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Rangeland Exclosures of Northeastern Oregon: Stories They Tell (1936–2004)

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Charles Grier Johnson, Jr., was the Area Ecologist for the Malheur, Umatilla, and Wallowa-Whitman National Forests from 1978 until his retirement in 2005. His specialties included plant community classification of alpine and subalpine vegetation, rangeland vegetation, and postfire succession in forest and rangeland plant communities. This publication, as well as his numerous other publications on the ecology of the Blue Mountains and Hells Canyon, testify to his lifelong scientific interest in and love for the area.

Cover: The Allen Springs three-way exclosure, Wallowa Valley Ranger District, Wallowa-Whitman National Forest. The game exclosure is located in the center-left, with the somewhat larger livestock exclosure behind it. The open (unfenced) monitoring plots are located in the foreground just out of view. 21 July 1978.

Charles Grier Johnson, Jr., 1943–2007.

Abstract

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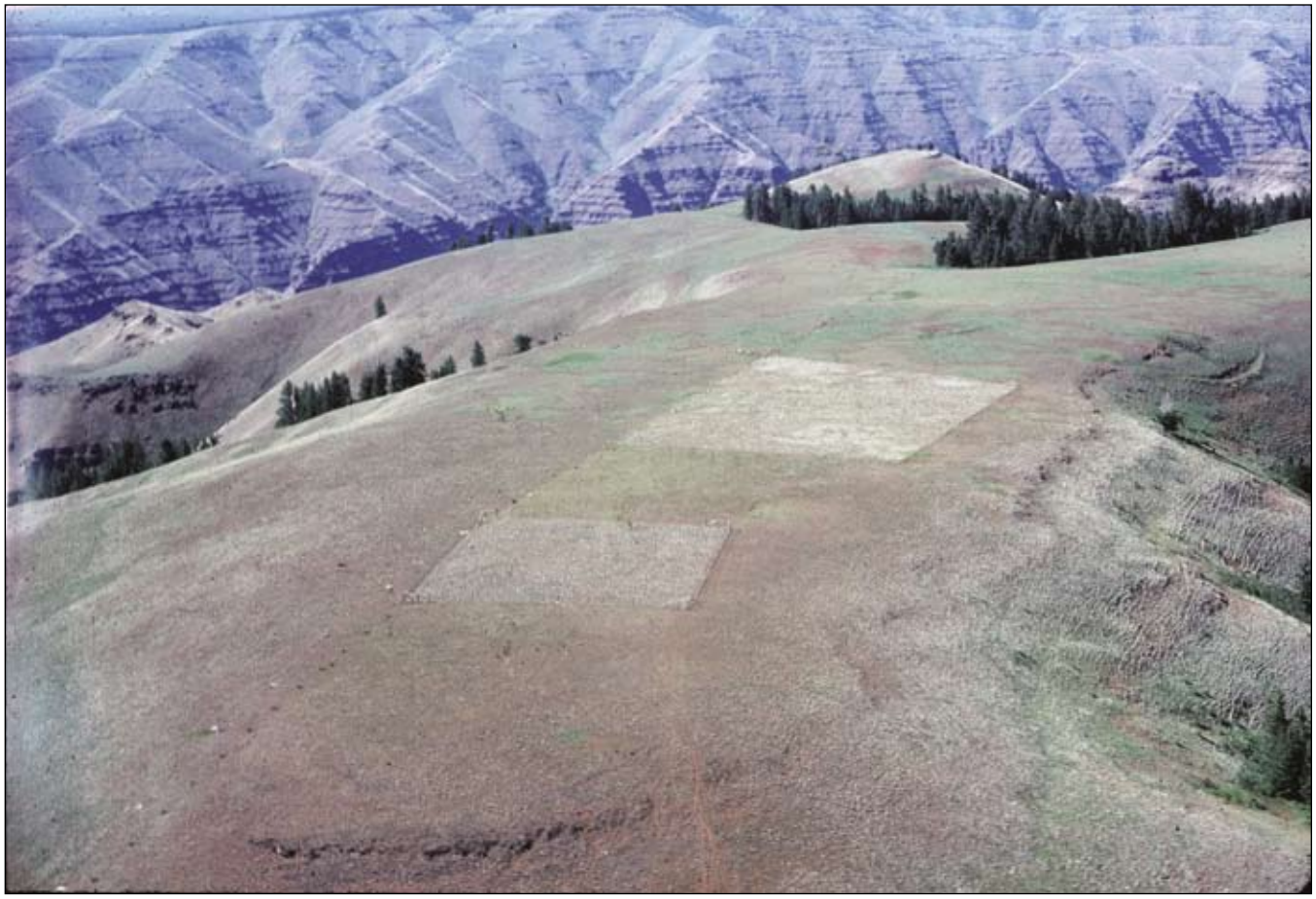
Rangeland exclosures installed primarily in the 1960s, but with some from the 1940s, were resampled for changes in plant community structure and composition periodically from 1977 to 2004 on the Malheur, Umatilla, and Wallowa-Whitman National Forests in northeastern Oregon. They allow one to compare vegetation with all-ungulate exclusion (known historically as game exclosures), all-livestock exclusion (known historically as stock exclosures), and with no exclusion (known as open areas). Thirteen upland rangeland exclosures in northeastern Oregon were selected and are presented with plant community trend data and possible causes of changes over time. Key findings are that moderate grazing by native ungulates afforded by the livestock exclosures generally stimulated bunchgrasses to retain dominance and vitality; native bunchgrasses can replace invasive rhizomatous plants given a reduction in disturbance over time; shrubs increased without ungulate use in shrubland communities; and invasive annuals that established following severe disturbances to the grassland community diminished with aggressive competition from perennial bunchgrasses.

Keywords: Exclosure, northeastern Oregon, plant community, plant association, trend.



The Grizzly Ridge three-way exclosure, Hells Canyon National Recreation Area, Wallowa-Whitman National Forest. The two light-colored squares are the livestock exclosure (the larger of the two) and the game exclosure (smaller and located below and to the left of the livestock exclosure). The open (unfenced) monitoring plots are located in the foreground between the camera and the game exclosure. 27 June 1977

Introduction

Rangeland and wildlife managers and natural resource scientists consider exclosures important tools for observing changes over time from lack of domestic ungulate use, wild ungulate use, usage by all ungulates including livestock, protection from other disturbances, and the natural climatic variation. Many exclosures were constructed in the 1960s with the idea that they would be maintained as long-term monitoring sites well past the span of a single generation of managers and scientists.

This paper synthesizes the results of multiple years of data collection, provides a selection of the findings from key exclosures located on the three national forests, and highlights the competitive relationships among plant species, the relations between plants and animals, and long-term succession.

The majority of the interpretations result from comparative analysis of plant community data collected at different times. Some of the interpretations related to cause and effect of vegetation change at the exclosure locations are based on published literature coupled with the author's observations over 30 years of plant ecology study.

Exclosures preserve areas as baselines against which areas affected by management of the natural environment can be evaluated.

Rangeland Reference Areas

The sites where exclosures have remained with integrity over time are excellent rangeland reference areas. Exclosures preserve areas as baselines against which areas affected by management of the natural environment can be evaluated (Allen 1986, Laycock 1975). These exclosures provide the land manager and rangeland scientist with the benchmarks for the potential vegetation that a site is capable of supporting in the absence of disturbances. They also give an indication of the vigor and vitality of the plants without grazing, with light to moderate grazing by wild ungulates, and with the effects from both wildlife and livestock grazing. These are areas set aside to illustrate and represent virgin conditions of forest or rangeland growth, as well as other conditions (grazed) that have special or unique characteristics of scientific interest and importance from a range resource standpoint, and are retained primarily for the purpose of science, research, and education (Laycock 1975). They have become excellent demonstration areas for other rangeland and wildlife professionals, rangeland scientists, educators and their students, and the general public.

Early History of Exclosures on Rangelands of the Western United States

Rangeland managers and rangeland scientists have long used relict areas protected from grazing by natural barriers as well as constructed exclosures as baseline areas to compare with grazed areas. G.D. Pickford (1932) compared plant composition within and adjacent to exclosures in Utah. He noted a severe degradation of the perennial grasses, an increase of perennial forbs and annual grasses, a decline in overall plant density, and an increase in big sagebrush outside the exclosure. In central Montana a similar observation in 1948 demonstrated that Sandberg's bluegrass, mountain big sagebrush, and gray rabbitbrush (see appendix for scientific names of species) were more abundant on grazed Idaho fescue communities than in the ungrazed exclosure (Evanko and Peterson 1955).

Problems With Early Exclosures

Early exclosures were often constructed by wildlife biologists to collect browse information. The sampling of a cohesive plant community, or of key plants within the excluded area, was often not intended. Even when vegetation communities were sampled correctly, often permanent plots were not established outside the exclosure to quantify the vegetation of the community as a comparison with that on the inside (USDA FS 1965a). For example, sampling big game study plots in northeastern Oregon consisted of recording browse species and their composition by line intercept, readings of pellet groups along a belt transect, measurements of browse use on 10 shrubs, and photographing from internal camera points (USDA FS 1965b). These generally were not set up with permanent vegetation sampling transects for acquiring data about the plant community composition and its change over time.

