W. H. Rickard
and
R. H. Sauer
Pacific Northwest Laboratory
Ecological Sciences Department
Richland, Washington 99352

Primary Production and Canopy Cover in Bitterbrush-Cheatgrass Communities

Abstract

Aboveground grass and forb production averaged 126 $g \cdot m^{-2} \cdot yr^{-1}$ and ranged between 10 and 195 grams over a four year period 1975-1978. The low production year was 1977, a year of extreme drought. Production was not significantly different between unburned sites and burned sites five years post burning (1970). Canopy cover and species composition were similar on burned and unburned sites except for the shrubs, bitterbrush (*Purshia tridentata*) and sagebrush (*Artemisia tridentata*), which were killed by burning. There was no indication that shrubs were invading the burned areas as seedlings or vegetatively through sprouting. The implications of burning and mule deer (*Odocoileus hemionus*) management are briefly discussed.

Introduction

The bitterbrush-cheatgrass community is widely spread vegetal cover type at lower elevations on the Hanford Site, Benton Co., Washington (Fig. 1). It occupies sandy soils, and for the most part it lacks the perennial bunchgrass (*Stipa comata*) that characterizes herbaceous understory of bitterbrush (*Purshia tridentata*) stands in undisturbed condition (Daubenmire 1970). Instead, the understory is dominated by cheatgrass brome (*Bromus tectorum*). Perennial grasses are mostly represented by a sparse cover of Sandberg bluegrass (*Poa sandbergii*). Two large wildfires burned through parts of the bitterbrush community in 1963 and again in 1970. The 1970 fire reburned some of the same area as the earlier burn.

There are excellent published botanical descriptions of shrub steppe communities in pristine condition, but there is a paucity of data on primary productivity and botanical descriptions of shrub steppe communities in other than pristine condition (Daubenmire 1970). Primary production has been measured in stands representative of the *Artemisia tridentata/Agropyron spicatum* association and in cheatgrass communities on long-time abandoned wheatfields on the Hanford Site (Rickard *et al.* 1976). However, there is no published data on primary production in the bitterbrush cover type.

This investigation compares primary production and canopy cover on burned and unburned parts of the bitterbrush cover type during the years 1975, 1976, 1977, and 1978.

The cover type of interest because of its large extent (~70,000 a), and because unlike most semi-arid rangelands in Washington, it has not been grazed by livestock since 1943. It is expected that the land will not be used for livestock grazing in the future but will be used as industrial sites for energy facilities such as commercial nuclear power plants (Fig. 1). These facilities will be widely spaced for safety reasons,

