types (Steele and others 1981).

Herbaceous information was difficult to obtain from equivalent sites inside the exclosed area and adjacent, but no differences were apparent that were attributable to exclusion from grazing. Cheatgrass in the exclosed site was on microsites that appeared to have been severely burned. Similar conclusions applied to the shrub component. Differences were more readily attributable to variation in fire than to exclusion from grazing. The area has served as winter range for elk and deer and was part of a horse allotment when the exclosure was established.

Cow Creek Exclosure Near Loon Creek

This exclosure was still in evidence when examined in July 1992, although the fences were sufficiently down to allow access by mule deer and elk. No evidence of pack stock grazing was apparent on the site. The site was burned in 1954, prior to establishment of the fence in the mid-1960s.

Differences in the herbaceous union in 1992 between the exclosed site and an adjacent comparable site were not substantial (table 8). The most striking differences were the presence of Idaho fescue, more forbs and higher coverage of bluebunch wheatgrass, cheatgrass and Sandberg bluegrass on the exclosed site. Stem densities for the shrub union were slightly lower overall inside the exclosure site than outside, primarily attributable to more mountain sagebrush and rubber rabbitbrush. Big sagebrush and bitterbrush heights were greater on the exclosed site than off. No differences in productivity, in terms of twig density or twig length, were evident in 1992, suggesting that browsing effects were equivalent by that time, even if shrub heights and densities suggested earlier differences when the site was effectively excluded from browsing and grazing.

The site contained bitterbrush/Idaho fescue and antelope bitterbrush/bluebunch wheatgrass habitat types. The combination of past horse, elk and mule deer grazing and browsing had probably altered the vegetation, primarily by reducing the coverage of the forb component, Idaho fescue,

Table 8—Vegetative characteristics of the Cow Creek exclosure site.

Herbaceous species (coverage >5%)	Inside (Canopy cover ± S.D.)	Outside (Canopy cover ± S.D.)	T-test T	T-test P
Bluebunch wheatgress *Pseudoroegneria spicata*	13.3 ± 15.65	7.7 ± 22.86	2.28	.0283
Cheatgrass *Bromus tectorum*	25.5 ± 24.22	20.5 ± 32.13	2.504	.0167
Cutleaf daisy *Erigeron compositus*	0.2 ± 0.59	0		
Green rabbitbrush *Chrysothamnus viscidlflorus*	0.8 ± 3.36	0		
Hoebell's rockcress *Arabis hoelbelli*	0.8 ± 3.36	0		
Idaho fescue *Festuca idahoensis*	0.2 ± 0.59	0		
Lesser spikemoss *Selaginella densa*	3.2 ± 8.82	3.7 ± 14.01	.738	.4649
Longleaf hawksbeard *Crepis acuminata*	0.8 ± 3.36	0		
Sandberg bluegrass *Poa secunda*	7.3 ± 7.25	2.0 ± 4.56	2.652	.0118
Silky lupine *Lupinus sereceus*	5.2 ± 9.42	0		
Silverleaf phacelia *Phacelia hastata*	0	0.1 ± 0.55		
Western gromwell *Lithospermum ruderale*	0.2 ± 0.59	0		
Bluebunch wheatgrass Seedstalk heights	67.6 ± 10.24	71.6 ± 11.1	.941	.3492
Shrubs				
Big sagebrush (*Artemisia tridentata)*				
Density/m^2	.12 ± 1.39	.56 ± .48	1.395	.1707
% decadence	40.0 ± 14.7	12.1 ± 23.5	4.39	.0023
Height (cm)	207.3 ± 181.5	159.7 ± 136.8	0.376	.7099
Twig density/m^2	12.4 ± 13.1	13.2 ± 20.9	1.93	.0611
Twig length (cm)	13.8 ± 5.8	13.7 ± 4.8	2.39	.0276
Heath goldenrod (*Ericameria nauseosa)*				
Density/m^2	.05 ± .34	.14 ± .34	.499	.6202
% decadence	20 ± 26.5	22.9 ± 29.8	.100	.9254
Height (cm)	66.4 ± 22.3	45.4 ± 28.5	.51	.613
Twig density/m^2	6.2 ± 15.4	3.8 ± 7.3	.64	.5279
Twig length (cm)	5.4 ± 1.1	4.6 ± 1.2	3.24	.0021
Antelope bitterbrush (*Purshia tridentata)*				
Density/m^2	.12 ± .11	.06 ± .14	.406	.6867
% decadence	29.4 ± 13.2	51.9 ± 17.8	3.154	.0129
Height (cm)	115.2 ± 43.4	78.3 ± 22.8	2.32	.0400
Twig density/m^2	13.1 ± 22.5	9.3 ± 16.2	.043	.9659
Twig length (cm)	11.8 ± 3.8	12.4 ± 3.2	1.18	.2427