Many early exclosures were too small with many not much larger than cages. Stoddart and Smith (1955), in their rangeland textbook, urged early rangeland conservationists to construct exclosures of at least ¼ acre. The Forest Service and Bureau of Land Management subsequently required exclosures to be at least 1 acre (Laycock 1975). It was determined that although a three-strand cattle-proof fence had little influence on microclimate, woven wire fencing used to deter sheep would modify the microclimate inside for a distance of 10 times the fence height (USDA FS 1965a). Exclosures were also found to attract animals (birds perching and depositing seed in droppings along the edge, small mammals, and rodent populations increasing owing to increased herbage—both standing and as litter) (Laycock 1975).

Exclosure locations were haphazard at first. Common problems were the establishment of an exclosure straddling two different environments, or the sample plots being established on different environments within the exclosure versus outside the exclosure. Another key factor was the need to regularly maintain the exclosure to retain its integrity. The entry of a grazing animal into an exclosure built to analyze the plant community in the absence of grazing compromised the value of that exclusion to investigators and managers.

Types of Exclosures

Three types of exclosures were used in this study.

1. The one-way exclosure was installed to evaluate only the included plants and plant community. Many of the earliest exclosures were one-way and too small.
2. The two-way exclosure was designed to compare the protected vegetation within the exclosure with the unprotected vegetation nearby. Sampling was conducted inside and outside the exclosure.
3. The three-way exclosure allowed for two kinds of protected areas and an unprotected area (plot). The all-ungulate-proof exclosure usually consisted of an 8- to 10-foot-high woven wire fence to exclude all large animals (ungulates) and was called the "game" exclosure. The livestock-proof exclosure usually consisted of a three-strand barbed-wire fence and was called the "stock" exclosure. The third area was unprotected and was called the "open" plot where effects of dual usage could be sampled.

Three-way exclosures have provided the most valuable information over time.

Three-way exclosures have provided the most valuable information over time. They allow for the separation of the effects from combined usage (open plot), wild ungulates (livestock exclosure), and total grazing and browsing exclusion (game exclosure). The data can then be analyzed for the effects of specific use on plant composition, palatability, and trend. Other uses are the evaluation of annual fluctuations in herbage production owing to climate effects (game exclosure) and the speed of recovery as determined by vegetation sampling for trend (game and livestock exclosures).

Stagnation in Three-Way Exclosures

Stagnation is defined as the accumulation of dead biomass including litter as well as standing dead plant material in the absence of fire or grazing. This multiyear accumulation provides cover that attracts rodents (especially mice and voles). Without grazing or fire these communities of range plants deteriorate and stagnate

from a reduction in productivity (Anderson et al. 1970, Tueller and Tower 1979). The increase in mice and voles leads to small areas with increased soil disturbance resulting from burrowing and foraging activities. The ground disturbance by rodents can lead to invasive plants. In fescue-dominated communities, Kentucky bluegrass (*Poa pratensis*) capitalizes on the disturbance event to dominate micro-sites. Barring cessation of the rodent infestation and lack of fire, the vegetation reverts to an earlier sere. Livestock exclosures have repeatedly been associated with the healthiest grassland vegetation over time with the plant community nearing potential in response to periodic grazing by wild ungulates (especially elk [*Cervus canadensis*]).

Where shrubs are a component in the protected plant communities, those shrubs within the game exclosures produced the least forage (Garrison 1953). For example, sampling at four exclosures in Nevada showed stagnation of antelope bitterbrush and mountain big sagebrush as early as 2 years after establishment of the game exclosures (Tueller and Tower 1979). This release from shrubs led to an increase in grass and forb production from the available nutrients and moisture. However, the increase in grass production within the game exclosure contained grasses with a higher percentage of dead material and a decline in thrift. This was not the case with the grasses of the livestock exclosure where grazing wild animals provided an annual stimulus to grasses.

Exclosures of Northeastern Oregon

For a complete listing of the exclosures with locations, dates of establishment, sizes, and plant communities, see appendix 3.

Exclosures of the Wallowa-Whitman National Forest

The Wallowa-Whitman National Forest contains 12 exclosures. Eleven are three-way exclosures constructed by Wade B. Hall, Forest range staff officer, between 1962 and 1969. The only one-way exclosure on the Wallowa-Whitman National Forest is at Bald Mountain on the Baker Ranger District of the Whitman Unit. It is the oldest, was built with logs in the 1940s, and encloses forest vegetation. The geographic coverage of the 1960s-era three-way exclosures provides a comprehensive sample of the key vegetation of the rangelands on both sides of the Wallowa Mountains and in the Blue Mountains of the Wallowa-Whitman National Forest. There are five exclosures in Hells Canyon National Recreation Area, one on Wallowa Valley Ranger District, and one in the Eagle Cap Ranger District on the north side of the Wallowa Mountains. Two exclosure sites are on the south side of the Wallowa

Mountains (on Pine Ranger District of the Whitman Unit). The final two sites are in the Blue Mountains on Baker and Unity Ranger Districts of the Whitman Unit.

Ridgetop Exclosures in Bunchgrasses

In 1963, the first three-way exclosure was constructed north of Allen Springs on a bunchgrass-dominated ridgetop overlooking Joseph Creek Canyon. In 1969, four more three-way exclosures were built on bunchgrass-dominated ridgetops running north to south from the Imnaha River canyon crest to the Snake River canyon crest. The elevations of the five sites were 4,600 feet (Allen Springs), 5,100 feet (Grizzly Ridge), 5,300 feet (Coffeepot), 5,500 feet (Lord Flat), and 5,900 feet (Mormon Flat). All sites are dominated by bunchgrass plant communities of the Idaho fescue-prairie junegrass (*Festuca idahoensis-Koeleria cristata*) plant association (Johnson and Simon 1987).

The game exclosures enclosed approximately 1 acre. The livestock exclosures differed but generally enclosed 3 acres. Two or three line transects were installed at the time of establishment within the exclosures and at an adjacent open area at each site.

These transects were initially sampled by using the ¾-inch loop technique (Parker 1951) to determine percentage composition by species. Subsequent sampling was performed by using a square-foot quadrat to acquire percentage composition by species (Daubenmire 1959). Only the multiple samples taken by the quadrat technique are compared arithmetically. There is no arithmetic comparison made between the two techniques.

The initial sample data are valuable as they provide the baseline information of the ecological condition at the time of exclusion. The subsequent comparison of data derived from the quadrat indicates the successional trend for the vegetation over time from the start of quadrat sampling.

Allen Springs Three-Way Exclosures (Established 1963)

In 1986, the Joseph-Starvation Fire burned with moderate severity through the plant communities of both exclosures on Allen Springs Ridge. The vegetation along the permanent monitoring transects was resampled the first growing season after the burn and subsequently at approximate 5-year intervals.

In the first 5 years after the burn, Idaho fescue increased in cover from 12 percent in 1987 to 21 percent in 1992 within the game exclosure (table 1). In the livestock exclosure, Idaho fescue declined initially from 17 percent in 1987 to 13 percent in 1992 (owing to the attraction of the succulent fescue plants for elk and deer [*Odocoileus* spp.] following the burn). Bluebunch wheatgrass showed a similar

Table 1—Vegetation trends of Wallowa-Whitman three-way exclosures

	Idaho fescue–prairie junegrass plant association															Snowberry-rose plant association		
	Allen Springs 1977–2003			Grizzly Ridge 1977–2002			Coffee Pot 1971–2003			Lord Flat 1977–2003			Mormon Flat 1971–2003			Pleasant Valley 1983–2002		
	G	S	O[a]	G	S	O	G	S	O	G	S	O	G	S	O	G	S	O
Perennial grasses:																		
Idaho fescue	↑	↑		↓	↓	↓	↑	↑	↑	→	↑	↑	↑	↑	↑			
Bluebunch wheatgrass	↓	→		↓	→	↓	→	↓	→				→	→	↓	→	↑	↑
Sandberg's bluegrass	→	↑		→	↑	→							↓	↓				
Kentucky bluegrass	↓						↓		↓	↓	↓	↓	↓	→	↑		↓	↓
Prairie junegrass	→	→		→	→		→	→	→	→	→	→	→	→	→			
Western needlegrass							→	→	↑									
Mountain brome										→	↓	↓	→	→	→			
Onespike oatgrass				↓	↓	↑							↓	↓				
Shrubs:																		
Common snowberry																↓		↑
Rose																↑	↑	↑
Perennial forbs:																		
Yarrow	→	→		→	→	→	↑		→	→	↓	↓	→	→	↑	→	↓	↓
Creamy buckwheat		→						→		↑	→	→	↑	↑				
Red avens										→	↓	↑	↑	↑	↑			
Lupines	↑	→						→		↓	↓	↓				→	→	↑
Sticky geranium										↑	↑	→						
Slender cinquefoil										↓	↓	↓						
Surface features:																		
Bare ground	↓	↓		→	→	→	↑	→	↑	→	→	↑	↑	↑	→	↓	→	→
Litter	↑	↑		↑	↑	↑	→	↑	→	→	→	→	↓	↑	↑	→	→	→
Moss	↓	↓		↓	↓	↓	→	↓	0	0	0	0	↓	→	0	0	0	0

Note:
G = game exclosure, S = livestock exclosure, O = open sampling area, ↑ = upward trend, ↓ = downward trend, → = static trend, 0 = not present.
[a] = Open area is on a different environment (site) than the exclosure sites. Data were not comparable.

trend in the first 5 years by increasing in the game exclosure while declining in the livestock exclosure. More than 15 years after the burn, however, these bunchgrasses now co-dominate the grasslands within the livestock exclosure. Within the game exclosure, Idaho fescue now dominates over bluebunch wheatgrass 34 to 9 percent. Following the burn, prairie junegrass increased slightly and then returned to preburn levels of approximately 3 to 5 percent.

