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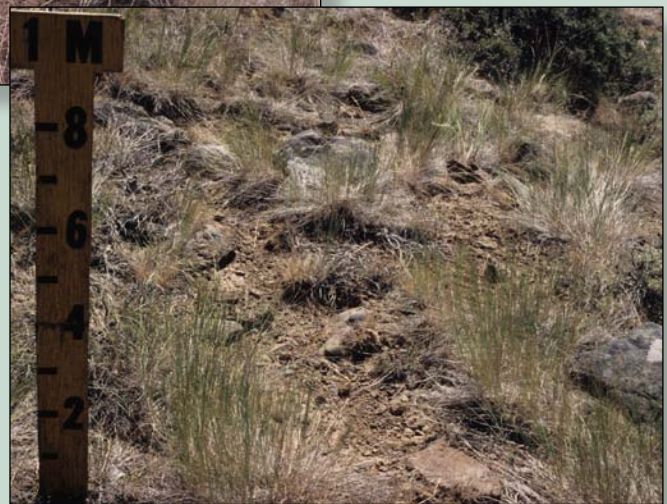
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# Variation in Shrub and Herb Cover and Production on Ungrazed Pine and Sagebrush Sites in Eastern Oregon: A 27-Year Photomonitoring Study

Frederick C. Hall



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## **Cover photos**

The photos on the cover depict the change in vegetation, from one year to the next, at the same sample point. The top photo was taken in 1994 and the bottom photo was taken one year later in 1995. Photos by Frederick C. Hall.

## Abstract

**Hall, Frederick C. 2007.** Variation in shrub and herb cover and production on ungrazed pine and sagebrush sites in eastern Oregon: a 27-year photomonitoring study. Gen. Tech. Rep. PNW-GTR-704 Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 44 p.

Study objectives were to evaluate yearly fluctuations in herbage canopy cover and production to aid in defining characteristics of range condition guides. Sites are located in the forested Blue Mountains of central Oregon. They were selected from those used to develop range condition guides where soil, topographic, and vegetation parameters were measured as a characterization of best range condition. Plant community dominants were ponderosa pine/pinegrass, ponderosa pine/bitterbrush/Idaho fescue savanna, low sagebrush/bluebunch wheatgrass, and rigid sagebrush scabland. None of the sites were grazed during the previous 30 years or during the 27-year study. Each location was permanently marked by fence posts, and a meter board was placed 10 m down an established transect line. Photographs (color slides) were taken down the transect with closeups left and right of the meter board. Sampling was limited to August 1–4 each year when canopy cover and herbage production were determined. Both total canopy cover and herbage production varied by about a 2.4-fold difference on each site over the 27 years. Apparently “good range condition” may be something of a “running target” and lacks a well-defined set of parameters. Canopy cover is a poor parameter for characterizing range condition. Three of the four plant communities were dominated by bunchgrasses. Abundance of seedheads is commonly used to indicate good range health. But on these sites, seedheads were not produced about half the time. Because these sites were in “good range condition,” lack of seedhead production may indicate maximum competition in the community. Maximum competition and maximum vigor do not seem to be synonymous. These bunchgrass communities varied in their greenness on the first of August each year from cured brown to rather vibrant green suggesting important annual differences in phenology. The pinegrass community, being dominated by rhizomatous species, showed surprising variance in seedhead production. Pinegrass did not flower, but Wheeler’s bluegrass, lupine, and Scouler’s woollyweed were quite variable, averaging inflorescences only 75 percent of the time.

Keywords: Range condition, flowering, canopy cover, herbage production, bunchgrass, yearly variability.

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## **Introduction**

Use of range condition guides presupposes that vegetation characteristics of good condition are reasonably consistent from year to year. The validity of this concept warrants consideration because it forms the basis for determining fair and poor range condition as part of an appraisal of range health, which determines the need for livestock adjustment. Seventeen sites representative of common range plant communities in the Blue Mountains of eastern Oregon were monitored August 1 to 4 from 1976 to 2006 for yearly changes in species dominance and herbage production at a consistent time of year. They were selected from those sites sampled to develop range condition guides by using the 3-Step Method (Parker and Harris 1959).

## **Plant Communities**

Four common plant communities were chosen for this report: ponderosa pine/pinegrass, ponderosa pine/bitterbrush/Idaho fescue savanna, low sagebrush/bluebunch wheatgrass, and rigid sagebrush scabland.<sup>1</sup> Data show that there is variability in species canopy cover and total herbage production between years. The data raise questions about the concept of a single set of criteria for “good” in range condition guides. The data also raise questions about what kind of sampling system is appropriate for characterizing these guides.

Ponderosa pine/pinegrass, often with Douglas-fir and grand fir, is the most widespread forested plant community, that is also grazed, east of the Cascade crest in both Oregon and Washington. As tree cover increases, shrub and herb species density, composition, and production decreases (USDA FS 1967a).

Ponderosa pine/bitterbrush/Idaho fescue is the second most common forested plant community that is grazed east of the Cascade crest. It represents the transition from grassland or sagebrush to forest as precipitation increases. And it, like ponderosa/pinegrass, suffers from a reduction of herbaceous species with an increase in tree cover. But it occupies a unique place in forested rangeland. Tree density for 1-in diameter growth per decade (Hall 2004) is so low that tree canopy, at this density, does not significantly affect herbaceous cover or production. However, tree cover in stagnated stands does reduce herbage production. Tree density also affects tree growth in both height and diameter. Grass canopy cover can reach 70 percent and herbage production 400 kg/ha.

Low sagebrush/bluebunch wheatgrass, the third most widespread plant community, occurs within the forest zone on soils too shallow for pine or fir. Juniper

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<sup>1</sup> See “Species List” for Latin names of species in this publication.

can colonize these sites. Grass seedhead production on these areas is a trait evaluated by photo interpretation. The parameter evaluated is the number of bunchgrass plants that flowered by August 1. Canopy cover can reach 70 percent and herbage production 600 kg/ha.

Rigid sagebrush scabland was the fourth most widespread kind of plant community studied. It occurs within the forest zone on very shallow soils, 1.5 to 3.0 dm deep, on poorly cracked bedrock. Soils are so shallow that they become waterlogged during winter. Soil protection is afforded by a gravel and stony cover with biological species such as moss and lichens intertwined. Herbaceous cover may reach 45 percent and production 250 kg/ha.

## Methods

August 1 to 4 was established as the time of year to sample. It was established as a reference point for plant phenological development including greenness, seedhead production, canopy cover, and herbage production.

### Photomonitoring

Photomonitoring (Hall 2002) was used to illustrate yearly changes based on recommendations by Reppert and Francis (1973) in their appraisal of the 3-Step Method. Their procedure was adapted as follows: (1) Each site was identified with steel fence posts or concrete reinforcing bars in rigid sagebrush sites. (2) The camera location was placed at the 0-ft end of the original range condition sampling transect. (3) A board 1 meter tall and marked in even decimeters was placed at the 10-m (33-ft) transect location and three images were recorded: a general view from the 0-ft end of the tape, and two at 2 m from the board, a view left of the meter board, and a view right of the board. These were used to appraise seedhead production, change in soil surface conditions, greenness of the vegetation, and as a check on estimates of canopy cover. Because of space limitations, only the right meter board image has been used.

### Canopy Cover

At each side of the meter board a 1-m square plot frame was placed to document canopy cover and estimate total herbage production. One decimeter marks were placed at each corner of the meter square to facilitate canopy estimates as a 1-dm square is 1 percent cover. Continuous vegetation (no open space) over at least 66 percent of the 1-dm square constitutes 1 percent cover.

## **Herbage Production**

Herbage production was also estimated by using the 1-dm square. Near the sample site, a 1-m square area was selected on which to adjust ocular herbage production estimates. The area would be estimated and then clipped to measure grams of dry matter. To focus attention on plant biomass, a 1-dm square area around each plant was evaluated to determine how many 1-square dm areas were covered by a plant; then grams were estimated. This simply focused my attention on plant biomass. Herbage samples were air dried.

Other observations were noted at each site. Subsequent careful observation of recorded images revealed items missed in the field. I was surprised at how much could be “seen” by comparing images year by year. Rocks “moved,” trees came and went, bunchgrass plants shifted location, foliage color changed, foliage length varied, and seedheads were amazingly variable by number of plants, by number per plant, and by shift in plant location.

## **Image Identification**

The USDA Forest Service Pacific Northwest Region has developed a system for archiving images, mostly color slides. About 5,000 long-term study slides have been identified and categorized to be made available online. All images used here have been identified by a code consisting of an alphanumeric site identification. For example, the ponderosa pine/bitterbrush/Idaho fescue site code is 203EPF identifying ecology plot 203 and is read as “plot 203 ecology plot forage.” Tables in this publication use the archiving codes to facilitate access to the slides.