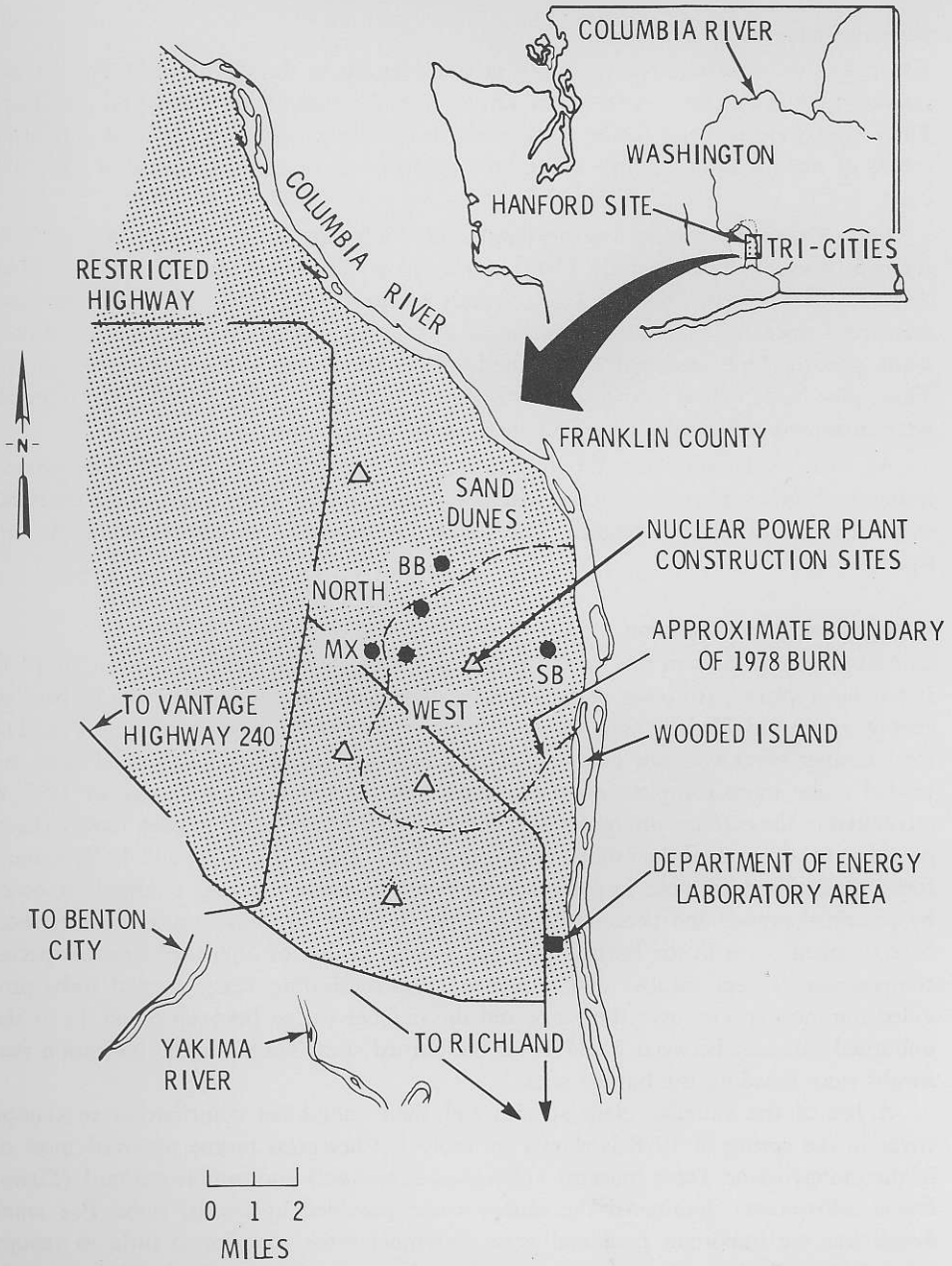

Figure 1. Map of the southeastern part of the U.S. Department of Energy, Hanford Site showing the extent of the bitterbrush-cheatgrass community, shaded area, the approximate boundaries of the 1970 burn and the location of study plots: BB = bitterbrush, MX = mixed, SB = sagebrush, North = burned site, West = burned site.

and the intervening land will probably be retained in natural vegetation. The absence of livestock grazing will likely allow for fuel (dry matter) accumulation, especially stems and leaves of cheatgrass brome; this accumulation will probably increase the incidence of wildfires in the future.

Methods Employed

Six study sites were selected for study in and adjacent to the 1970 burn (Fig. 1) but remote from industrial construction activities and transmission lines and roadways. Three sites were in parts of the community that had not been burned; these supported stands of mature shrubs. Three other sites were devoid of shrubs because of the 1970 burn.

Canopy-cover by species was measured at all study sites using Daubenmire's (1959) method of vegetational analysis. Plant names follow Hitchcock and Cronquist (1973). A 50 m long tape was read at 1 m intervals using 50—0.1 m^2 plot frames. The lines were read once in April or May at what was judged to be the peak of herbaceous plant growth. Line intercepts were used to determine the canopy cover of shrubs. Three plots each (20 x 50 m) were established, and four parallel lines at 5 m intervals were measured. All shrubs rooted in these plots were counted.

At each study site five 0.1 m^2 plots were hand-harvested of all aboveground living herbaceous phytomass. Live material was separated from dead plant material, oven dried at 50°C, and weighed. The results are expressed as grams dry weight per square meter.