Sandberg's bluegrass (*Poa secunda*) was only present at 1 percent cover in the game exclosure historically but has exhibited increases in the livestock exclosure attributed to ungulate trampling and resulting microsite disturbance. After the burn, Sandberg's bluegrass increased from 5 to 9 percent. This shallow-rooted bunchgrass is an opportunist when disturbance results from trampling of interstitial areas and when fire reduces coverage by the dominating deeper rooted bunchgrasses.

Kentucky bluegrass became established in the game exclosure from a 1976–77 rodent infestation. This is considered to be a direct result of total exclusion from foliar removal (fire, ungulates) within the game exclosure and exclusion of rodent predators. As a result, litter accumulated affording cover for mice and voles to create bunchgrass mortality in patches.

The first year following the 1986 fire, there was a dramatic increase from 7 to 21 percent in Kentucky bluegrass in the game exclosure. Like the prairie junegrass, Kentucky bluegrass has now reverted to subordinate status within the bunchgrass-dominated community with a cover of 4 percent.

Litter has markedly increased in the game exclosure reaching a high of 75 percent of the amount before the 1986 burn. It was partially consumed by the fire and has now accumulated to a surface cover of 85 percent. In marked contrast, litter within the livestock exclosure covered 25 percent of the surface before the burn, dropped to 16 percent after the fire, and has increased to 55 percent. The amount of litter within the livestock exclosure is directly related to fluctuations in foliar growth owing to climatic conditions and to use by wild ungulates.

Grizzly Ridge Three-Way Exclosures (Established 1969)

The ridgetop site of the Grizzly Ridge exclosures had been severely overgrazed when the exclosures were installed in 1969 (table 1, fig. 1). The dominant bunchgrass then was Sandberg's bluegrass, with a strong associate—onespike oatgrass (*Danthonia unispicata*). These shallow-rooted bunchgrasses are found commonly on scabland sites where soil is less than 10 inches deep to bedrock. However, when deeper soil sites that historically carry the deeper-rooted bunchgrasses are depleted,

Figure 1—The Grizzly Ridge game exclosure, Hells Canyon National Recreation Area, Wallowa-Whitman National Forest. 21 July 1980.

the shorter bunchgrasses often increase and invade to occupy these sites. Soils here ranged from 12 to 21 inches in depth.

In 1971, shortly after the exclosures were installed, Idaho fescue was found on all three sampling sites (within the game and livestock exclosures as well as in the open area). By 1981, Idaho fescue was completely absent from the open sampling area. Onespike oatgrass had established from the excluded areas to occupy the open site with a dominant 28 percent cover. Idaho fescue had not fared well in the exclosures either. In 1977, both Idaho fescue and bluebunch wheatgrass made up a combined cover of 35 percent in the game exclosure. By 2002, the cover of both within the two exclosures was down to only 16 percent; Idaho fescue was at a precarious cover of less than 5 percent. The loss of fescue, the decline in bluebunch wheatgrass, and the increase in onespike oatgrass can be attributed to fire and drought in both exclosures and to a combination of drought and grazing pressure by wild and domestic ungulates in the livestock exclosure and in the open area.

In 2001, the Horse Creek Fire burned through the Grizzly Ridge exclosures site. It burned moderately resulting in a dramatic increase by Sandberg's bluegrass the year following the burn. Prior to the burn, the bluegrass was only minimally present in both exclosures at less than 3 percent cover. In 2002, Sandberg's bluegrass covered 13 percent within the game exclosure and 18 percent in the livestock exclosure. Mosses and lichens had dramatically declined by 2002. They historically occupied coverages of 35 to 55 percent in the exclosures, but in 2002, they constituted less than 5 percent cover in the exclosures. The loss of bunchgrass canopy, subsequent drying and heating of the microsite, and direct heat from the wildfire is suspected to have caused the high mortality.

Coffeepot Three-Way Exclosures (Established 1969)

The exclosure is characterized by a dramatic increase in Idaho fescue (figs. 2a and 2b). In 1971, Idaho fescue did not occur within the two exclosures. Kentucky bluegrass completely dominated the game exclosure. It was less prominent in the livestock exclosure where bluebunch wheatgrass and Sandberg's bluegrass were the dominant plants. In the open area, Kentucky bluegrass was the dominant grass. By 2003, Idaho fescue had replaced Kentucky bluegrass in the game exclosure as the dominant grass with a cover of 32 percent. In the livestock exclosure, Idaho fescue also had overtaken the other bunchgrasses with a cover of 20 percent. The story was the same in the open area where Idaho fescue dramatically increased to a cover of 18 percent with a resultant decline by Kentucky bluegrass to only 10 percent. The probable increase in fescue at the expense of bluegrass and wheatgrass can be attributed to natural succession with decreased ungulate impacts inside the two exclosures. The reversal of dominance from Kentucky bluegrass to Idaho fescue in the open area can be a result of less grazing impact by livestock over the 30-year period with preferential grazing of the bluegrass by elk. Other notable bunchgrass trends were that western needlegrass had invaded since establishment of the exclosures but was present in the exclosures at coverages less than 5 percent in 2003. However, it occurred at 7 percent in the more heavily grazed open area. Prairie junegrass was static throughout the 1971–2003 period on all sites.

The probable increase in fescue at the expense of bluegrass and wheatgrass can be attributed to natural succession with decreased ungulate impacts inside the two exclosures.

Mormon Flat Three-Way Exclosures (Established 1969)

In the game exclosure, Idaho fescue doubled in cover to 13 percent with declines by Kentucky bluegrass, Sandberg's bluegrass, and the loss of onespike oatgrass. In 1971, Sandberg's bluegrass dominated (41 percent cover) with onespike oatgrass strongly associated (9 percent cover). The exclusion and time (32 years) have given the competitive advantage to the fescue over the others. In the livestock exclosure,

Figure 2a—The Coffee Pot game exclosure, Hells Canyon National Recreation Area, Wallowa-Whitman National Forest. The livestock exclosure is also partially visible at the top of the photograph. 27 June 1977.

Idaho fescue was co-dominant with Sandberg's bluegrass and onespike oatgrass in 1971. By 2003, Idaho fescue had dramatically increased to dominate at a cover of 26 percent. Both of the other shallow-rooted bunchgrasses were less than 5 percent cover by 2003 with the strong increase by fescue. Idaho fescue also nearly doubled in cover in the open area (11 percent in 1971, 19 percent in 2003). However, Kentucky bluegrass, common yarrow (*Achillea millefolium* var. *lanulosa*), and red avens (*Geum triflorum*) all made dramatic increases over the 22-year period. Although cattle use ceased in 1979, elk numbers steadily increased through the mid 1980s. The resultant bluegrass-forb-dominated open site can be attributed to the long-term grazing effects as well as the more recent grazing impacts by elk. Mormon Flat had long-term domestic sheep use prior to the construction of the exclosures and has had heavy use by herds of elk. Mountain brome (*Bromus carinatus*) and prairie junegrass have remained static throughout the sampling period on all sites here.

Figure 2b—The Coffee Pot livestock exclosure, Hells Canyon National Recreation Area, Wallowa-Whitman National Forest. 27 June 1977.

Lord Flat 3-Way Exclosures (Established 1969)

This is the one site that has been heavily modified from its presettlement state. The nearby Dorrance Ranch used the large flat for summer grazing of domestic sheep early after homesteading. Later, domestic cattle used the flat in summers until 1979. The site of the exclosures was apparently plowed and hayed for a number of years. The story the exclosures tell is one of secondary succession in the absence of total ungulate use over time in the game exclosure and of native ungulate use in the livestock exclosure.

In 1969, Kentucky bluegrass dominated the "old field" of the flat. Idaho fescue was either absent (game exclosure) or with less than 5 percent cover (livestock exclosure and open area). Over the 34 years since construction of the exclosures, major changes have occurred. The game exclosure has become forb-rich with dominance in 2003 by red avens (17 percent cover), sticky geranium (*Geranium viscosissimum*) with a cover of 26 percent, and creamy buckwheat (*Eriogonum*

heracleoides) (10 percent cover). Kentucky bluegrass is still the dominant grass (22 percent) with Idaho fescue only weakly present at 1 percent cover (table 1).

In the livestock exclosure, native ungulate use has allowed Idaho fescue to out-compete Kentucky bluegrass to attain co-dominance on the site. In 1977, Kentucky bluegrass cover was 65 percent. However, forbs are still the overwhelming dominant plants on the "old field." Since 1977, geranium has quadrupled to 24 percent cover. Other forbs have declined over the period but still have double-digit coverages (slender cinquefoil [*Potentilla gracilis*] 14 percent; red avens 18 percent).

The open area is still dominated by Kentucky bluegrass (23 percent cover), but forbs are collectively the most dominant plants on the site. Since 1977, Idaho fescue has tripled to 15 percent cover while Kentucky bluegrass cover has declined from 53 to 23 percent. The most dominant increasing forb is red avens. Slender cinquefoil is also prominent (12 percent cover).

Pleasant Valley Three-Way Exclosures (Established 1969)

In 1969, a three-way exclosure was constructed on the Snake River bench in Pleasant Valley (table 2, fig. 3). The relatively flat bench is located at a mid-canyon level (2,530 feet elevation) approximately 1,500 feet above the river. The Pittsburg Ranch was located on the river near Pleasant Valley Creek. Domestic sheep heavily used the bench over many grazing seasons prior to the 1969 establishment of the exclosures. In the later years prior to cessation of livestock use on the allotment, Lem Wilson converted to cattle. As with the rest of the Snake-Imnaha range, elk were a presence in Pleasant Valley, peaking in 1986. The ideal habitat of the grass-dominated bench and an adjacent forested north slope beside the creek allowed a herd of elk to take up residency surrounding the exclosure sites.