## **Photomonitoring**

All images used here are the same colors found on the slides. In no case was color altered. A few times brightness was altered to modify effects of shadows. Note that images from 1957 to 1960 show effects of color fade. Kodak Ektachrome<sup>2</sup> was used in preference to Kodachrome because the latter gave too much red and an unrealistic color to vegetation. Ektachrome ISO was 100 in 1957 and 200 after 1966.

Capturing the subtleties of greenness in August proved to be a challenge. The degree of greenness varied considerably.

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<sup>2</sup> Use of firm or trade names in this publication is for reader information and does not imply endorsement by the U.S. Department of Agriculture of any product or service.



Camera technique was important in comparing images (Hall 2002). First, both camera location and photopoint at the meter board must be permanently marked with steel fence posts or stakes. The meter board for general pictures was used to orient the camera by focusing on the "1M." Then it was used to photograph a specific tract of ground for repeat images. This requires another camera location in front of the board. For camera focal length of 50mm, the camera was held 2 m from the board. The camera was oriented to place the board at one side of the image so it reached from top to bottom.

Digital cameras usually have zoom lenses so distance is very critical if any kind of change is to be documented. For general images, the zoom was adjusted to show the meter board at 25 percent of the image height. For the closeup images, the camera is oriented 2 m in front of the board and zoomed to just fill the one side of the image with the board.

## **Viewing Images**

Each of the following four sections is organized with an introductory page followed by four pages of images to the right of the meter board. When the pages are opened, one can view 12 years. Read from left to right across both pages.



## Ponderosa Pine/Pinegrass Site: Herbage Dominance and Production

This site is located at the south edge of Big Summit Prairie, Lookout Mountain District, Ochoco National Forest. The area was historically a sheep allotment but was converted to a cattle allotment after the Second World War. It was selected because both woody and herbaceous vegetation seem near site potential for the area (USDA FS 1967a). All sampling was done between August 1 and 4 starting in 1979 to the present.

All images are shown as they appear on color slides of Kodak Ektachrome, ISO 200. In 1986, the roll of film was overexposed and the images are not presented here.

The intent was to show yearly differences in both species dominance and seasonal color.



**1979:** The ponderosa pine/pinegrass site during a drought. The log to the right of the meter board appears in all subsequent images of herbage species. Note the slight differences in dominance of pinegrass. This is due to variation in Mazama ash depth. Less ash means less vigor of pinegrass and more vigor of elk sedge. The image for 1986 is not included.

Soil profile shows ash depth of 0.5 to 0.6 m over a buried soil. Basalt bedrock produced a moderately stony clay-loam soil.



**1979:** View right of the meter board: pinegrass 40 percent cover, elk sedge 10 percent, and dried lupine 10 percent cover; 300 kg/ha herbage production. A pine seedling is next to the meter board between 6 and 8 dm. It was missing by 1982.







**1980:** Percent cover: pinegrass 55, elk sedge 20, lupine 15, Wheeler's bluegrass 5; herbage production 650 kg/ha.



**1981:** Percent cover: pinegrass 50, elk sedge 25, Wheeler's bluegrass 25 (seed heads), no lupine; herbage production 550 kg/ha.



**1984:** Percent cover: pinegrass 55, lupine 30 (white seed heads), elk sedge 20; herbage production 600 kg/ha.



**1985:** Percent cover: pinegrass 35, lupine (dry) 30, elk sedge 15, Scouler's woollyweed 5; herbage production 425 kg/ha.



**1989:** Percent cover: pinegrass 45, lupine 25 (white seed heads), elk sedge 20; herbage production 500 kg/ha.



**1990:** Percent cover: pinegrass 60, Wheeler's bluegrass 15 (seed heads), Scouler's woollyweed 5; herbage production 600 kg/ha.





**1982:** Percent cover: pinegrass 40, lupine 20, elk sedge 15, Wheeler's bluegrass 5; herbage production 450 kg/ha. Pine now dead.



**1983:** Percent cover: pinegrass 50, elk sedge (dark green) 25, herbage production 400 kg/ha. Pine seedlings top right near log.



**1987:** Percent cover: pinegrass 40, lupine 25, elk sedge 20; herbage production 500 kg/ha.



**1988:** Percent cover: pinegrass 55, lupine 35 (brown), Scouler's woollyweed 10; herbage production 600 kg/ha.



**1991:** Percent cover: pinegrass 55, lupine 20, Wheeler's bluegrass 10, Scouler's woollyweed 15; herbage production 600 kg/ha.



**1992:** Percent cover: pinegrass 40, lupine 10, Wheeler's bluegrass 20; herbage production 500 kg/ha. Pine seedlings top right.

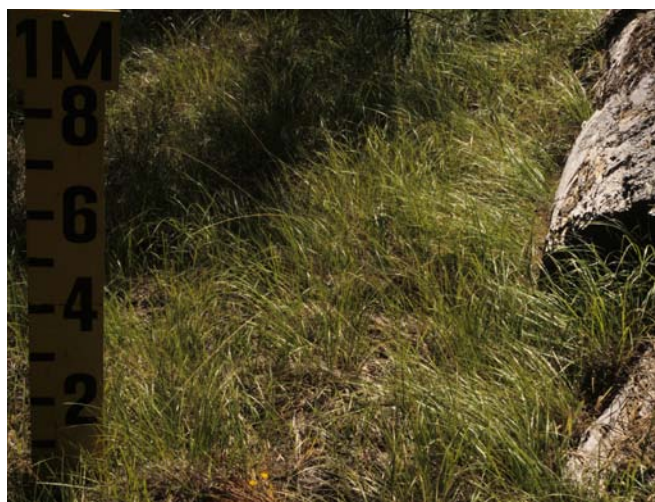




**1993:** Percent cover: pinegrass 55, lupine 15, Wheeler's bluegrass 10, elk sedge 10; herbage production 675 kg/ha.



**1994:** Percent cover: pinegrass 55, Wheeler's bluegrass 20, elk sedge 10, lupine 2; herbage production 600 kg/ha.



**1997:** Percent cover: pinegrass 70, Wheeler's bluegrass 20, lupine 10, elk sedge 10; herbage production 675 kg/ha.



**1998:** Percent cover: pinegrass 55, Wheeler's bluegrass 20, lupine 15, Scouler's woollyweed 8; herbage production 500 kg/ha.



**2001:** Percent cover: pinegrass 55, Wheeler's bluegrass 15, lupine 15, Scouler's woollyweed 5; herbage production 500 kg/ha.



**2002:** Percent cover: pinegrass 40, Scouler's woollyweed 10, lupine 10; herbage production 450 kg/ha. Pine seedlings top right.





**1995:** Percent cover: pinegrass 40, Scouler's woollyweed 10, lupine 10; herbage production 500 kg/ha. Pine seedlings top right near log.



**1996:** Percent cover: pinegrass 70, Wheeler's bluegrass 20, Scouler's woollyweed 5; herbage production 600 kg/ha.



**1999:** Percent cover: pinegrass 40, lupine 10, Scouler's woollyweed 5; herbage production 400 kg/ha.



**2000:** Percent cover: pinegrass 50, Wheeler's bluegrass 20, Scouler's woollyweed 10, no lupine; herbage production 550 kg/ha.



**2003:** Percent cover: pinegrass 40, Scouler's woollyweed 10, lupine 10, Wheeler's bluegrass 10; herbage production 400 kg/ha.



**2004:** Percent cover: pinegrass 45, Wheeler's bluegrass 25, Scouler's woollyweed 10, elk sedge 10; herbage production 450 kg/ha.





**2005:** View of the pine/pinegrass site after 27 years. The regenerating pines shown in 1983, 1992, 1995, and 2002 are just behind the end of the log and about 2 m tall after about 25 years. Root competition from dominant pines has greatly reduced height growth, which should be about 6 m on this site index of 23 m.

Difference in density of pinegrass, the dominant herb, is caused by variation in ash depth over the buried soil. The image for 1979 shows less contrast because the drought limited height of pinegrass.



**2005:** Percent cover: pinegrass 40, Wheeler's bluegrass (seed-heads) 20, elk sedge 10, Scouler's woollyweed 8; herbage production 450 kg/ha. Pine seedlings at the top-right are now only saplings after 25 years.

A crude estimate of herbage production may be obtained by multiplying total herbage cover by a factor of 6.2. For the example above:  $40 + 20 + 10 + 8 = 78$ ;  $78 \times 6.2 = 483$  kg/ha.