and by keeping shrubs at lower heights. Evidence of alteration from grazing and browsing was judged to be more apparent than evidence from the fire of 40 years earlier, but evidence of both will undoubtedly disappear if the originally enclosed site remains accessible to native ungulates.

Pence Report

This report is a sequence of photographs taken by Thomas Pence, Mackay, Idaho, in October 1925, and by Dan T. Pence, Salmon National Forest, in December 1968. The area covered included Brush Creek to Short Creek on the west side of the Middle Fork River in the vicinity of the "Flying B" and Bernard Guard Station. These sites were found again in June 1988 and rephotographed. The original typewritten report, written by Dan Pence, forester at Cobalt Ranger District, was on file at the supervisor's office, Salmon National Forest, and the report and current photographs are on file with the current author.

Four sites with repeated photographs suggest decreases in antelope bitterbrush and increases in heath goldenrod from 1925 to 1968, with both species appearing to decline subsequently through 1988. Photographs suggested that both species had declined on this site in the intervening 20 years.

The 1968 Pence report stated that the Wilson brothers owned the Mormon Ranch and the "Flying B" property in 1925. The brothers wintered cattle and horses in the area. The Wilsons were reported to have lost up to 500 head of cattle during the 1928 winter, a severe one in this area, after which they sold these properties.

Thomas Pence reported that deer were abundant in 1925 but less abundant in 1968. He felt there was less antelope bitterbrush in 1968 than in 1925 and less grass cover.

Discussion

Much shrub-steppe vegetation on the Middle Fork Salmon River drainage has been undergoing a transition from past disturbance. The areas have a relatively long history of use by humans and their associated livestock, so it should not be surprising that the vegetation has been modified. The area around the "Flying B" was known to serve as a winter range for up to 1,200 head of pack stock that supplied mining operations in the adjacent higher country. Farming was practised at these inholdings, and the associated livestock were no doubt left to graze the adjacent rangelands without much thought being given to effects on the vegetation.

Parts or all of some exclosures did not appear to be within antelope bitterbrush-dominated habitat types but were seral communities of which antelope bitterbrush was a part. The exclosures above the "Flying B" and at Cave Creek appear to represent this condition. These exclosures were established essentially to demonstrate the adverse effects that game, mainly mule deer, were having on antelope bitterbrush and other vegetation, or were established to help judge the effect that livestock grazing was having. Some 40 years after their establishment, there were considerable changes within exclosures, notably that the antelope bitterbrush plants were quite decadent; shifts in plant composition in the understory were also readily apparent. The exclosures were established not long after livestock grazing was reduced in the areas, and they originally excluded vegetation that reflected the effects of this kind of grazing pressure, plus the grazing pressure of the high mule deer populations of the time. The suspicion is that these high mule deer populations were basically attributable to alterations in the shrub complex by the earlier livestock grazing. This type of grazing would likely have favored invasion of big sagebrush, heath goldenrod and bitterbrush onto sites adjacent to sites occupied before the advent of livestock in the area; it would also have favored increases of these shrubs at the expense of the more palatable grasses and forbs on sites formerly occupied as well. An alternative explanation implicating fire suppression along with grazing in enhancing shrub communities was also tenable, but this assumes that fire suppression was effective in the 1910s and 1920s. Now shrubs are becoming decadent over thrifty stands of grass in the exclosures and there are shifts in the understory composition from species like cheatgrass and needle-and-thread to bluebunch wheatgrass and the associated forbs. Mule deer are still common but populations are lower than earlier years, and it is significant that the elk population has increased. The apparent transition from shrubs to grass will probably favor elk over mule deer. Current fire management policies should enhance that transition.