Table 2—Pleasant Valley three-way exclosures

	Game exclosure			Livestock exclosure			Open		
Species	**1983**	**1996**	**2002**	**1983**	**1996**	**2002**	**1983**	**1996**	**2002**
					Percent cover				
Kentucky bluegrass	0	0	0	43	32	0	29	31	3
Bluebunch wheatgrass	0	6	5	2	18	52	2	16	42
Rose	10	13	18	1	1	4	2	1	7
Common snowberry	59	31	36	0	0	0	1	2	5
Common yarrow	0	3	0	5	1	0	7	3	2
Silky lupine	3	12	5	11	5	10	0	5	16
Arrowleaf balsamroot	0	7	12	1	0	0	0	0	0
Bare ground	4	0	0	0	1	1	1	0	1
Litter	93	95	99	86	98	98	90	96	95

Figure 3—The Pleasant Valley three-way exclosure, Hells Canyon National Recreation Area, Wallowa-Whitman National Forest. The game exclosure (center) has been strongly colonized by shrubs. The livestock exclosure is faintly visible above the game exclosure. The open (unfenced) monitoring plots are located near the edge of the photograph to the right of the game exclosure. 14 June 1983.

Unfortunately the three sites selected are not readily comparable. The game exclosure is located with one side adjacent to a gulch where shrubs persist. Since construction in 1969, a common snowberry-rose stand has increasingly invaded the grassland of the interior that was co-dominated by Kentucky bluegrass and bluebunch wheatgrass. The livestock exclosure is a distance up the sloping bench, and in 1969 there was no snowberry or rose component. This was not due to a site difference per se. The open area was, however, offsite on a rocky promontory where bluebunch wheatgrass was dominant over Sandberg's bluegrass.

The vegetation on the sites of the two exclosures is the common snowberry-rose (*Symphoricarpos albus-Rosa* spp.) plant association (Johnson and Simon 1987). Over the sampling history from 1971 to 2002, the rose component that initially dominated within the game exclosure has declined as snowberry increased its occupancy. However, both shrub species dominate together over the herbaceous component. Visually, as revealed in photographs, the shrub migration from south to

north within the game exclosure has been dramatic over this time. The shrubs have overtaken the grasslands–once having bluebunch wheatgrass and Kentucky bluegrass as co-dominants (figs. 4a and 4b). In 2002, only 5 percent cover remained of the wheatgrass, and Kentucky bluegrass had been eliminated altogether. Arrowleaf balsamroot (*Balsamorhiza sagittata*), initially absent in the game exclosure, was present in 1996 at 7 percent cover and continued increasing with a cover of 12 percent in 2002 (table 1).

In the livestock exclosure, as with the game exclosure, bluebunch wheatgrass and Kentucky bluegrass initially co-dominated at the time of construction. By 2002, bluebunch wheatgrass had become totally dominant within the exclosure as Kentucky bluegrass was eliminated. The probable causes for the changes are drought favoring the wheatgrass, elk preference for the bluegrass early in the season when it is most vulnerable, persistent standing litter in bluebunch wheatgrass reducing its palatability, and an overall lessening of grazing use resulting from the exclusion of domestic livestock. Another sign that grazing pressure has lessened is the slow increase by shrub seedlings within the exclosure.

The Pleasant Valley sampling demonstrates how severe use can maintain dominance by herbaceous vegetation that would otherwise be shrub dominated.

The 1971 open sample area was offsite and therefore unusable as a comparison with the two exclosure sites. Therefore in 1983, line transects were installed between the two exclosures in an area of the same snowberry-rose plant association. In 1983, the site was almost totally dominated by Kentucky bluegrass (29 percent cover) with only 2 percent cover by bluebunch wheatgrass. Snowberry and rose existed as strongly hedged plants well beneath the grasses at only 3 percent combined cover. This site looked like a well-mown lawn at the time of livestock use. By 2002, livestock use had ceased. The two grasses reversed dominance with Kentucky bluegrass now only 3 percent coverage on the site. Bluebunch wheatgrass increased occupancy from 2 percent to a dramatic 42 percent over the 19-year span of time. The shrubs were now making an emergence as well. The combined cover of snowberry and rose was 12 percent in 2002. In summation, the story told by the Pleasant Valley sampling over the past 31 years demonstrates the effects of grazing and browsing animals on plant succession and how severe use can maintain dominance by herbaceous vegetation that would otherwise be shrub dominated.

The effects of fire at Pleasant Valley—

The Pleasant Valley exclosure site burned twice over the past 31 years, in 1985 (a hunter-caused fire) and 1996 (Salt Creek Burn). The vegetation within the game exclosure burned with moderate severity in both fire events. Within the livestock exclosure, the plant communities were lightly burned by both fires. After the fires, the sites were visited to determine the extent and severity of the burn on the vegetation along the transects within each sample area. Then the first year after the fires

Figure 4a—The Pleasant Valley three-way exclosure on 18 June 1976. Vegetation in this portion of the exclosure was dominated by bluebunch wheatgrass. The abundant white flowers are yarrow.

Figue 4b—The Pleasant Valley three-way exclosure on 6 June 1996. The vegetation is now dominated by rose and snowberry shrubs.

(1986, 1997), the vegetation was sampled at the culmination of annual growth. Thus fire succession was determined for the snowberry-rose plant association at the Pleasant Valley site, as sampling has been performed every 5 years following the initial resample after the burn year.

In the game exclosure, the moderate burns reduced the canopy cover initially and also promoted rose over snowberry (1985: snowberry 4 percent, rose 16 percent). Five years later, snowberry had regained its preburn dominance over rose and maintained it following the 1996 burn as well. The first year after the burns, annuals capitalizing on the abundance of sunlight and growing space were the dominant plants within the game exclosure. Thymeleaf sandwort (*Arenaria serpyllifolia*) and yellow salsify (*Tragopogon dubius*) totaled 50 percent cover. By the fifth year, the sandwort was present only as a trace and salsify was absent. Annual bromes also capitalized on the fire event with increases of over 10 percent from preburn levels of only 2 percent. The bromes were absent by the 10th year, returned to 5 percent cover after the 1996 fire, and were absent by 2002. Increasing annual forbs of note were chervil (*Anthriscus scandicina*) and bedstraws (*Galium aparine*, *G. trifidum*) after both fires. These continue to be present at 15 percent cover each.

The fires did little to deter the Kentucky bluegrass dominance in the livestock exclosure and the open sample area, but natural succession through reduced grazing pressure did deter it.

In the livestock exclosure, the two burns did not negatively influence the Kentucky bluegrass. It had coverage of 43 percent prior to the 1985 burn, was 31 percent in 1986 after the first burn, 32 percent before the 1996 burn, and 29 percent in 1997 after the second burn. In the 5 years following, Kentucky bluegrass was replaced by bluebunch wheatgrass. As in the game exclosure, annuals were dominant in cover the first year after the burns. Thymeleaf sandwort and annual bromes were abundant. Small bedstraw (*Galium trifidum*) was especially prominent after the 1985 fire and continued with high cover (59 percent) after the 1997 burn.

In the open area where Kentucky bluegrass had so thoroughly dominated owing to ungulate repression of the shrubs and bunchgrasses, bluegrass was unaffected by the fire in 1996. The dramatic change in 1997 was the emergence of a new annual grass species. Ventenata (*V. dubia*) emerged with a cover of 22 percent to occupy the charred ground surface, with bedstraw at 30 percent cover. Five years later in 2002, the bedstraw was even more prolific (56 percent cover) replacing ventenata, which was totally absent from the site.

In summation, the fires did little to deter the Kentucky bluegrass dominance in the livestock exclosure and the open sample area, but natural succession through reduced grazing pressure did deter it. The well-known fact that populations of annual vegetation can provide a showy dominance one year following enhanced growing conditions is often followed by the same dramatic change when they become a minor component the next year.

Exclosures of the Umatilla National Forest

The oldest exclosure existing today on the Umatilla National Forest is the Skookum three-way exclosure established in 1945 on the Heppner Ranger District. The forest contains seven existing exclosures (three three-way; one two-way; and three one-way). Two of the one-way exclosures are in forested plant communities on the Walla Walla Ranger District.

Skookum Three-Way Exclosures (Established 1945)

The Swale Creek Allotment on the southern end of the Heppner Ranger District has had a long history of grazing use and abuse. Permitted sheep use initiated in 1922. Before 1935, a high number of sheep grazed over a 4-month season coupled with many deer, elk, and trespass livestock. After 1935, the Forest Service reduced numbers of permitted livestock with shortened grazing seasons in 1940 and 1952. In 1962, the allotment was converted to cattle use.

In 1945, three 2-acre sites were selected in communities of the western juniper/bitterbrush/Idaho fescue-bluebunch wheatgrass plant association (*Juniperus occidentalis/Purshia tridentata/Festuca idahoensis-Agropyron spicatum*) (Johnson and Clausnitzer 1992) for a three-way exclosure on a gentle ridge near Skookum Spring. In 1946, wildlife biologist Chuck Waldron established study plots on the three sites. His purpose was to analyze the vegetation of the plant communities there and to determine effects from big game (deer and elk) and livestock grazing and browsing. In 1962, range conservationist Emory Clapp and Waldron resampled the vegetation on Waldron's plots and took photos at the 11 camera points he had established earlier. They attempted to compare Waldron's earlier data with their 1962 data. Waldron had employed the square-foot density method (Stoddart and Smith 1955) and they replicated the technique.