## Comments

Over a 26-year period (data from table 1-BSPCF-ponderosa pine/pinegrass):

- Pinegrass, the dominant species, varied from 35 to 55 percent cover, a 1.5-fold difference, which was not affected by livestock utilization. This variation suggests that estimation of range condition by use of canopy cover is questionable.
- Sampling of vegetation to estimate range condition should consider methods that are sensitive to species presence as well as dominance. For example, lupine was measurable for canopy cover only 73 percent of the time, yet it was still rooted in the plant community. During good lupine growing conditions, it attained 25 to 35 percent canopy cover and produced heavy seeds enhancing herbage production.
- Total herbage production averaged 520 kg/ha but varied from 300 to 675 kg/ha, a 2.25-fold difference on the same good range condition site. Exercise caution when estimating allotment carrying capacity based on range condition.
- Only pinegrass had measurable canopy cover 100 percent of the time. Four other species, lupine, Scouler's woollyweed, elk sedge, and Wheeler's bluegrass were evident only 65 to 75 percent of the time. They were present but not measurable for canopy cover or herbage production. This situation should be considered when describing vegetation characteristics for range condition guides.

**Table 1-BSPCF—Ponderosa pine/pinegrass. Yearly canopy cover by species and statistics on total yearly canopy cover, herbage production, and ratio of production to canopy cover**

	Canopy cover by species code <sup>a</sup>										
Year	CARU	LUCA	HISC2	CAGE2	PONE2	NOTR2	ARCO9		Herb cover	Herbage production	Ratio cover/ kg/ha
	Percent								Percent	kg/ha	Ratio
1979	40	10	20						60	300	5.0
1980	50	25	5	25		2	10		95	550	5.8
1981	50			25	15				100	650	6.5
1982	40	20	2	20	10	5			80	450	5.6
1983	50			25	1				75	400	5.3
1984	55	30		20					105	600	5.7
1985	35	30	5	15					85	450	5.0
1987	40	25		20					85	500	5.9
1988	55	35	10	1	1				100	600	6.0
1989	45	25		20					90	500	5.6
1990	60		5	1	15				81	600	7.5
1991	45	20	5	1	10		5		90	600	6.7
1992	40	10		1	20				70	500	7.1
1993	45	15	5	10	10				90	675	7.5
1994	45	1		10	20				87	600	6.9
1995	40	10	10						60	500	8.3
1996	50		5	1	20				60	600	6.3
1997	50	10	5	10	20				95	675	7.1
1998	45	15	8		20				98	500	5.1
1999	40	10	5						60	400	6.7
2000	50		10		20				80	550	6.9
2001	55	15	5		15				90	500	5.6
2002	40	10	10						60	450	7.5
2003	40	10	10		10				70	400	5.7
2004	50		10		25				90	550	6.1
2005	40	18	8	10	30				83	450	5.1
Mean	46.0	18.1	6.8	13.1	15.4	3.5	7.5	Mean	83.8	520.2	6.2
Count	26	19	18	18	17	2	2	SD	13.5	94.6	0.9
Percent	100	73	69	69	65	8	8	5% CI	5.2	36.4	0.4

Note: SD = standard deviation; CI = confidence interval.

<sup>a</sup>See “Species List: Codes” for plant code definitions.





## Ponderosa Pine/Bitterbrush/Idaho Fescue Site: Herbage Dominance and Production

This study was placed on ecology plot number 203 installed in 1957 to measure vegetation and soil attributes for development of range condition guides (USDA FS 1967b). It is located on the Lookout Mountain District, Ochoco National Forest, on the east edge of Big Summit Prairie. All sampling was done between August 1 and 4 each year starting in 1977 to the present.



**1957:** The ponderosa/bitterbrush/fescue community in 1957 with small, sapling sized ponderosa regeneration, hedged bitterbrush, and vigorous fescue. Color in the slide has faded over 45 years.



Soil is Mazama ash over basalt-derived residual soil. A 9-in finger spread was replaced by a meter tape for subsequent images. Total soil depth was 0.6 m.



**1978:** Same stand in 1978 when this study was initiated. Pine saplings have only grown about 6 dm in 20 years. The area was underburned in spring 2002 when the log left rear of the meter board was consumed. A precommercial thinning was applied in 2003.



**1978:** Idaho fescue is the dominant herb. The foreground individual has produced abundant seed stalks. Compare to following images. It was killed by the prescribed burn of 2002.





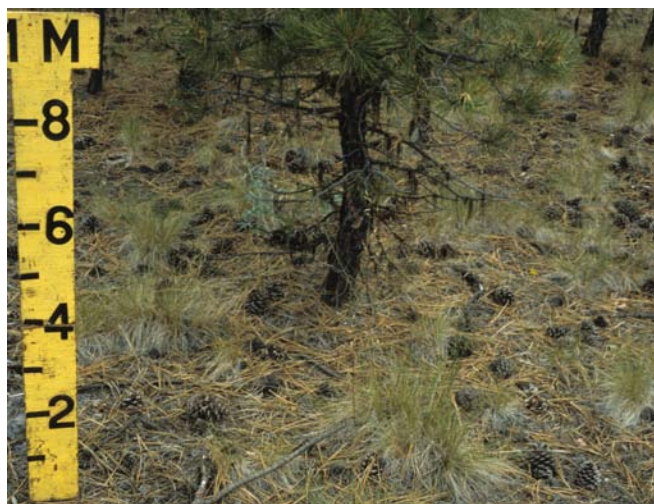
**1979:** No seedheads; percent cover: Idaho fescue 20, squirreltail 5, wheatgrass 5; herbage production 300 kg/ha.



**1980:** No seedheads; percent cover: fescue 15, wheatgrass 5, Ross sedge 2, squirreltail 2; herbage production 250 kg/ha.



**1983:** No seedheads; percent cover: fescue 15, wheatgrass 2, Ross sedge 2, pussytoes 2; herbage production 200 kg/ha.



**1984:** No seedheads; percent cover: fescue 15, Ross sedge 2, needlegrass 2, yarrow 1; herbage production 225 kg/ha.



**1987:** 50 percent seedheads; percent cover: fescue 15, wheatgrass 8, needlegrass 3, junegrass 2; herbage production 250 kg/ha.



**1988:** No seedheads; percent cover: fescue 15, wheatgrass 2, squirreltail 2, Ross sedge 2; herbage production 200 kg/ha.





**1981:** 60 percent seedheads; percent cover: fescue 25, wheatgrass 7, needlegrass 2; herbage production 350 kg/ha.



**1982:** 10 percent seedheads; percent cover: fescue 25, wheatgrass 2, lupine 5, pussytoes 2; herbage production 300 kg/ha.



**1985:** No seedheads; percent cover: fescue 20, Japanese brome 8 (heads), squirreltail 5; herbage production 325 kg/ha.



**1986:** No seedheads, percent cover: fescue 12, wheatgrass 2, pussytoes 1, Ross sedge 1; herbage production 150 kg/ha.



**1989:** 20 percent seedheads; percent cover: fescue 18, wheatgrass 2, squirreltail 3, bluegrass 2; herbage production 235 kg/ha.



**1990:** No seedheads; percent cover: fescue 20, wheatgrass 5, junegrass 2, Ross sedge 2; herbage production 300 kg/ha.





**1991:** 10 percent seedheads; percent cover: fescue 10, wheatgrass 2, pussytoes 1, needlegrass 1; herbage production 175 kg/ha.



**1992:** No seedheads; percent cover: fescue 15, pussytoes 2, Ross sedge 2, squirreltail 2; herbage production 225 kg/ha.



**1995:** No seedheads; percent cover: fescue 12, wheatgrass 2, squirreltail 2, Ross sedge 2; herbage production 225 kg/ha.



**1996:** No seedheads; percent cover: fescue 18, wheatgrass 2, squirreltail 4, Ross sedge 3; herbage production 300 kg/ha.

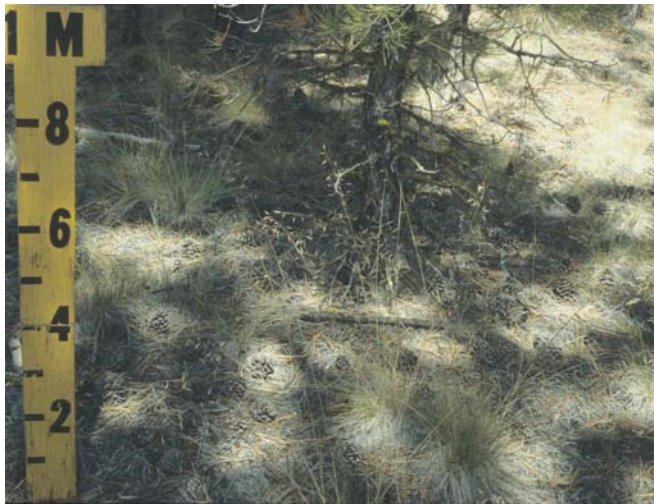


**1999:** 5 percent seedheads; percent cover: fescue 15, wheatgrass 3, squirreltail 2, needlegrass 2; herbage production 250 kg/ha.