Canopy Cover and Production

One of the study sites in the burned area was lost to off-road vehicular traffic in 1976. It was not replaced. All other plots remained undamaged. A summary of the herbaceous canopy cover provided by four major botanical categories is shown in Figure 2. The total canopy cover was not greatly different between burned and unburned sites but tended to be more complete on the burned sites. The low canopy cover in 1977 is attributed to the extreme drought which occurred that year. Annual grasses, mostly cheatgrass brome, dominated the canopy cover during the years 1975, 1976, and 1978. Annual forbs were the next most important contributor to canopy cover, followed in order by perennial grasses and perennial forbs. After five post fire growing seasons, the herbaceous plant cover in the burned sites was similar to that of unburned sites in species composition (except shrubs) and remained so in succeeding years. Annual forbs provided the most species over the years, and the number varied between 6 and 14 in the unburned sites and between 5 and 11 in the burned sites. There was no indication that shrubs were invading the burned sites.

A list of the vascular plant species and their individual contribution to canopy cover in the spring of 1978 is shown in Table 1. Cheatgrass brome provided most of of the canopy cover. Tansy mustard (*Descurainea pinnata*) and tumble mustard (*Sisymbrium altissimum*) dominated the canopy cover provided by annual forbs. *Poa sandbergii* was the important perennial grass. Perennial forbs contributed little to canopy cover, although they were conspicuous throughout the community because of their large, showy flowers. There was no statistically significant differences in net aboveground production between burned and unburned sites. The data were pooled and the results summarized in Table 2. The 1977 drought resulted in low plant production, only 10 $g \cdot m^{-2} \cdot yr^{-1}$. The highest production of 195 $g \cdot m^{-2} \cdot yr^{-1}$ was measured in 1975 and the average was 126 $g \cdot m^{-2} \cdot yr^{-1}$. This is near the 100 $g \cdot m^{-2} \cdot yr^{-1}$ production listed for North America shrub steppe communities (Lauenroth 1979) and is at the low end of the scale of production by grassland communities worldwide. It is

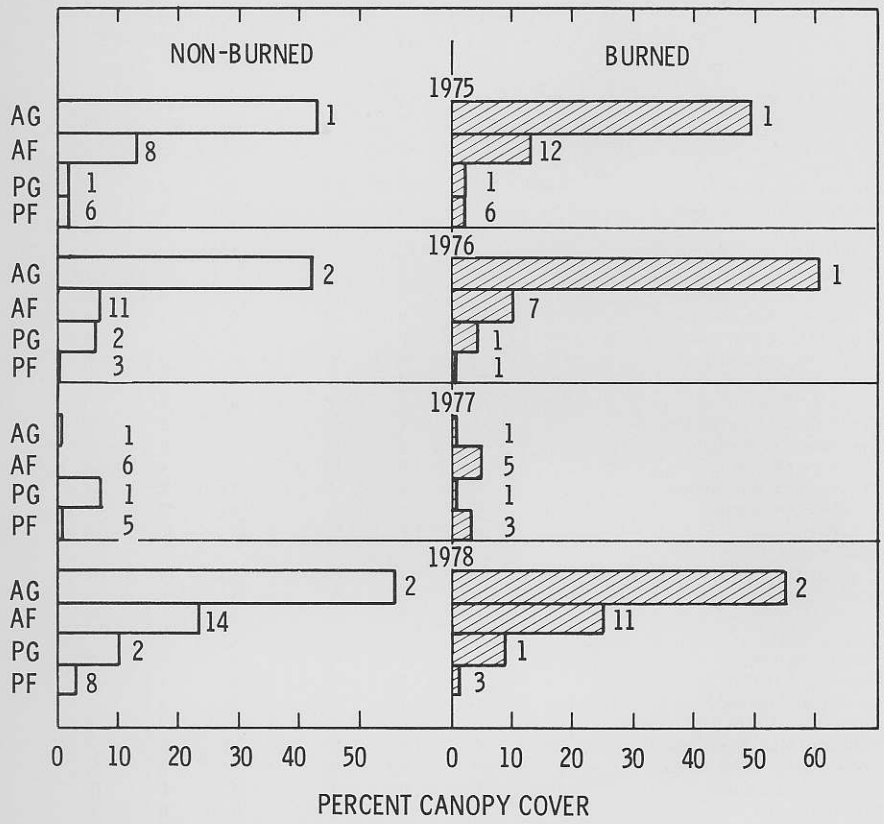

Figure 2. Percent canopy cover provided by herbaceous species during the spring of 1975, 1976, 1977, and 1978. The numerical values at the bars indicate the number of species in each botanical category.