The 1946–1962 comparison—
Over 16 years (1946–1962), total forage increased on all three sites (table 3). The two exclosures exhibited the greatest increase (7 to 71 percent in the game exclosure; 7 to 63 percent in the livestock exclosure). Even in the open area, now with decreased ungulate pressure, forage species increased from 5 to 54 percent. The main contributors were the two principal bunchgrasses (bluebunch wheatgrass and Idaho fescue). Of the two bunchgrasses, Idaho fescue increased along with a consistent decline of bluebunch wheatgrass. The probable reason for the increase in fescue was the increased moisture retention caused by increased litter on the ground surface and increased foliar canopy shading helping to moderate the desiccating temperatures of the summer months.

Table 3—Skookum three-way exclosures (square foot density method)

	Game exclosure		Livestock exclosure		Open	
	1946	1962	1946	1962	1946	1962
			Percent cover			
Bitterbrush	12	13	6	2	8	t
Idaho fescue	17	40	22	33	19	37
Bluebunch wheatgrass	43	27	45	35	57	46
Total forage species	7	71	7	63	5	54

t = trace

The other story over the period between samples was with bitterbrush. The shrub was stable over the period in the game exclosure where no browsing could occur. However, within the livestock exclosure and on the open control site, the shrubs were found to be severely hedged, decadent, and in jeopardy of loss to the communities. Within the game exclosure, the plants had full crowns developing from the previous hedged state, and juvenile shrubs were present providing a greater vitality to the community.

The 1981–2002 comparison—
In 1962, Parker 3-step condition and trend transects were installed within the game and livestock exclosures for initiating a new sampling technique that used a ¾-inch loop to attain composition and frequency of the plants within the community (table 4). The open area plots were on a rocky site that was not comparable to the sites where the exclosures reside. The transects were resampled periodically. With the increase in elk populations of the 1980s, renewed sampling was conducted to observe the impact of dual usage by cattle and elk with the excluded communities as benchmarks. Key sample years were 1981 (prior to the peaking of elk use), 1986 (at the peak of elk use), and 2002 (after the peak when elk numbers declined). In 1998, a fire burned through the exclosures.

From 1981 to 1986, there was a slight increase in bluebunch wheatgrass and Idaho fescue in the game exclosure with a slight decrease of those grasses in the livestock exclosure where deer and elk could graze. Bitterbrush increased by 5 percent within the game exclosure over this period. After the fire, bitterbrush mortality was severe. Within the game exclosure, 86 percent of the bitterbrush died within the sampled community. Foliar canopy coverage by bitterbrush declined from 21 percent to only 5 percent. Slight postburn increases in cover were made by prairie junegrass and yarrow.

Table 4—Skookum exclosures (Parker 3/4-inch loop technique)

	Game exclosure			Livestock exclosure		
	1981	1986	2002	1981	1986	2002
			Percent cover			
Bitterbrush	16	21	5	2	2	1
Idaho fescue	42	34	35	25	15	21
Bluebunch wheatgrass	21	35	31	30	37	25
Sandberg's bluegrass	16	7	10	28	17	34
Prairie junegrass	1	1	4	0	0	1
Yarrow	2	1	7	0	0	1
Bare ground	27	22	23	63	35	39
Rock	6	8	3	1	1	2
Gravel	0	0	2	0	0	2
Moss	3	6	8	2	6	4
Lichen	0	0	1	0	0	2
Litter	41	51	62	17	49	52

The 1989–2003 comparison—

Ocular macroplots (table 5) were established in the exclosures and open control area in 1989 and 1993 for acquiring data to assist in the plant community classification project for the Blue Mountains. Observations resulting from the data acquired on these plots reinforce the trends demonstrated in the earlier work here. In the game exclosure, there was the least bare ground (30 percent), and litter was highest (60 percent). In the livestock exclosure, bare ground (40 percent) was higher than in the game exclosure. In the open sample area, bare ground was highest of all sites at 55 to 60 percent.

Table 5—Skookum three-way exclosures (ocular macroplot)

	Game exclosure		Livestock exclosure		Open	
	1989	2001	1993	2003	1993	2003
			Percent cover			
Bitterbrush	20	3	10	10	3	1
Idaho fescue	20	25	15	20	t	3
Bluebunch wheatgrass	25	20	30	15	10	20
Bare ground	30	30	40	40	60	55
Rock	3	3	5	3	30	10
Gravel	t	5	1	1	5	5
Moss	1	0	1	t	1	1
Lichen	3	0	1	t	0	0
Litter	55	60	40	40	3	25

t = trace

The sampling in 2001 and 2003 encountered an invasive plant new to the plant community as well as northeastern Oregon.

Bitterbrush had open crowns with 3 to 4 foot branches inside the game exclosure. Inside the livestock exclosure, deer and elk had severely impacted the crowns of bitterbrush and the recruitment of juvenile shrubs. The burn of 1998 reduced the populations in the game exclosure to less than 5 percent but had less effect on the shrubs inside the livestock exclosure where fire had apparently traveled faster along the ground surface leaving the postburn community intact. The bunchgrasses remained stable inside the exclosures over the 1989–2003 period with the burn apparently not detrimentally affecting them.

The sampling in 2001 and 2003 encountered an invasive plant new to the plant community as well as northeastern Oregon. Ventenata, a European annual grass, apparently was introduced by animals and established in the grassland communities. It was not present in the sampled data previously. It is a disturbance opportunist and occurred with greatest cover in the open area (10 percent), less in the livestock exclosure (5 percent), and none within the game exclosure.

Stumbough Exclosure (Established 1983)

In 1983, the Walla Walla Ranger District constructed a game exclosure near the end of Stumbough Ridge to assess the effect of elk and trespass horses on the bunchgrass vegetation of the gentle ridgetop. At the time of establishment, line transects were installed within the exclosure and in a similar vegetation outside the exclosure. The vegetation was initially sampled for percentage composition by using the Parker ¾-inch loop technique. That technique was followed through the subsequent sampling periods. Although highly impacted, the vegetation fit the Idaho fescue-bluebunch wheatgrass plant association (*Festuca idahoensis-Agropyron spicatum*) (Johnson and Clausnitzer 1992). Kentucky bluegrass thoroughly dominated at 66 percent cover inside the exclosure and 61 percent cover outside (table 6). However, the two bunchgrasses, Idaho fescue and bluebunch wheatgrass, accounted for a cover of only 1 percent each inside the exclosure and a combined 15 percent outside the exclosure in 1983, a result of heavy use by ungulates prior to exclosure establishment. An invasive grass, Canada bluegrass (*Poa compressa*), was present at 3 percent cover inside the exclosure and 11 percent cover outside. Yarrow and sheep sorrel (*Rumex acetosella*) were the dominant forbs with a cover of 8 percent each both inside and outside.

In 1989, 6 years later, Kentucky bluegrass cover had declined inside the exclosure by 7 percent with a minor increase of 1 percent (4 to 5) by bluebunch wheatgrass. It was even more dramatic outside. Kentucky bluegrass declined 44 percent to a cover of 17 percent with a slight increase by the bunchgrasses to a combined 17 percent cover. The Canada bluegrass made only a slight increase inside the

Table 6—Stumbough exclosure

	Game exclosure					Open area				
	1983	**1989**	**1998**	**2003**	**20-year trend**	**1983**	**1989**	**1998**	**2003**	**20-year trend**
					Percent cover					
Kentucky bluegrass	66	59	33	26	↓	61	17	12	2	↓
Idaho fescue	1	1	5	6	↑	3	7	23	30	↑
Bluebunch wheatgrass	1	5	7	11	↑	12	10	13	19	↑
Canada bluegrass	3	5	1	0	↓	11	33	12	10	→
Goatweed	0	1	19	13	↑	0	0	24	19	↑
Yarrow	8	1	15	20	↑	4	3	3	8	→
Sheep sorrel	8	3	0	2	↓	7	7	0	0	↓
Bare ground	4	10	1	5	→	9	21	9	26	↑
Moss/lichen	2	1	1	1	→	2	7	3	3	→
Litter	73	70	75	78	→	63	50	55	49	↓

exclosure while it dramatically increased by 22 percent outside the exclosure. In 1983, forbs were subordinate to the grasses. Outside the exclosure in 1989 there was a 12-percent increase in forb composition. These changes outside the exclosure were probably due to continued heavy use by ungulates coupled with the drought period in the mid 1980s.

Nine years later in 1998, the vegetation was again sampled. The decline of Kentucky bluegrass continued. It now covered only 33 percent of the exclosure, half its area of extent within the exclosure 15 years previously in 1983. Outside the exclosure, Kentucky bluegrass also declined to just 12 percent cover from its 61 percent cover of 1983. Canada bluegrass also was in decline and was now almost absent within the exclosure. Inside the exclosure, the two bunchgrasses continued to increase, doubling cover from 1989 to 12 percent. Invading both inside and outside the exclosure was a new plant for this site—goatweed (*Hypericum perforatum*). It covered large areas; 19 percent within the exclosure and 24 percent outside. Yarrow had also doubled from the 1983 population of 8 percent to a cover of 15 percent inside the exclosure.