**2000:** 10 percent seedheads; percent cover: fescue 18, wheatgrass 2, Ross sedge 2, pussytoes 1; herbage production 250 kg/ha.





**1993:** 10 percent seedheads; percent cover: fescue 20, wheatgrass 3, Japanese brome 6, yarrow 2; herbage production 300 kg/ha.



**1994:** 40 percent seedheads; percent cover: fescue 20, wheatgrass 10, yarrow 2, needlegrass 3; herbage production 350 kg/ha.



**1997:** 30 percent seedheads; percent cover: fescue 15, wheatgrass 2, Japanese brome 3, yarrow 2; herbage production 250 kg/ha.



**1998:** 10 percent seedheads; percent cover: fescue 18, wheatgrass 4, needlegrass 1, pussytoes 1; herbage production 275 kg/ha.



**2001:** 10 percent seedheads; percent cover: fescue 15, wheatgrass 2, pussytoes 2, needlegrass 1; herbage production 225 kg/ha.

The next few pages document a spring underburn and a precommercial thinning on this site.





**2002:** The stand was underburned in spring 2002. Patchy pine saplings were not thinned. Single trees in fuel-loaded areas were killed. The log in left background of 1978 was consumed.



**2002:** Spring underburn. Fescue (front center) was killed (white ash); some unburned fescue are green.



**2004:** Fescue has recovered and has abundant seedheads. Stand density is now appropriate for this savanna ponderosa pine site with its low stockability.



**2004:** 100 percent seedheads; percent cover: fescue 25, wheatgrass 1, Ross sedge 1, few species; herbage production 350 kg/ha.





**2003:** The stand was precommercially thinned to adjust stocking level in fall 2002. Slash was untreated. Fescue has greened up since the underburn in 2002.



**2003:** Precommercial thin, fall 2002. The cut pine sapling was only 5 cm diameter after 30 years.



**2005:** Some overstory trees have been harvested in the background. Fescue has several years accumulated dry foliage showing lack of livestock grazing. Most of the bitterbrush shown in 1957 and 1978 is missing, presumably owing to underburning, increasing tree canopy, and utilization by ungulates.



**2005:** 80 percent seedheads on older fescue; percent cover: fescue 20, some young fescue, few species; herbage production 300 kg/ha.



**2006:** Little change is apparent since 2004. There is scant evidence of bitterbrush reestablishment. Herbage production is between 300 and 350 kg/ha.



**2006:** 100 percent seedheads on all fescues; percent cover: fescue 20, wheatgrass 2. The grey patch in the front center is killed fescue, but one corner is apparently alive.

## Comments

Over a 27-year period (data from table 2-203EPF-Pine/fescue):

- Seedheads were produced only 60 percent of the time. Abundant seedhead production, more than 50 percent of the bunchgrass plants flowering, only occurred 15 percent of the time. Yet abundant seedhead production has been used as an indication of good vigor and a healthy plant community (Committee on Rangeland Classification 1994, Pellant et al. 2005).

Good range condition means an end point in succession where the plant community is so competitive that earlier seral species are excluded (Committee on Rangeland Classification 1994, Pellant et al. 2005). How can maximum competition equate to maximum vigor and thus maximum seedheads? I feel they are not synonymous. Good condition has fewer seedheads than upward trend communities.

The precommercial thinning of 2002 reduced tree cover and root competition sufficiently to foster abundant seedhead production not seen in the previous 26 years.

- Herbage production averaged 262 kg/ha but varied from 150 to 350 kg/ha, a 2.25-fold difference on the same good range condition site. Production seemed to increase following precommercial thinning. Pellant et al. (2005) considered herbage production a criteria for evaluating rangeland health.
- Color of fescue varied from greenish-gray to green over the years. Inclusion of dead, gray leaves and stems tends to reduce fescue palatability to ungulates. Thus differences in August color suggest variability in dates when forage is preferred implying that a flexible grazing management system might be beneficial for ungulates.
- Change in the plant community since precommercial thinning suggests an “upward range trend” shown by plant vigor and production. On forested rangeland,



tree cover and competition can influence herbaceous vegetation at least as much as livestock.

- Savanna pine sites are a transition from grassland or sagebrush to forest. Trees can **barely** become established and grow. This site is an example. Stockability is only 14 m<sup>2</sup>/ha (Hall 2004) for a site index of 19 m. Normal yield tables suggest an average of 40 m<sup>2</sup>/ha (Meyer 1938). Compare height of saplings between 1957 and 2002: a period of 45 years, yet they are only 4 m tall, not 12 m (Meyer 1938). Saplings have stagnated and have not self-thinned. Thinning to low stand densities provides room for trees to grow and room for herbaceous vegetation to flourish.

**Table 2-203EPF—Ponderosa pine/Idaho fescue. Yearly canopy cover by species, plants with seedheads per year, and statistics on total yearly herbage production, canopy cover, and ratio of production to canopy cover**

	Canopy cover by species code <sup>a</sup>										Herb cover	Herbage production	Ratio cover/kg/ha
Year	FEID	PSSPS	ELELE	CARO5	ANST2	ACOC9	BRJA	ACMI2	Seedheads				
	Percent										Percent	kg/ha	Ratio
1979	20	5	5								30	300	10.0
1980	15	5	2	2							24	250	10.4
1981	25	7				2			60		34	350	10.3
1982	25	2			2				10		29	300	8.8
1983	15	2		2	2						21	200	9.5
1984	15			2		2		1			20	225	11.3
1985	20		5				8				33	325	9.8
1986	12	2		1	1						18	150	9.4
1987	15	8				3			50		28	250	8.9
1988	15	2	2	2							21	200	9.5
1989	18	2	3						20		23	235	10.3
1990	20	5		2							29	300	10.3
1991	10	2			1	1			10		14	175	12.5
1992	15		2	2	2						21	225	10.7
1993	20	3					6	2	10		31	300	9.7
1994	20	10				3		2	40		35	350	10.0
1995	12	2	2	2							18	225	12.5
1996	18	2	4	3							27	300	11.1
1997	15	2					3	2	30		22	250	11.4
1998	18	4			1	1			10		24	275	11.5
1999	15	3	2			2			5		22	250	11.4
2000	18	2		2	1				10		23	250	10.9
2001	15	2			2	1			10		20	225	11.3
2004	25	1		1					100		27	350	13.0
2005	20				11				80		31	300	9.6
Mean	17.4	3.4	3.0	1.9	1.5	1.9	5.7	1.7	XXX	Mean	25.0	262	10.7
Count	25	21	9	12	8	8	3	4	15	SD	5.9	54.3	1.6
Percent	100	85	35	48	31	31	12	16	60	5% CI	2.3	21.3	0.63

Note: SD = standard deviation; CI = confidence interval.

<sup>a</sup>See "Species List: Codes" for plant code definitions.



## Low Sagebrush/Bluebunch Wheatgrass Site: Herbage Dominance and Production

An original ecology plot, number 88, is the sampling location for this study. It was installed in 1959 to measure vegetation and soil attributes for development of range condition guides (USDA FS 1967c). The area had been sheep range that was converted to cattle range. It has not been grazed since 1950. It is located on the Emigrant Creek District, Malheur National Forest about 64-km north of Burns, Oregon. All herbage production sampling was done between August 1 and 4 each year since 1977 and is continuing.



**1959:** The low sagebrush/bluebunch wheatgrass community in 1959 with juniper slowly colonizing the site. The colonization is very slow as shown below and on the last pages of this section.



The soil is residual derived from flow andesite and is stony on the surface. Texture is stony silt loam. The 4-dm depth occurs in a 500-mm precipitation zone supporting ponderosa pine. Because the shallow soil's field capacity is exceeded, it becomes water logged in the winter and early spring apparently precluding pine establishment. Juniper occurs on fault lines.



**1978:** The first sampling season for this study showing little change in juniper density. Herbaceous vegetation is dominated by bluebunch wheatgrass. Bitterbrush occurs sporadically and is heavily hedged. Images were not available for 1986 and 2000.



**1978:** Percent cover: bluebunch wheatgrass 40, low sagebrush 8, Sandberg bluegrass 8, and squirreltail at 3. Wheatgrass did not produce seedheads, only bluegrass had heads. Grass was still fairly green the first of August; herbage production 350 kg/ha.