similar to the 100 $g \cdot m^{-2} \cdot yr^{-1}$ measured in *Artemisia/Agropyron* communities (Daubenmire 1970) but less than the 240 $g \cdot m^{-2} \cdot yr^{-1}$ for cheatgrass brome communities at higher elevations with silt loam soils on the Hanford Site (Rickard *et al.* 1976). The efficiency of conversion of precipitation to dry matter averaged 11.4 g of dry matter per cm of growing season precipitation and ranged between 3.3 and 17.1 (Table 2).

Shrub Canopy Cover and Density

The three unburned shrub-dominated study sites had different amounts of shrub cover. One study site labelled SB (Fig. 1) was dominated by sagebrush. Total shrub cover was 14 percent. There were 76 sagebrush and 19 rabbitbrush shrubs on the 1000 m^2 plot. The plot labelled BB was dominated by bitterbrush and had a shrub canopy cover of

TABLE 1. Canopy cover (percent) provided by herbaceous taxa in the bitterbrush-cheatgrass community, April 1978.

Taxa	Non-Burned				Burned			All
	SB	BB	MX	$\bar{x}$	NO	WE	$\bar{x}$	$\bar{\bar{x}}$
Annual Grasses								
+Bromus tectorum	51	67	51	56	68	42	55	56
Festuca sp.	0	0	T	T	T	0	T	T
Total	51	67	51	56	68	42	55	56
Annual Forbs								
Descurainia pinnata	8	6	37	17	1	5	3	11
+Sisymbrium altissimum	15	0	0	5	11	2	6	6
°+Salsola kali	3	0	0	1	4	8	6	3
+Holosteum umbellatum	1	1	T	1	3	4	3	2
+Draba verna	T	2	0	1	T	1	1	1
Microsteris gracilis	1	1	1	1	1	3	2	1
Plantago patagonica	5	0	0	2	0	0	0	1
Amsinckia lycopsoides	T	0	T	T	0	0	0	T
°Ambrosia acanthicarpa	T	0	0	T	0	1	T	T
Cryptantha pterocarya	T	T	0	T	0	0	0	T
Phacelia linearis	0	T	0	T	0	0	0	T
Cryptantha circumscissa	0	0	T	T	0	T	T	T
Epilobium paniculatus	0	0	T	T	0	1	T	T
Layia glandulosa	0	0	T	T	0	0	0	T
Polemonium micrantha	0	0	0	0	3	T	1	1
°°+Tragopogon dubius	0	0	0	0	0	T	T	T
Total	33	10	38	28	23	25	22	26
Perennial grass								
Poa sandbergii	11	17	3	10	8	7	7	9
Stipa comata	0	1	0	T	0	0	0	T
Total	11	18	3	10	8	7	7	9
Perennial forbs								
Phlox longifolia	2	0	1	1	0	1	T	1
Oenothera pallida	0	0	6	2	0	1	0	1
Brodiaea douglasii	1	0	1	1	2	1	1	1
Crepis atrabarba	1	0	0	T	0	0	0	T
Balsamorhiza careyana	T	0	0	T	0	0	0	T
Commandra umbellatum	1	0	0	T	0	0	0	T
Psoralea lanceolata	0	0	0	0	0	T	T	T
Lomatium sp.	0	T	0	T	0	0	0	T
Astragalus sp.	0	T	0	T	0	0	0	T
Total	5	0	8	4	2	3	1	3

°Summer annual
+Introduced species
°°Biennial

T = trace amount, < 0.5
SB = Sagebrush dominant
BB = Bitterbrush dominant

MX = Mixed SB and BB
NO = North location
WE = West location

TABLE 2. Average grass and forb production and growing season (Oct.-April) precipitation, 1975 through 1978.

Year	Production $g \cdot m^{-2} \cdot yr^{-1}$	Ppt cm	Production/Ppt efficiency ratio
1975	195 ± 33	12.6	15.5
1976	159 ± 18	9.3	17.1
1977	10 ± 2	3.0	3.3
1978	139 ± 12	14.1	9.9
Average	126	9.7	11.4

± Standard error.