The last reading of the transects was in 2003—twenty years after the installation of the exclosure and the initiation of sampling vegetation. Kentucky bluegrass continued its decline inside the exclosure with cover now down to 26 percent from an initial 66 percent. It was even more dramatic outside where the bluegrass was all but eliminated, now just 2 percent cover. Idaho fescue continued to increase its occupancy most dramatically outside the exclosure where it now covered 30 percent of the ground and dominated over bluebunch wheatgrass. Idaho fescue increased as well within the exclosure but was still dominated by Kentucky bluegrass and bluebunch wheatgrass. The two bunchgrasses now were covering almost 50 percent

What appeared to be impeding the rate of bunchgrass increase in the protected exclosure was the deep thatch of litter occupying the interstitial areas between perennial plants.

of the open site while the increases in bunchgrasses were much less within the exclosure (now covering just 17 percent). What appeared to be impeding the rate of bunchgrass increase in the protected exclosure was the deep thatch of litter occupying the interstitial areas between perennial plants. There was a surface cover of litter of 78 percent within the exclosure! In contrast, there was only 49 percent cover by litter outside where ungulates used the plants. The percentage of bare ground was about 1 to 10 percent within the exclosure over the 20 years. In summation for the sites as a whole at this time, Kentucky bluegrass had continued to decline, bluebunch wheatgrass and Idaho fescue had continued to increase, and goatweed increased.

Burrowing rodents (field mice [*Peromyscus* spp.], voles [*Microtus* spp.], and pocket gophers [*Thomomys talpoides*]) provided the principal disturbance within the exclosure over the years since 1983. They had been protected from their predators by the fencing. A higher "weediness" was exhibited within the exclosure as a result of the rodent population growth afforded by the cover of a deep litter layer on the surface of the ground. Outside the exclosure, ungulates (predominantly elk) had provided the principal disturbance. Their trampling displaced plants and also compacted the soil to a higher degree than the soils within the exclosure.

Malheur National Forest Exclosures

The Malheur National Forest contains the greatest number of existing exclosures in northeast Oregon national forests with 17. The majority (9) were established in the mid 1950s to early 1960s to study the effects of livestock exclusion on the vitality of bitterbrush in key winter ranges. In the 1940s, the mule deer (*Odocoileus hemionus*) population exploded and outgrew the food supply on the winter range. Many deer starved. Contributing to the lack of food supply for deer was an explosive population increase by mice in the late 1930s and early 1940s (USDA FS 1961).

In northeast Oregon, the oldest extant exclosures are found on the Malheur National Forest. The Wickiup one-way exclosure was installed in 1933 on a sedge meadow. The Canyon Creek three-way exclosure, constructed in 1936, represents the oldest protected site in the uplands. Both the Wickiup and Canyon Creek sites are located on the Blue Mountain Ranger District. Of the 18 exclosures on the Malheur National Forest, the majority were established as browse study plots by Forest wildlife staff Rodney J. Miller in the early 1960s. These one-way exclosures averaged ¼ acre and principally enclosed bitterbrush communities. The majority of these exclosures are on the Emigrant Creek Ranger District. The remaining three are on the Blue Mountain Ranger District.

Five three-way exclosures were established on sites where bitterbrush was a component. These usually enclosed areas of approximately 1 acre each. The remaining exclosures were single, smaller livestock-proof exclosures enclosing about a quarter-acre (from 0.2 to 0.4 acre).

With one exception (Rainbow three-way), all of the exclosures installed included photopoint stakes/posts and transects for measuring the pellets of wild ungulates but did not include vegetation sampling transects. The author installed vegetation sample plots in each of the exclosures in 1994 and returned in 2004 to resample. Thus, the data spans only the last decade, but longer term changes can be inferred by comparing the different exclosures with the open plot. Photopoints were re-established in 1994 and retaken in 2004.

The following five Malheur National Forest exclosures have been selected to demonstrate their value to scientists and specialists. Their integrity has been continuous (ungulates have been wholly or partially excluded per the intentions of those who constructed them). Exclosures that had been breached by ungulates they were constructed to exclude are not included in this selection.

Canyon Creek Three-Way Exclosures (Established 1936)

This exclosure on Bear Valley Ranger District (table 7) is one of the best exclosures in the study area from the standpoint of construction and long-term maintenance. Its fencing has not been breached, and repairs have been timely. The plant community is in the ponderosa pine/antelope bitterbrush/Idaho fescue-bluebunch wheatgrass plant association (*Pinus ponderosa*/*Purshia tridentata*/*Festuca idahoensis-Agropyron spicatum*) (Johnson and Clausnitzer 1992).

Table 7—Canyon Creek three-way exclosures

	Game exclosure		Livestock exclosure		Open	
	1994	2004	1994	2004	1994	2004
			Percent cover			
Bitterbrush	20	24	t	t	1	t
Bluebunch wheatgrass	5	3	10	3	5	5
Idaho fescue	10	20	10	15	30	25
Sandberg's bluegrass	1	t	5	3	3	1
Prairie junegrass	1	t	1	1	1	t
Bare ground	5	5	15	3	10	1
Rock	10	10	20	15	10	15
Gravel	30	30	10	15	5	5
Moss	10	10	3	1	5	3
Lichen	5	5	10	3	1	1
Litter	15	35	35	60	40	70

t = trace

The bitterbrush had severely hedged crowns in the surrounding community outside the game exclosure.

Game exclosure—
Bitterbrush and Idaho fescue both exhibited increases in cover. The open crowns to 4-foot stature of the enclosed bitterbrush plants is a sight not normally seen elsewhere in northeastern Oregon forests and rangelands; in marked contrast, the bitterbrush had severely hedged crowns in the surrounding community outside the game exclosure. Idaho fescue was dominant over bluebunch wheatgrass and doubled in cover over the decade.

Livestock exclosure—
A livestock-proof fence permits deer and elk to enter the stand adjacent to the game exclosure. Bitterbrush was severely hedged inside with no juvenile plants. Interestingly Idaho fescue also increased, as in the game exclosure, increasing in cover as bluebunch wheatgrass declined. Over the 10-year period since the previous sampling, bare ground has sharply declined with a large increase in ground surface now covered by litter (60 percent). This relationship between the bunchgrasses, litter accumulation, and decline in bare ground indicated a progressive successional trend with decreased use of the herbage by livestock.

Open plot—
There was little change over the 10-year period where all ungulates could graze and browse. The bitterbrush was present now as only a trace with plants severely hedged. The bunchgrasses remained at or near their coverage levels from 10 years previous. Litter, which had increased in the exclosures, also had significantly increased here as well.

The increase in litter with decline in bare ground appeared to be a reflection of less ungulate movement and less utilization in the livestock exclosure and in the open plot. In the game exclosure, bare ground was static at a low 5 percent.

Antelope Spring Game Exclosure (Established 1955)

Unlike the adjacent livestock exclosure and open plot that have invasive exotic grasses, the game exclosure at Antelope Spring (also on Blue Mountain Ranger District) provides one of the best intact communities of protected bitterbrush in the exclosure system of northeast Oregon. It lost its integrity when wild horses and mule deer were able to enter the downed fencing of the exclosure in 1989–1990 before repairs were made to re-establish the exclusion. It is now solidly reconstructed. The western juniper/bitterbrush/Idaho fescue-bluebunch wheatgrass plant community dominates the site (*Juniperus occidentalis*/*Purshia tridentata*/*Festuca idahoensis-Agropyron spicatum*) Johnson and Clausnitzer 1992.

Bitterbrush is uniformly 3 to 5 feet tall within the exclosure, and younger age classes are represented. Branches with annual growth may extend to 6 feet in height! This is a demonstration of the growth bitterbrush can achieve on the mountainous ridgetops at the upper limits (5,000 feet) of its elevational range in the Blue Mountains. Outside the exclosure, ungulates have hedged the shrubs severely, with most shrubs only 12 to 24 inches tall. Over the decade, bitterbrush increased its cover within the exclosure from 15 to 25 percent.

Western juniper has increased on the sample area inside the exclosure. In 1994, it was present at only 1 percent cover. Now young trees account for 6 percent cover. As with many of the rangelands in the southern Blue Mountains, western juniper is invading because of fire suppression. Certainly the lack of all disturbances within the exclosure over the past decade of monitoring has promoted its increase. There has been a stable cover of the herbaceous vegetation within the exclosure over the 10-year sample period.

Venator Creek Exclosure (Established 1963)

This ¼-acre livestock-proof exclosure on the Emigrant Creek Ranger District provides a good benchmark for a bitterbrush community containing the two principal bunchgrasses, Idaho fescue and bluebunch wheatgrass (*Purshia tridentata*/*Festuca idahoensis*-*Agropyron spicatum*) (Johnson and Clausnitzer 1992). Unlike the bitterbrush at Antelope Springs, where all-ungulate exclusion has enabled the bitterbrush to establish multiple age classes and attain full crowns, the bitterbrush in this livestock-proof exclosure is susceptible to mule deer browsing. Deer use is high: over 90 percent of the shrubs are decadent and few have branches growing free of hedging. The decrease in cover by bluebunch wheatgrass from 30 to 10 percent over the 1994–2004 sampling period may be attributed to grazing by deer and elk. It may also be attributed to drought, as mosses once as high as 20 percent cover on the ground surface are presently now at only a trace. The loss of the mosses and bluebunch wheatgrass led to the doubling of the bare ground from 25 percent in 1994 to 50 percent in 2004. During this sample period, Idaho fescue cover did not change.