Thus, major habitat change attributable to the varying kinds of grazing pressures in this area over the years is hypothesized to be the major precursor to changes in big game populations, rather than the big game being the major cause of vegetation change. This represents a working hypothesis that may be explored further. The exclosures serve as a valuable guide to plant succession, and the task now is to examine potential reasons for the observed vegetation differences.

Finally, climatic change, including the major drought of the 1930s, quite likely substantially affected these plant communities. Shrubs would be expected to proliferate during those conditions, both on sites where individual species may exist as seral dominants or codominants and on sites where they occur in the climax. During periods of high moisture, the associated bunchgrasses would be favored. Thus, vegetation change would occur in response to natural climatic fluctuation in the absence of human interference, especially since fire frequencies are also affected by these climatic changes. When climate predisposed higher fire frequencies, the combined effects would be reflected in vegetation condition. The fluctuating climate predisposes change in the vegetation complex and, subsequently, the animal complex, that should not be replicated in the future (Holling and Meffe 1996). This contrasts with the concept that change occurs as a long-term cyclic pattern, with conditions repeated at an as-yet undefined long-term interval. These nonforested communities appear to be sensitive to moisture changes and may demonstrate changes through relatively short time periods. in comparison with other less sensitive communities; they are worthy of consideration for long-term monitoring. This is especially true because of the record already available for them. First, however, we should establish the causes of their current condition.

There are conflicting trends in shrub-steppe species composition across the Western rangelands. Burkhardt and Tisdale 1976), Gruell (1983), Hull and Hull (1975), Johnson (1986), Madany and West (1983), Martin and Turner (1977), Passey and Hugie (1962), Tisdale and others (1965) and Vale (1975) suggest that woody species, including the sagebrushes, have increased over this century, in some cases because of grazing, in other cases due to fire suppression, and in others where neither grazing nor fire were important. Grazing and fire prevention are generally held responsible for changes in plant composition in forest and shrub-steppe across the arid West (Gruell 1983, Branson 1985). More recently, evidence has appeared that the increasingly higher concentrations of atmospheric carbon dioxide will alter community composition and function (Bazzaz 1990), with much uncertainty about results (Idso 1998, Vitousek 1994, Strain 1969, Marshall and Zyhang 1994). However, Polley (1997) reported that transition zones between grasslands and forest may be among the first areas to experience species change as CO_2 rises or climate changes, and that trees and shrubs may increase at the expense of grasses.

There is also evidence of long-term increases in the herbaceous components in shrub-steppe (Yeo and others 1990, Austin and Urness 1998). These changes were attributed to changes in livestock and native ungulate grazing, deliberate efforts to reduce or eradicate woody plants to favor herbaceous forages for livestock, and prescribed burns and wildfires that favored herbaceous species over woody species.

If fire suppression and livestock grazing have been the major human influences on these communities, current policy that eliminates or dramatically reduces these influences provides substantial opportunity to investigate systems to detect natural change or climate-induced change, as well as changes related to the effects of rising atmospheric CO_2 as this affects photosynthesis, respiration and plant growth. Lindroth and others (1993) reported that elevated CO_2 atmospheres predicted for the next century will produce measurable changes in individual plant species and affect community structure and nutrient cycling on a broad level. Polley (1997) reported that transition zones between grasslands and forest may be among the initial areas experiencing species change as CO_2 rises or climate changes, and trees and shrubs may increase at the expense of grasses.

These changes may ultimately be related to changes in fauna. Among the herbivorous species, Post and others (1997) concluded that recent trends of increasingly warm winters in northern Europe and Scandinavia would lead to reduced body size and fecundity of red deer (*Cervus elaphus*). If this is an indication of how global warming could affect ungulates, interactions between predator and prey, as well as between prey and forage, may also be affected. The opportunity to assess trends in plant and animal communities in a large, relatively intact ecosystem where other human intrusion is minimized could materially help understanding of the effects of global changes in the northern Rocky Mountains.

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