**1979:** No seedheads; percent cover: wheatgrass 30, bluegrass 8, low sagebrush 9; herbage production 250 kg/ha.



**1980:** 20 percent seedheads on wheatgrass; percent cover: wheatgrass 45, bluegrass 7, low sagebrush 8; herbage production 350 kg/ha.



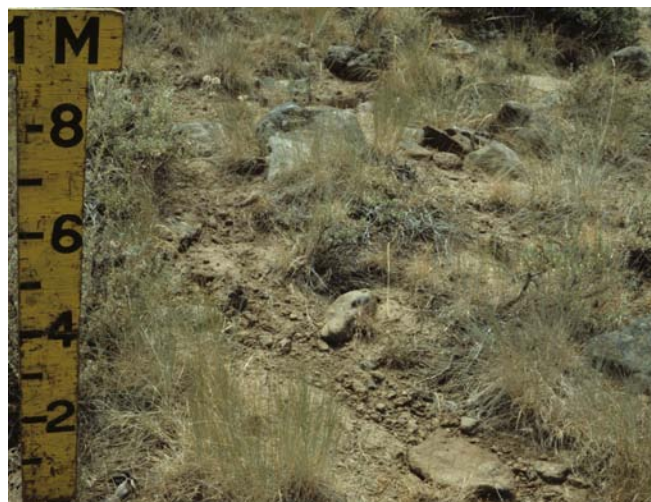
**1983:** No seedheads; percent cover: wheatgrass 35, bluegrass 8, squirreltail 2, low sagebrush 8; herbage production 300 kg/ha.



**1984:** 10 percent seedheads; percent cover: wheatgrass 30, bluegrass 8, squirreltail 2, low sagebrush 7; herbage production 250 kg/ha.



**1988:** No seedheads; percent cover: wheatgrass 40, bluegrass 8, squirreltail 3, junegrass 2, low sagebrush 11; herbage production 350 kg/ha.



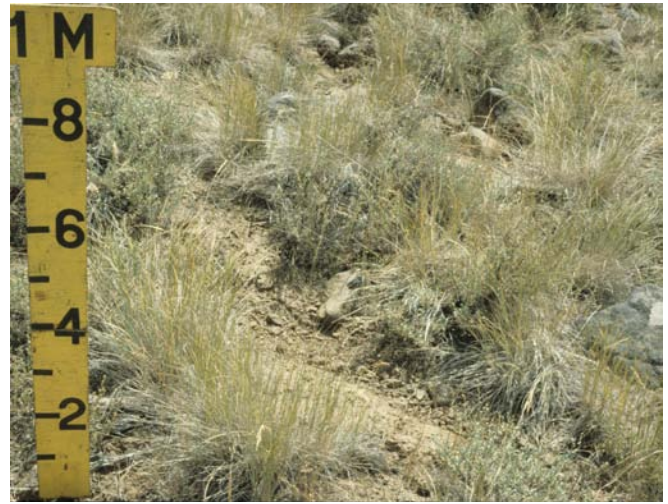
**1989:** No seedheads; percent cover: wheatgrass 35, bluegrass 7, junegrass 1, phlox 1, low sagebrush 11; herbage production 325 kg/ha.



*Variation in Shrub and Herb Cover and Production on Ungrazed Pine and Sagebrush Sites in Eastern Oregon*



**1981:** 60 percent seedheads; percent cover: wheatgrass 50, bluegrass 8, squirreltail 2, onion 2, low sagebrush 9; herbage production 500 kg/ha.



**1982:** No seedheads; percent cover: wheatgrass 45, bluegrass 6, onion 2, low sagebrush 8; herbage production 350 kg/ha.



**1985:** 10 percent seedheads; percent cover: wheatgrass 25, bluegrass 4, low sagebrush 8; herbage production 200 kg/ha.



**1987:** 10 percent seedheads; percent cover: wheatgrass 40, bluegrass 8, junegrass 4, low sagebrush 10; herbage production 400 kg/ha.



**1990:** 10 percent seedheads; percent cover: wheatgrass 50, bluegrass 8, squirreltail 8, needlegrass 5, low sagebrush 11; herbage production 600 kg/ha.



**1991:** 20 percent seedheads; percent cover: wheatgrass 45, bluegrass 10, junegrass 3, low sagebrush 11; herbage production 475 kg/ha.





**1992:** No seedheads; percent cover: wheatgrass 45, bluegrass 10, squirreltail 8; low sagebrush 11; herbage production 475 kg/ha.



**1993:** 30 percent seedheads; percent cover: wheatgrass 35, bluegrass 10, junegrass 12, squirreltail 8, low sagebrush 10; herbage production 400 kg/ha.



**1996:** No seedheads; percent cover: wheatgrass 35, bluegrass 8, junegrass 2, squirreltail 4, low sagebrush 5; herbage production 400 kg/ha.



**1997:** No seedheads; percent cover: wheatgrass 40, bluegrass 8, lomatium 2, low sagebrush 4; herbage production 425 kg/ha.



**2001:** 40 percent seedheads; percent cover: wheatgrass 50, bluegrass 10, junegrass 6, low sagebrush 3; herbage production 550 kg/ha.



**2002:** No seedheads; percent cover: wheatgrass 35, bluegrass 8, junegrass 4, low sagebrush 4; herbage production 350 kg/ha





**1994:** 80 percent seedheads; percent cover: wheatgrass 55, bluegrass 10, squirreltail 8, low sagebrush 8; herbage production 525 kg/ha.



**1995:** No seedheads; percent cover: wheatgrass 25, bluegrass 8, junegrass 2, squirreltail 2, low sagebrush 6; herbage production 300 kg/ha.



**1998:** No seedheads; percent cover: wheatgrass 40, bluegrass 8, onion 4, junegrass 4, low sagebrush 4; herbage production 400 kg/ha.



**1999:** No seedheads; percent cover: wheatgrass 35, bluegrass 6, oatgrass 2, low sagebrush 3; herbage production 325 kg/ha.



**2003:** 10 percent seedheads; percent cover: wheatgrass 25, bluegrass 10, phlox 2, dandelion 1, low sagebrush 6; herbage production 250 kg/ha.



**2004:** 30 percent seedheads; percent cover: wheatgrass 20, bluegrass 12, phlox 2, low sagebrush 6; herbage production 200 kg/ha.





**2005:** Juniper, low sagebrush, some bitterbrush, wheatgrass, and Sandberg bluegrass as it looks after 26 years. Note the decline in wheatgrass since 2002 and compare this image with the 1978 image.



**2005:** No seedheads; percent cover: wheatgrass 22, bluegrass 14, needlegrass 3, low sagebrush 7; herbage production 250 kg/ha.

## Comments

Over a 26-year period (table 3-088EPF-low sagebrush/bluebunch wheatgrass):

- Seedheads were produced only 54 percent of the time. Bluegrass usually contributed most when seedhead density was low. Because best range condition suggests maximum competition, which excludes early seral species, one should question maximum seedhead production if it also implies maximum vigor (Committee on Rangeland Classification 1994, Pellant et al. 2005).  
My interpretation is that this is the best condition plant community for this site potential and would produce fewer seedheads than an upward trend community.
- However, something seems to have happened starting in 2002. Cover of wheatgrass and herbage production decreased from an average of about 60 percent and 375 kg/ha, to only 42 percent and 250 kg/ha, respectively. There is no evidence of livestock overgrazing; in fact, no evidence of grazing at all. I do not have an explanation for this change in the plant community.
- Herbaceous canopy cover averaged 50 percent and varied from 29 to 83 percent, a 2.9-fold difference. This yearly variation clearly limits canopy cover as a means for evaluating range condition. When observer variability is considered, the 16 to 44 percent reported by Coles-Ritchie et al. (2004) further reduces the value of canopy cover.
- A crude estimation of herbage production may be obtained by multiplying total herbage cover by a factor of 7.3. For the 2005 example above:  $22 + 14 + 3 = 39$ ;  $39 \times 7.3 = 285$  kg/ha. Low sagebrush 7 percent cover is not counted as contributing to herbage.
- Herbage production varied from 200 to 600 kg/ha over the 26-year period, averaging 367 kg/ha, a threefold difference. Production less than 275 kg/ha occurred five times (20 percent). This yearly variation might be considered in livestock manage-

ment. Pellant et al. (2005) considered herbage production as a criteria for evaluating rangeland health. These data suggest it should be used with caution.

- Color of wheatgrass during the first four days of August varied from totally dry (1979) to bright green (1993) with all degrees of curing in between. Because curing of vegetation affects its palatability, this seasonal variation might be considered in livestock management.