Larsen Spring Exclosure (Established 1963)

Three exclosures in the Blue Mountains (Emigrant Creek Ranger District) include curlleaf mountain-mahogany. Larsen Spring exclosure is the best benchmark of a mountain-mahogany community: all age classes are well represented, assuring a future community of the shrub barring disturbance that jeopardizes the health

and vitality of the plants. This exclosure is dominated by the curlleaf mountain-mahogany (35 percent cover) compared to the 15 percent cover of ponderosa pine (*Pinus ponderosa*). The plant association here is ponderosa pine/curlleaf mountain-mahogany/Idaho fescue-bluebunch wheatgrass (*Pinus ponderosa*/*Cercocarpus ledifolius*/*Festuca idahoensis-Agropyron spicatum*) (Johnson and Clausnitzer 1992). Other prominent shrubs are mountain big sagebrush (*Artemisia tridentata* var. *vaseyana*), wax currant (*Ribes cereum*), and bitterbrush. This livestock-proof ¼-acre exclosure enables wild ungulates to enter. The bitterbrush were decadent, hedged, and had increased only to 3 percent cover from the 1994 sample. Mountain-mahogany increased by 5 percent during the same period. Dramatically increasing species were Idaho fescue (1 to 25 percent) and gray hawksbeard (*Crepis intermedia*), from 5 to 35 percent.

Skookum Spring Exclosure (Established 1963)

The ¼-acre livestock exclosure near Skookum Spring on Capps Mountain (Emigrant Creek Ranger District) provides the best benchmark for the mountain big sagebrush/Idaho fescue-bluebunch wheatgrass plant association in the Blue Mountains (Johnson and Clausnitzer 1992). It was breached in 1994 at the time of the first sample but was quickly restored that season and has maintained its integrity since. Sagebrush dominates at 35 percent cover. Idaho fescue has been stable at 25 percent cover and is the dominant herbaceous plant. Bluebunch wheatgrass declined from 10 to 3 percent cover. Concurrently, spurred lupine (*Lupinus laxiflorus*) increased from 3 to 20 percent over the same period.

The key finding of the three-way exclosure sampling over time is that the plant communities within the livestock exclosure are generally the densest and most vigorous.

Discussion of Results

The key finding of the three-way exclosure sampling over time is that the plant communities within the livestock exclosure are generally the densest and most vigorous. Many studies have demonstrated that long-term herbivory can increase the dominance of highly palatable plants (Augustine and McNaughton 1998, Parker et al. 2006). Bunchgrasses are stimulated by wild ungulate use: seedlings emerge from the bare ground left by light trampling and are afforded early moisture retention by moderate or light litter levels.

In contrast, the bunchgrass plant communities within the game exclosure tend to become decadent over time as thatch builds from lack of ungulate utilization. Rodent populations tend to have the greatest increase in game exclosures capitalizing on the increased cover and lack of predation. The lack of utilization of bunchgrass vegetation allows a deep thatch of herbaceous litter to build over time and provide protected runways and burrow cover. Mammalian predators are thwarted

by the coyote-proof fencing usually employed at the lower levels of game exclosures, and raptors are less successful in seeing the prey from flight. The vegetation becomes progressively weedier with invasive plants occupying areas of disturbance from the rodents. The livestock exclosures have repeatedly demonstrated that bunchgrass vegetation is healthier when stimulated by natural disturbances of fire and native ungulates, and that total exclusion afforded by game exclosures is detrimental to perennial bunchgrasses.

In the plant communities of the Idaho fescue-prairie junegrass plant association, with exclusion of ungulates, Kentucky bluegrass (*Poa pratensis*) has declined and Idaho fescue (*Festuca idahoensis*) increased over time. The only exceptions occur when Kentucky bluegrass is not a component and at Lord Flat where the native vegetation was once plowed under and is still in the early stages of development.

Bluebunch wheatgrass (*Agropyron spicatum*) has either declined or remained static with dominance by Idaho fescue in the ungulate exclosures. No upward trend in bluebunch wheatgrass abundance has occurred at the five Wallowa Mountain sites with exclusion. Prairie junegrass (*Koeleria cristata*) has remained static (no significant change) at these sites with or without exclusion.

The most overgrazed site (Grizzly Ridge) exhibits a consistent decline by all deep-rooted bunchgrasses inside and outside the exclosure. It exemplifies how, on a droughty site, exclusion of grazers may not result in recovery even after decades have passed. Here Kentucky bluegrass was not a component at the time of exclosure installation in 1971. Onespike oatgrass (*Danthonia unispicata*) was a component of the communities within the Grizzly Ridge exclosures in 1971, but did not occur in the sampled open area. Interestingly, with a combination of overgrazing and drought, the deep-rooted bunchgrasses (Idaho fescue and bluebunch wheatgrass) have been eliminated since 1977 in the open area with dominance now achieved by onespike oatgrass.

The invasive exotic, *Ventenata dubia*, has spread across the mountainous rangelands and canyon lands of the inland Pacific Northwest including where exclosures were present prior to the invasion. This annual grass requires active soil disturbance for establishment. Populations of ventenata were highest in open areas where ungulates made the greatest impact from trampling. Ventenata was less pronounced in the livestock exclosures and absent in the game exclosures. At the open sample site at Pleasant Valley, when wildfires burned and provided a barren ground surface, ventenata dramatically dominated the year after the fire. However, within 5 years it was replaced by other plants and was no longer part of the plant community.

In general, annual forbs and grasses dominated in the year after fires in bunchgrass communities. Replacement by perennial forbs and grasses was well underway 5 years after the fire. Native perennial grasses performed predictably in bunchgrass communities burned by wildfires. Both Sandberg's bluegrass and prairie junegrass increased following moderate burns but declined to preburn levels within the first 5 years. Idaho fescue and bluebunch wheatgrass declined in cover from moderate and severe burns in the first 5 years but rebounded thereafter (especially when protected from all ungulates within the game exclosures). In the communities of the central and southern Blue Mountains, western juniper is invading the deeper soil in bitterbrush sites sampled within exclosures.

Within the game exclosures, bitterbrush has emerged with long, free-branching crowns from a hedged state. In stark contrast, the shrubs located in the open areas have remained severely hedged or have died.

The impacts on shrubs, resulting from browsing ungulates, was demonstrated by some exclosures in shrubland communities. At Pleasant Valley in the Snake River Canyon, the game exclosure dramatically encloses a dense rhizomatous shrubland. Outside in the open area, Kentucky bluegrass was the dominant vegetation with minor shrub composition owing to heavy use by livestock and wild ungulates. With the cessation of use by livestock, the lesser use by elk and deer is allowing the emergence of the shrubs. Perhaps no single exclosure within the study area so dramatically displays the zoomorphic influence on vegetation.

The bitterbrush community exclosures located in the central and southern Blue Mountains have demonstrated the impact that browsing animals have made on this shrub. Within the game exclosures, bitterbrush has emerged with long, free-branching crowns from a hedged state. In stark contrast, the shrubs located in the open areas have remained severely hedged or have died.

Metric and English Equivalents

When you know:	Multiply by:	To find:
Inches (in)	2.54	Centimeters (cm)
Inches (in)	.254	Decimeters (dm)
Feet (ft)	.3048	Meters (m)
Acres (ac)	.405	Hectares (ha)

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Appendix 1: Plants Listed by Scientific Name

Scientific name[a]	PLANTS code[b]	Common name[a]
Abies grandis (Dougl. ex D. Don) Lindl.	ABGR	grand fir
Achillea millefolium L. ssp. *lanulosa* (Nutt.) Piper	ACMIL	common yarrow
Agropyron spicatum (Pursh) Scribn. & J.G. Sm.	AGSP	bluebunch wheatgrass
Anthriscus scandicina (Weber ex Wiggers) Mansf.	ANSC8	chervil
Arenaria serpyllifolia L.	ARSE2	thymeleaf sandwort
Artemisia tridentata Nutt. var. *vaseyana* (Rydb.) Beetle	ARTRV	mountain big sagebrush
Balsamorhiza sagittata (Pursh) Nutt.	BASA3	arrowleaf balsamroot
Bromus carinatus Hook. & Arn.	BRCA5	mountain brome
Calamagrostis rubescens Buckl.	CARU	pinegrass
Carex sp. L.	CAREX	sedge species
Cercocarpus ledifolius Nutt.	CELE3	curlleaf mountain-mahogany
Chrysothamnus nauseosus (Pallas ex Pursh) Britt.	CHNA2	gray rabbitbrush
Clintonia uniflora (Menzies ex J.A. & J.H. Schultes) Kunth	CLUN2	beadlily
Crepis intermedia Gray	CRIN4	gray hawksbeard
Danthonia unispicata (Thurb.) Munro ex Macoun	DAUN	onespike oatgrass
Eriogonum heracleoides Nutt.	ERHE2	creamy buckwheat
Festuca idahoensis Elmer	FEID	Idaho fescue
Galium aparine L.	GAAP2	cleavers; bedstraw
Galium trifidum Michx.	GATR3	small bedstraw
Geranium viscosissimum Fisch. & C.A. Mey. ex C.A. Mey.	GEVI2	sticky geranium
Geum triflorum Pursh	GETR	red avens
Hypericum perforatum L.	HYPE	goatweed
Juniperus occidentalis Hook.	JUOC	western juniper
Koeleria cristata auct. p.p. non Pers.	KOCR	prairie junegrass
Lupinus laxiflorus Dougl. ex Lindl., non Amer. auct.	LULA3	spurred lupine
Lupinus sericeus Pursh	LUSE4	silky lupine
Pinus ponderosa P.& C. Lawson	PIPO	ponderosa pine
Poa compressa L.	POCO	Canada bluegrass
Poa pratensis L.	POPR	Kentucky bluegrass
Poa secunda J. Presl	POSE	Sandberg's bluegrass
Potentilla gracilis Dougl. ex Hook.	POGR9	slender cinquefoil
Pseudotsuga menziesii (Mirbel) Franco	PSME	Douglas-fir
Purshia tridentata (Pursh) DC.	PUTR2	antelope bitterbrush
Ribes cereum Dougl.	RICE	wax currant
Rosa sp. L.	ROSA	rose species
Rumex acetosella L.	RUAC3	sheep sorrel
Stipa occidentalis Thurb. ex S. Wats.	STOC2	western needlegrass
Symphoricarpos albus (L.) Blake	SYAL	common snowberry
Symphoricarpos oreophilus Gray	SYOR2	mountain snowberry
Taxus brevifolia Nutt.	TABR2	Pacific yew
Tragopogon dubius Scop.	TRDU	yellow salsify
Ventenata dubia (Leers) Coss. & Durieu	VEDU	ventenata

[a] Hitchcock and Cronquist 1973.
[b] USDA NRCS 2004.