26 percent. There were 86 bitterbrush, seven rabbitbrush, and only two sagebrush shrubs on this plot. The plot labelled MX had about equal amounts of sagebrush and bitterbrush shrubs, and together provided 22 percent of the total shrub cover. *Eriogonum niveum*, a small subshrub, provided an additional 15 percent canopy cover for a total

shrub canopy of 37 percent. There were 51 bitterbrush, 59 sagebrush, and 627 *E. niveum* shrubs on this plot.

No attempt was made to estimate the annual production by shrubs. Mack (1976) estimated the annual litterfall of a sagebrush community on the Hanford Site at 12 $g \cdot m^{-2} \cdot yr^{-1}$, and this value is probably valid for our sites as well.

It appears that the presence of mature shrubs had little influence on herbage production. The shrubs probably exploit soil water that penetrates deeply into the sandy soil, whereas the herbs, especially cheatgrass brome, exploits shallow penetrating soil water. Cline and Rickard (1977) report that cheatgrass was not very effective at exploiting soil water that had penetrated below 0.5 m deep. Sagebrush has an extensive root system that can penetrate to depths of 2 m (Sturges 1977). How long a time will pass before shrubs re-colonize the burn is unknown. Daubenmire (1976) reports that abandoned wheatfields colonized by cheatgrass brome have resisted invasion by native species for 50 years. Fires also influence the ability of shrubs to occupy the land because sagebrush and bitterbrush are easily killed by fire and do not sprout vegetatively after burning.

Wildlife Implications

Reinvasion of burned areas by bitterbrush and sagebrush is restricted to self-established seedlings. Of these two species, bitterbrush would be the choice of wildlife managers because it provides browse for mule deer, which are a part of the fauna of the Hanford Site (Hedlund 1975); they range throughout the bitterbrush cover type. Increased incidents of fire could dramatically reduce the amount of browse available to mule deer by eliminating bitterbrush shrubs from large land areas. This could be important because the land surrounding the Hanford Site is largely in agricultural use, and crop damage by deer is not generally tolerated by land owners. At the present time crop damage by deer on croplands east of the Columbia River is believed to be very small.

Acknowledgments

Work performed in part under contract number DE-AC06-76RL0-1830 with the U.S. Department of Energy and with the Washington Public Power Supply System, Richland, Washington.

Literature Cited

Cline, J. F., D. W. Uresk, and W. H. Rickard. 1977. Comparison of soil water used by a sagebrush-bunchgrass and a cheatgrass community. J. Range Mgmt. 30:199-201.
Daubenmire, R. 1959. A canopy coverage method of vegetational analysis. Northw. Sci. 33:43-64.
———. 1970. Steppe Vegetation of Washington. Wash. Agr. Expt. Sta. Tech. Bull. 62.
———. 1976. Plant succession on abandoned fields and fire influences in a steppe area in southeastern Washington. Northw. Sci. 49:36-48.
Hedlund, J. D. 1975. Tagging mule deer fawns in south-central Washington. Northw. Sci. 49: 253-260.
Hitchcock, C. L., and A. Cronquist. 1973. Flora of the Pacific Northwest. Univ. of Wash. Press, Seattle.
Lauenroth, W. K. 1979. Grassland primary production: North American grasslands in perspective, *in* Perspectives in Grassland Ecology. N. R. French (ed.). Springer-Verlag, N.Y.
Mack, R. N. 1977. Mineral return via the litter of *Artemisia tridentata*. Am. Medl. Nat. 97:189-197.
Rickard, W. H., D. W. Uresk, and J. F. Cline. 1976. Productivity Response to Precipitation by Native and Alien Plant Communities. Proceedings of the Symposium on Terrestrial and

Aquatic Ecological Studies of the Northwest. Sponsored by the Northwest Scientific Association. Eastern Wash. State College Press.
Sturges, D. C. 1977. Soil water withdrawal and root characteristics of big sagebrush. Am. Midl. Nat. 98:257-274.

Received March 27, 1980
Accepted for publication June 10, 1980