**Table 3-088EPF—Low sagebrush/bluebunch wheatgrass. Yearly canopy cover by species, plants with seedheads per year, and statistics on total yearly herbage canopy cover, herbage production, and ratio of production to herbage canopy cover**

Year	Canopy cover by species code <sup>a</sup>								Seedheads	Herb cover	Herbage production	Ratio cover/production kg/ha
	PSSPS	POSE	ELELE	KOMA	ACOCO	ALAC4	PHDO3	ARAR8				
	Percent									Percent	kg/ha	Ratio
1978	40	8	5					8	10	51	350	6.7
1979	30	6						8		34	250	7.3
1980	45	6						7	10	51	350	6.9
1981	50	8	2			2		7	60	60	500	8.3
1982	45	6				2		8		53	350	6.6
1983	35	8	2					8		45	300	6.7
1984	30	8	2					7	10	40	250	6.3
1985	25	4						8	10	29	200	6.9
1987	40	8		4				10	10	52	400	7.7
1988	40	8		2				11		50	350	7.0
1989	35	7		3			1	11		46	325	7.1
1990	50	8	8		5			11	10	71	600	8.5
1991	45	10		3				11	20	58	475	8.2
1992	45	10	8					11		63	475	7.5
1993	35	10	8	12				10	30	65	400	6.1
1994	55	10	8	10				8	80	83	525	6.3
1995	25	8	2	2				6		37	300	8.1
1996	35	8	4	2				5		49	400	8.2
1997	40	8						4		48	425	8.9
1998	40	8		4		3		4		55	400	7.3
1999	35	6						3		41	325	7.9
2001	50	10		6				3	40	66	550	8.3
2002	35	8		4				4		47	350	7.4
2003	25	10					2	6	10	37	250	6.6
2004	20	12					2	6	30	34	200	5.9
2005	22	14			3			7	13	39	250	6.4
Mean	37.4	8.3	4.7	4.7	4.0	2.3	1.7	7.4	XXX	Mean 50.2	367.3	7.3
Count	26	26	10	11	2	3	3	26	14	SD 12.7	107.0	0.8
Percent	100	100	38	42	8	11	11	100	54	5% CI 4.9	41.1	0.3

Note: SD = standard deviation; CI = confidence interval.

<sup>a</sup>See "Species List: Codes" for plant code definitions.





## Rigid Sagebrush Scabland Site: Herbage Dominance and Production

This site was selected in 1960 on which to measure vegetation and soil characteristics for developing range condition guides (USDA FS 1963). It is located on the Lookout Mountain District, Ochoco National Forest on the east edge of Big Summit Prairie shown in the background below left. All sampling was done between August 1 and 4 each year from 1977 to the present.



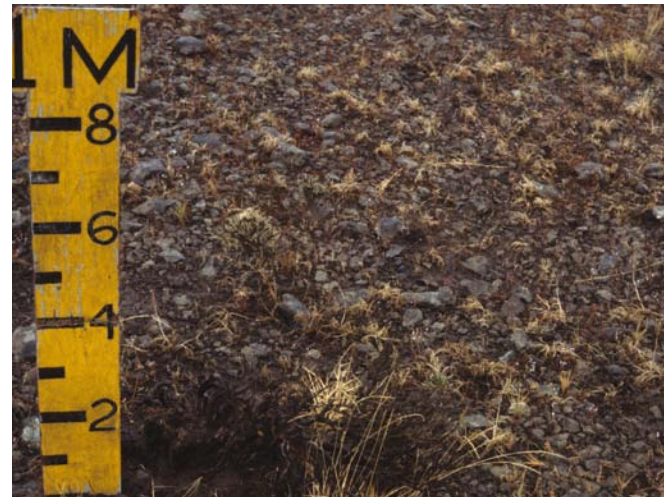
**1960:** The rigid sagebrush scabland site sampled for range condition guides. It is located within the forest zone supporting ponderosa pine, Douglas-fir and grand fir. Scabland is characterized by very shallow soils shown at the right, which preclude tree establishment.



Soil is derived from recent andesite lava flows, and is characteristically only 1.5 to 3 dm deep. Precipitation is enough to cause water logging during much of the winter, which limits plant community diversity.



**1977:** The site at the start of herbage production sampling. It is characterized by a desert pavement of gravel and rigid sagebrush, Sandberg bluegrass, pipe clover, and oatgrass, all capable of surviving saturated soils and frost heaving. Site characteristics are shown at the end of this section. Images were not available for 1986 and 1988.



**1977:** 80 percent seedheads; percent cover: bluegrass 10, pipe clover 6, lomatium 7, oatgrass 6, rigid sage 4; herbage production 150 kg/ha.

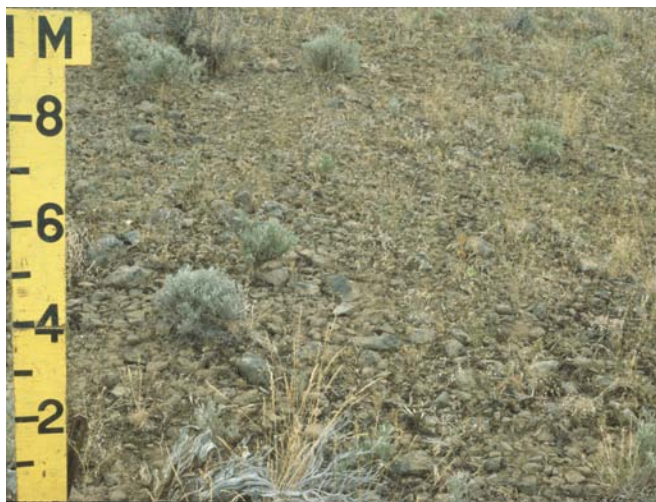




**1978:** 40 percent seedheads; percent cover: bluegrass 10, pipe clover 5, lomatium 8, oatgrass 5, sagebrush 5; herbage production 125 kg/ha.



**1979:** No seedheads; percent cover: bluegrass 10, pipe clover 4, lomatium 7, oatgrass 4, sagebrush 6; herbage production 125 kg/ha.



**1982:** 80 percent seedheads; percent cover: bluegrass 10, pipe clover 5, lomatium 6, oatgrass 6, wheatgrass 3, sagebrush 7; herbage production 200 kg/ha.



**1983:** 100 percent seedheads; percent cover: bluegrass 12, pipe clover 6, lomatium 6, oatgrass 7, wheatgrass 3, sagebrush 7; herbage production 125 kg/ha.



**1987:** No seedheads; percent cover: bluegrass 9, pipe clover 4, lomatium 6, oatgrass 6, wheatgrass 1, sagebrush 9; herbage production 125 kg/ha.



**1989:** No seedheads; percent cover: bluegrass 9, pipe clover 3, lomatium 5, oatgrass 4, wheatgrass 1, sagebrush 9; herbage production 125 kg/ha.





**1980:** No seedheads; percent cover: bluegrass 8, pipe clover 4, lomatium 6, oatgrass 4, sagebrush 6; herbage production 100 kg/ha



**1981:** 50 percent seedheads; percent cover: bluegrass 8, pipe clover 4, lomatium 6, oatgrass 6, sagebrush 6; herbage production 175 kg/ha.



**1984:** 100 percent seedheads; percent cover: bluegrass 12, pipe clover 6, lomatium 8, oatgrass 7, wheatgrass 3, sagebrush 8, herbage production 200 kg/ha.



**1985:** 80 percent seedheads; percent cover: bluegrass 10, pipe clover 4, lomatium 9, oatgrass 6, sagebrush 8; herbage production 125 kg/ha.



**1990:** No seedheads; percent cover: bluegrass 9, pipe clover 3, lomatium 4, oatgrass 4, wheatgrass 1, sagebrush 9; herbage production 125 kg/ha.



**1991:** No seedheads; percent cover: bluegrass 9, pipe clover 3, lomatium 4, oatgrass 3, wheatgrass 1, sagebrush 9; herbage production 100 kg/ha.





**1992:** 30 percent seedheads; percent cover: bluegrass 9, pipe clover 3, lomatium 4, oatgrass 3, wheatgrass 2, sagebrush 9; herbage production 170 kg/ha.



**1993:** 70 percent seedheads; percent cover: bluegrass 9, pipe clover 3, lomatium 3, oatgrass 3, wheatgrass 1, sagebrush 10; herbage production 110 kg/ha.