Appendix 2: Plants Listed by Common Name

Common name[a]	Scientific name[a]	PLANTS code[b]
antelope bitterbrush	*Purshia tridentata*	PUTR2
arrowleaf balsamroot	*Balsamorhiza sagittata*	BASA3
beadlily	*Clintonia uniflora*	CLUN2
bluebunch wheatgrass	*Agropyron spicatum*	AGSP
Canada bluegrass	*Poa compressa*	POCO
chervil	*Anthriscus scandicina*	ANSC8
cleavers; bedstraw	*Galium aparine*	GAAP2
common snowberry	*Symphoricarpos albus*	SYAL
common yarrow	*Achillea millefolium* var. *lanulosa*	ACMIL
creamy buckwheat	*Eriogonum heracleoides*	ERHE2
curlleaf mountain-mahogany	*Cercocarpus ledifolius*	CELE3
Douglas-fir	*Pseudotsuga menziesii*	PSME
goatweed	*Hypericum perforatum*	HYPE
grand fir	*Abies grandis*	ABGR
gray hawksbeard	*Crepis intermedia*	CRIN4
gray rabbitbrush	*Chrysothamnus nauseosus*	CHNA
Idaho fescue	*Festuca idahoensis*	FEID
Kentucky bluegrass	*Poa pratensis*	POPR
mountain big sagebrush	*Artemisia tridentata* var. *vaseyana*	ARTRV
mountain brome	*Bromus carlinatus*	BRCA5
mountain snowberry	*Symphoricarpos oreophilus*	SYOR2
onespike oatgrass	*Danthonia unispicata*	DAUN
Pacific yew	*Taxus brevifolia*	TABR2
pinegrass	*Calamagrostis rubescens*	CARU
ponderosa pine	*Pinus ponderosa*	PIPO
prairie junegrass	*Koeleria cristata*	KOCR
red avens	*Geum triflorum*	GETR
rose species	*Rosa* sp.	ROSA
Sandberg's bluegrass	*Poa secunda*	POSE
sedge species	*Carex* sp.	CAREX
sheep sorrel	*Rumex acetosella*	RUAC3
silky lupine	*Lupinus sericeus*	LUSE4
slender cinquefoil	*Potentilla gracilis*	POGR9
small bedstraw	*Galium trifidum*	GATR3
spurred lupine	*Lupinus laxiflorus*	LULA3
sticky geranium	*Geranium viscosissimum*	GEVI2
thymeleaf sandwort	*Arenaria serpyllifolia*	ARSE2
ventenata	*Ventenata dubia*	VEDU
wax currant	*Ribes cereum*	RICE
western juniper	*Juniperus occidentalis*	JUOC
western needlegrass	*Stipa occidentalis*	STOC2
yellow salsify	*Tragopogon dubius*	TRDU

[a] Hitchcock and Cronquist 1973.
[b] USDA NRCS 2004.

Appendix 3: Area 3 Permanent Upland Exclosures

Malheur, Umatilla, and Wallowa-Whitman National Forests

Exclosure	District	Established	Legal description	Size	Plant community
				Acres	
Malheur National Forest:					
Canyon Creek 3-Way	Blue Mountain	1936	T15S,R32E,SEC.17	G = 1.0; S = 1.1	PIPO/PUTR/FEID-AGSP
Antelope Spring	Blue Mountain	1955	T15S,R28E,SEC.31	G = 1.4	JUOC/PUTR/FEID-AGSP
Wickiup	Blue Mountain	1933	T16S,R29E,SEC. 3		CAREX Meadow
Birch Creek 3-Way	Blue Mountain	1961	T12S,R29E,SEC.22	G = 1.1	CELE/PUTR/AGSP
Donaldson Ridge	Blue Mountain	1963	T12S,R29E,SEC. 6	S only = 0.3	PIPO/PUTR/AGSP-POSE
Dry Creek 3-Way	Blue Mountain	1939	T12S,R30E,SEC.30	G = 1.1	AGSP-POSE-ERHE2
Hamilton Ridge	Blue Mountain	1963	T10S,R28E,SEC.25	S only = 0.3	PUTR/AGSP/POSE-DAUN
Raddue #4	Blue Mountain	1963	T12S,R30E,SEC.1		PUTR/AGSP
Raddue Ridge 3-Way	Blue Mountain	?	T11S,R30E,SEC.35	G = 1.1; S = 1.1	PIPO-JUOC/CELE-SYOR
Cougar Creek 3-Way	Prairie City	1966	T18S,R35E,SEC.11	G = 1.1; S = 1.3	PUTR-ARTRV/FEID-AGSP
Gilbert Ridge	Emigrant Creek	1963	T18S,R28E,SEC.12	S only = 0.2	PIPO/ARTRV/FEID-AGSP
Venator Creek	Emigrant Creek	1963	T18S,R29E,SEC.20	S only = 0.2	PUTR/FEID-AGSP
Larsen Spring	Emigrant Creek	1963	T21S,R31E,SEC. 3	S only = 0.2	PIPO/CELE/FEID-AGSP
Jake Green Spring	Emigrant Creek	1963	T21S,R32.5E,SEC.14	S only = 0.2	ARTRV/FEID-AGSP
Whiting Spring	Emigrant Creek	1963	T20S,R31E,SEC.30	S only = 0.4	ARTRV/FEID-KOCR
Skookum Spring	Emigrant Creek	1963	T19S,R33E,SEC.12	S only = 0.3	ARTRV/FEID-AGSP
Duck Creek	Emigrant Creek	1950	T18S,R33.5E,SEC.14	G only = 1.0	ARTRV/FEID-KOCR
Rainbow 3-Way	Emigrant Creek	1957	T20S,R29E,SEC. 2	G = 1.0; S = 1.0	PUTR-ARTRV/FEID-AGSP
Umatilla National Forest:					
Skookum 3-Way	Heppner	1945	T6SW,R28E,SEC.30		JUOC/PUTR/FEID-AGSP
Long Hollow 3-Way	North Fork John Day	1962	T6S,R32E,SEC.7		AGSP-POSA3
Pine Grove 3-Way	North Fork John Day	1962	T6S,R32E,SEC.20		FEID-AGSP
Stumbough	Walla Walla	1983	2N,R36E,SEC.9		FEID-AGSP
Pataha RNA	Pomeroy	Transects 1960	T9N,R42E,SEC.1		FEID-KOCR MOUND
Mottet	Walla Walla	1965	T4N,R39E,SEC.20		ABGR/TABR/CLUN
Hoodoo	Walla Walla	1965	T5N,R42E,SEC.8		ABGR/CLUN
Wallowa-Whitman National Forest:					
Allen Springs 3-Way	Wallowa Valley	1963	T5N,R45E,SEC.24		FEID-KOCR RIDGE
Coffee Pot 3-Way	Hells Canyon	1969	T2N,R49E,SEC.23		FEID-KOCR RIDGE
Corral Gulch 3-Way	Pine	1962	T8S,R45E,SEC.23	G = 1.1; S = 1.2	ARTRV-PUTR/FEID
Grizzly Ridge 3-Way	Hells Canyon	1969	T2N,R48E,SEC.34		FEID-KOCR RIDGE
Goose Creek 3-Way	Pine	1964	T8S,R43E,SEC. 3		ARTRV-PUTR/FEID
Lord Flat 3-Way	Hells Canyon	1969	T2N,R50E,SEC. 7	G = 1.0; S = 3.5	FEID-KOCR RIDGE
Mormon Flat 3-Way	Hells Canyon	1969	T2N,R50E,SEC.29	G = 1.2; S = 2.8	FEID-KOCR MOUND
Pleasant Valley 3-Way	Hells Canyon	1969	T2N,R51E,SEC.19	G = 1.1; S = 1.7	SYAL-ROSA
Three Cent 3-Way	Unity	1962	T10S,R36E,SEC.12	G = 0.9; S = 1.3	ECOTONAL (Shrub-grass)
Bald Mountain	Baker	1940s	T11S,R38E,SEC. 7		ABGR/CARU
Sumpter 3-Way	Baker	1962	T10S,R37E,SEC.15	G = 1.1; S = 2.4	PIPO/PUTR/FEID
Little Sheep 3-Way	Eagle Cap	1964	T2S,R41E,SEC.14		PSME/SYAL

G = Game (10-foot fence).
S = Livestock (4-foot fence).

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