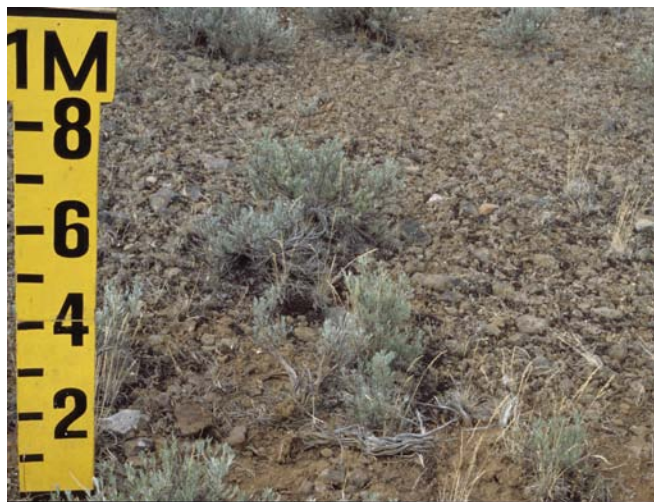
**1996:** 50 percent seedheads; percent cover: bluegrass 8, pipe clover 3, lomatium 4, oatgrass 3, sagebrush 10; herbage production 75 kg/ha.



**1997:** 50 percent seedheads; percent cover: bluegrass 8, pipe clover 3, lomatium 3, oatgrass 3, sagebrush 11; herbage production 150 kg/ha.



**2000:** No seedheads; percent cover: bluegrass 5, pipe clover 2, lomatium 2, oatgrass 2, sagebrush 12; herbage production 75 kg/ha.



**2001:** 80 percent seedheads; percent cover: bluegrass 5, pipe clover 2, lomatium 2, oatgrass 2, sagebrush 12; herbage production 100 kg/ha.





**1994:** No seedheads; percent cover: bluegrass 9, pipe clover 4, lomatium 4, oatgrass 3, wheatgrass 1, sagebrush 10; herbage production 150 kg/ha.



**1995:** 20 percent seedheads; percent cover: bluegrass 9, pipe clover 3, lomatium 3, oatgrass 3, wheatgrass 1, sagebrush 10; herbage production 125 kg/ha.



**1998:** 30 percent seedheads; percent cover: bluegrass 9, pipe clover 3, lomatium 3, oatgrass 3, sagebrush 11; herbage production 125 kg/ha.



**1999:** No seedheads; percent cover: bluegrass 8, pipe clover 2, lomatium 2, oatgrass 3, sagebrush 11; herbage production 100 kg/ha.



**2002:** No seedheads; percent cover: bluegrass 6, pipe clover 2, lomatium 2, oatgrass 2, sagebrush 12; herbage production 100 kg/ha.



**2003:** No seedheads; percent cover: bluegrass 6, pipe clover 2, lomatium 2, oatgrass 2, sagebrush 13; herbage production 100 kg/ha.





**2005:** The rigid sagebrush scabland after 27 years. Rigid sagebrush seems a little denser, and the pines in the background have grown. This is what “80 percent seedheads” looks like!



**2005:** 80 percent seedheads; percent cover: bluegrass 9, pipe clover 4, lomatium 3, oatgrass 3, sagebrush 12; herbage production 125 kg/ha.

## Comments

Over a 27-year period (table 4-045EPF-rigid sagebrush/scabland):

- Seedheads, limited primarily to bluegrass, were produced only 59 percent of the time. Lack of abundant seedheads over the years suggests a plant community in near maximum competition and thus full occupancy of the site. Pellant et al. (2005), on the other hand, considered seedhead production one criteria for evaluating rangeland health. These data suggest it should be used with caution.
- Herbage production varied from 75 to 225 kg/ha averaging 131 kg/ha, a threefold difference. A crude estimation of herbage production may be obtained by multiplying herbage cover by a factor of 6.3. For the 2005 example above:  $9 + 4 + 3 + 3 = 19$ ;  $19 \times 6.3 = 120$  kg/ha. Sagebrush cover is not counted as herbage. Pellant et al. (2005) considered production as another element in evaluating rangeland health. Again it should be used with caution.
- All herbaceous vegetation was dry by August 1. Shallow soil and lack of precipitation after the middle of June preclude active growth. However, the deciduous rigid sagebrush is quite palatable to deer, elk, cattle, and sheep. Note the hedged appearance.

Ungulate use during wet soil periods can damage the biological crust by trampling. Fortunately, insufficient herbage production generally limits heavy use.



Soil is saturated with water during winter and early spring. The change from saturated to summer bone dry seriously limits the variety of plant species capable of competing on this site. Revegetation with domestic species is not possible. It also limits hunters in the fall. They may drive out on frozen soil in early morning only to return in the evening to find their vehicle rim deep in mud.



Frost heaving during saturated soil conditions is common. Water freezes at night and then thaws during the day. The expanding ice crystals push gravels out of the top 1 to 2 in of soil and deposits them on the soil surface, a condition resulting in a “desert pavement.” The “A” horizon is vesicular as a result of frost heaving (Springer 1958). The gravel, in conjunction with microbiotic plants, successfully protect the soil surface (Belnap et al. 2001).



Scabland lichen-encrusted rocks with a biological soil crust successfully protects the soil surface. This is the primary indication of “good range condition” as vascular vegetation cannot protect the soil (Belnap et al. 2001).



**Table 4-045EPF—Rigid sagebrush scabland. Yearly canopy cover by species, plants with seedheads per year, and statistics on total yearly herbage production, canopy cover, and ratio of production to canopy cover**

Year	Canopy cover by species code <sup>a</sup>							Herb cover	Herbage production	Ratio cover/kg/ha
	POSE	TRMA3	LOGR	DAUN	PSSPS	ARRI2	Seedheads			
	<i>Percent</i>							<i>Percent</i>	<i>kg/ha</i>	<i>Ratio</i>
1977	10	6	7	6		4	50	29	150	5.2
1978	10	5	8	5		5	40	28	125	4.5
1979	10	4	7	4		6		25	125	5.1
1980	8	4	6	4		6		22	100	4.5
1981	8	4	6	6		6	50	24	175	7.3
1982	10	5	6	6	3	7	80	30	200	6.7
1983	12	6	6	7	3	7	100	31	225	7.2
1984	12	6	8	7	3	8	100	36	200	5.6
1985	10	4	9	6		8	80	29	125	4.3
1987	9	4	6	6	1	9		26	125	4.8
1989	9	3	5	4	1	9		22	125	5.6
1990	9	3	4	4	1	9		21	125	5.9
1991	9	3	4	3	1	9		20	100	5.1
1992	9	3	4	3	2	9	30	21	170	8.1
1993	9	3	3	3	1	10	70	19	110	5.8
1994	9	4	4	3	1	10		21	150	7.1
1995	9	3	3	3	1	10	20	19	125	6.6
1996	8	3	4	3		10	50	18	75	4.2
1997	8	3	3	3		10	50	17	150	8.8
1998	9	3	3	3		11	30	18	125	6.9
1999	8	2	2	3		11		15	100	6.7
2000	5	2	2	2		12		11	75	6.8
2001	5	2	2	2		12	80	11	100	9.1
2002	6	2	2	2		12		12	100	8.3
2003	6	2	2	2		13		12	100	8.3
2004	10	4	4	4		13	20	22	125	5.7
2005	9	4	3	3		12	80	19	125	6.6
Mean	8.7	3.6	4.6	3.9	1.6	9.2	XXX	Mean	21.4	130.7
Count	27	27	27	27	11	27	16	SD	6.4	37.1
Percent	100	100	100	100	41	100	54	5% CI	2.5	14.0

Note: SD = standard deviation; CI = confidence interval.

<sup>a</sup> See "Species Lists: Codes" for plant definitions.



## Summary

### Canopy Cover

Over a 27-year period, canopy cover varied as follows: BSPCF pine/pinegrass a 2.2-fold difference, 203EPF pine/fescue 2.3-fold, 088EPF low sagebrush/wheatgrass three-fold, and 045EPF rigid sagebrush scabland at a threefold difference. Reasons for this wide variation are open to speculation because the sites had not been grazed. I suspect growing conditions.

Herbage cover fluctuated widely bringing into question the use of canopy cover as a measure of range condition. This fluctuation coupled with observer variability in estimating canopy cover (Coles-Ritchie et al. 2004) leads me to look for other vegetation measurements for characterizing range condition guides.

### Ratio of Cover to Productivity

This study was designed to evaluate yearly changes in shrub and herbaceous cover and herbage productivity. Table 5 summarizes the relationship between percentage of herbage canopy cover and kilograms per hectare herbage production. Herbage production in kilograms per hectare was divided by total herbage percentage of canopy cover to calculate a ratio between the two. The four ratios and their 5 percent confidence intervals are shown in table 5. For each site, the confidence interval was calculated as a percentage of the ratio mean. These ratios are then compared for 50-percent herbage canopy cover. For example, the BSPCF ratio is 6.2:  $6.2 \times 50$  percent = 310 kg/ha estimated production.

One ratio stands out as significantly different, 203EPF pine/bitterbrush/fescue, at 10.7. I suspect the dense, fine leaves of fescue contribute to increased weight per square decimeter of canopy cover.

### Image Evaluation

Interpretation of color images greatly enhanced this investigation. Because season of sampling was constant, August 1 to 4, differences in greenness of the vegetation could be evaluated. Pinegrass was reasonably consistent in color. However wheatgrass and fescue varied from cured brown to bright green reflecting major differences in phenological development and thus nutritive value and palatability to animals.

Careful scrutiny of images also revealed items not measured in this study. Tree regeneration and growth was one. The BSPCF ponderosa pine/pinegrass is an example. In 1979, a pine seedling was present next to the meter board between 6 and 8 dm. By 1982 it was gone. On the same site, a pine had become established in 1982 at the top center of the image. By 1992 it had grown to 1 cm in diameter, and

by 2004 it was 2 cm diameter. In 22 years, this sapling had only grown about 2 cm in diameter.

Another illustration of tree growth is shown in 203EPF ponderosa pine/bit-terbrush/fescue. Saplings in 1957 were about 1 m in height. By 1978, 21 years later, they were only 2 m tall. And by 2002, 45 years later, they were about 4 m tall. They should be 12 m in height according to normal yield tables (Meyer 1938). They were stagnated, growing at about 1 cm/decade in diameter. Years 2003 to 2006 document upward range trend resulting from tree thinning.

Erosion may also be appraised by use of photomonitoring. The low movement of rocks shown in both 088EPF low sagebrush/wheatgrass and 045EPF rigid sagebrush/ scabland suggests no accelerated erosion.

**Table 5—Statistical summary of the ratio between herbage cover and kilograms per hectare herbage production illustrated for 50 percent canopy cover**

Site	Ratio	5% CI	CI % of mean	Herbage at 50% canopy cover	5% CI variation in production
Kilograms per hectare					
BSPCF	6.2	0.4	6	310	290 to 330
203EPF	10.7	0.6	6	535	505 to 565
088EPF	7.3	0.3	4	365	350 to 380
045EPF	6.3	0.5	8	315	290 to 340

Note: CI = confidence interval.



## Species List: Common Names

Common name	Scientific name	Code
Arnica	<i>Arnica cordifolia</i> Hook.	ARCO9
Bluebunch wheatgrass	<i>Pseudoroegneria spica</i> ssp. <i>spicata</i> (Pursh) A. Love	PSSPS
(old name)	<i>Agropyron spicatum</i> (Pursh) Scribn. & J.G. Sm.	(AGSP)
Dandelion	<i>Nothocalais troximoides</i> (Gray) Greene	NOTR2
(old name)	<i>Microseris troximoides</i> Gray	(MITR5)
Douglas-fir	<i>Pseudotsuga menziesii</i> var. <i>glauca</i> (Beissn.) Franco	PSMEG
Elk sedge	<i>Carex geyeri</i> Boott	CAGE2
Grand fir	<i>Abies grandis</i> (Dougl. ex D. Don) Lindl.	ABGR
Idaho fescue	<i>Festuca idahoensis</i> Elmer	FEID
Japanese brome	<i>Bromus japonicus</i> Thunb. ex Murr.	BRJA
Junegrass	<i>Koeleria macrantha</i> (Ledeb.) J.A. Schultes	KOMA
(old name)	<i>Koeleria cristata</i> auct. p.p., non Pers.	(KOCR)
Juniper	<i>Juniperus occidentalis</i> Hook.	JUOC
Lomatium	<i>Lomatium grayi</i> (Coult & Rose) Coult & Rose	LOGR
Low sage	<i>Artemisia arbuscula</i> Nutt.	ARAR8
Lupine	<i>Lupinus caudatus</i> Kellogg	LUCA
Needlegrass	<i>Achnatherum occidentale</i> Barkworth ssp. <i>occidentale</i>	ACOCO
(old name)	<i>Stipa occidentalis</i> Thurb. ex S. Wats	(STOC2)
Oatgrass	<i>Danthonia unispicata</i> (Thurb.) Munro ex Macoun	DAUN
Onion	<i>Allium acuminatum</i> Hook.	ALAC4
Phlox	<i>Phlox douglasii</i> Hook.	PHDO3
Pinegrass	<i>Calamagrostis rubescens</i> Buckl.	CARU
Pipe clover	<i>Trifolium macrocephalum</i> (Pursh) Poir.	TRMA3
Ponderosa pine	<i>Pinus ponderosa</i> P.& C. Lawson	PIPO
Pussytoes	<i>Antennaria stenophylla</i> (Gray) Gray	ANST2
Rigid sage	<i>Artemisia rigida</i> (Nutt.) Gray	ARRI2
Ross' sedge	<i>Carex rossii</i> Boott	CARO5
Sandberg bluegrass	<i>Poa secunda</i> J. Presl	POSE
Scouler's woollyweed	<i>Hieracium scouleri</i> Hook.	HISC2
Squirreltail	<i>Elymus elymoides</i> (Raf.) Swezey spp. <i>elymoides</i> (Raf.)	ELELE
(old name)	<i>Sitanion hystrix</i> (Nutt.) J.G. Sm.	(SIHY)
Wheatgrass	<i>Pseudoroegneria spicata</i> ssp. <i>spicata</i> (Pursh) A. Love	PSSPS
(old name)	<i>Agropyron spicatum</i> (Pursh) Scribn. & J.G. Sm.	(AGSP)
Wheeler's bluegrass	<i>Poa nervosa</i> (Hook.) Vasey	PONE2
Yarrow	<i>Achillea millefolium</i> L.	ACMI2

## Species List: Codes

Code	Scientific name	Common name
ACMI2	<i>Achillea millefolium</i> L.	Yarrow
ACOCO	<i>Achnatherum occidentale</i> ssp. <i>occidentale</i> Barkworth	Needlegrass
ALAC4	<i>Allium acuminatum</i> Hook.	Onion
ARAR8	<i>Artemisia arbuscula</i> Nutt.	Low sage
ARCO9	<i>Arnica cordifolia</i> Hook.	Arnica
ARRI2	<i>Artemisia rigida</i> (Nutt.) Gray	Rigid sage
ANST2	<i>Antennaria stenophylla</i> (Grey) Grey	Pussytoes
BRJA	<i>Bromus japonicus</i> Thunb. ex Murr.	Japanese brome
CAGE2	<i>Carex geyeri</i> Boott	Elk sedge
CARO5	<i>Carex rossii</i> Boott	Ross' sedge
CARU	<i>Calamagrostis rubescens</i> Buckl.	Pinegrass
DAUN	<i>Danthonia unispicata</i> (Thurb) Munro ex Macoun	Oatgrass
ELELE	<i>Elymus elymoides</i> spp. <i>elymoides</i> (Raf.) Swezey	Squirreltail
FEID	<i>Festuca idahoensis</i> Elmer	Idaho fescue
HISC2	<i>Hieracium scouleri</i> Hook.	Scouler's woollyweed
KOMA	<i>Koeleria macrantha</i> (Ledeb.) J.A. Schultes	Junegrass
LOGR	<i>Lomatium grayi</i> (Coult & Rose ) Coult & Rose	Lomatium
LUCA	<i>Lupinus caudatus</i> Kellog	Lupine
NOTR2	<i>Nothocalais troximoides</i> (Gray) Greene	Dandelion
PHDO3	<i>Phlox douglasii</i> Hook.	Phlox
PONE2	<i>Poa nervosa</i> (Hook.) Vasey	Wheeler's bluegrass
POSE	<i>Poa secunda</i> J. Presl	Sandberg bluegrass
PSSPS	<i>Pseudoroegneria spica</i> ssp. <i>spicata</i> (Pursh) A. Love	Bluebunch wheatgrass
TRMA3	<i>Trifolium macrocephalum</i> (Pursh) Poir.	Pipe clover

## English Equivalents

When you have:	Multiply by:	To get:
Centimeters (cm)	.394	Inches
Decimeters (dm)	3.94	Inches
Meters (m)	3.28	Feet
Kilograms per hectare (kg/ha)	.89	Pounds per acre
Millimeters (mm)	.0394	Inches
Square meters (m <sup>2</sup> )	1.2	Square yards
Square meters per hectare (m <sup>2</sup> /ha)	4.37	Square feet per acre



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