Rattlesnake Hills

by the authors is gratefully

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Productivity Response to Precipitation by Native and Alien Plant Communities

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Abstract

The aboveground production of native bluebunch wheatgrass, *Agropyron spicatum*, was remarkably uniform and over a 4-year study period averaged 42 grams per square meter. During the same time period, the production of alien cheatgrass, *Bromus tectorum*, varied greatly and averaged 204 grams per square meter.

Cheatgrass responded to a growing season with above average precipitation by increasing production. Bluebunch wheatgrass did not increase production during a year of above average precipitation.

Introduction

This investigation compares net above ground primary production of native sagebrush-bluebunch wheatgrass communities in nearly pristine condition with that of cheatgrass communities on 30-year old abandoned agricultural fields. These communities occur on similar soils with similar climatic regimes on the Arid Lands Ecology (ALE) Reserve located on the United States Energy Research and Development Administration's Hanford Reservation in Benton County, Washington.

Although the natural vegetation is well known in a qualitative sense, there is a paucity of information on the quantitative aspects of production dynamics.

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Study Sites

One site is a nine hectare portion of a plant community representative of the *Artemisia tridentata/Agropyron spicatum* association (Daubenmire, 1970). The other is a former agricultural field abandoned in the early 1940's when the land was incorporated into the Hanford Reservation. The vegetation of the field consists mostly of cheatgrass, *Bromus tectorum*, an alien weed introduced to North America from Europe more than a century ago. These sites have experienced little or no cattle grazing for 30 years.

Method

The harvest method was employed to estimate above ground productivity for four growing seasons: 1971, 1972, 1973, and 1974. Two macro-plots, each 20 x 50 m, were located centrally in the cheatgrass community. Thereafter, sampling was conducted by randomly locating 10 plots within each macro-plot. Each of these, 0.1 m^2, was hand-harvested of all live plant material at approximately three-week intervals from March until plants dried from maturity in May or June. Live material was separated from dead plant material by hand, oven dried (50-60° C), and weighed separately by species. In the sagebrush-bluebunch wheatgrass community, 8 macro-plots, each 15 x 30 m were randomly located within the nine hectare study area. At each sampling period two plots, within each macro-plot, were randomly selected for harvest. One-half square meter circular plots were harvested by hand-clipping all vegetation including shrubs. Live material was separated from dead material and weighed by species as in the cheatgrass community.

Rainfall was measured at each study site using a standard U.S. Weather Bureau raingauge.

Results

Herbaceous Phytomass

A comparison of change in above ground phytomass of cheatgrass and sagebrush-bluebunch wheatgrass communities over a 4-year period is shown in Figure 1. These data show that production varied greatly from year to year in the cheatgrass community with peak phytomass ranging between 126 and 358, g m^{-2}. However, growth in the sagebrush-bluebunch wheatgrass community showed less production and peak phytomass values were not very different during the 4 years of record. Rainfall for the two communities is shown in Table 1. On the average, the cheatgrass community was only slightly drier than the sagebrush bluebunch

wheatgrass community (17 cm vs 20 cm). The years 1971, 1972, and 1973 were similar in seasonal distribution and total accumulated precipitation, but 1974 was much wetter.

FIGURE 1.

Comparisons of the spring growth of cheatgrass and sagebrush-bluebunch wheatgrass communities during 1971□, 1972◇, 1973○, and 1974△.

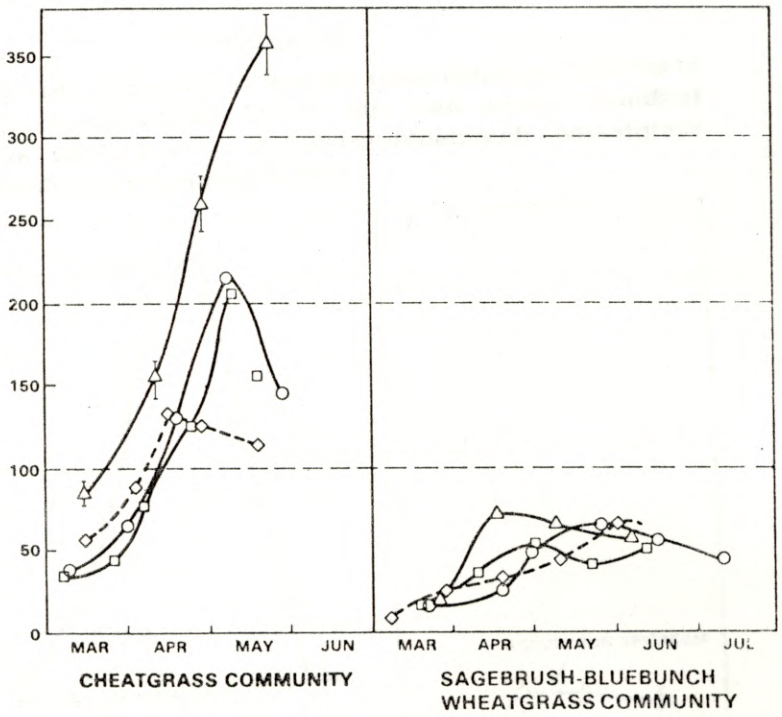


TABLE 1.

Average October to May (growing season) precipitation (cm) in cheatgrass and sagebrush-bluebunch wheatgrass communities.

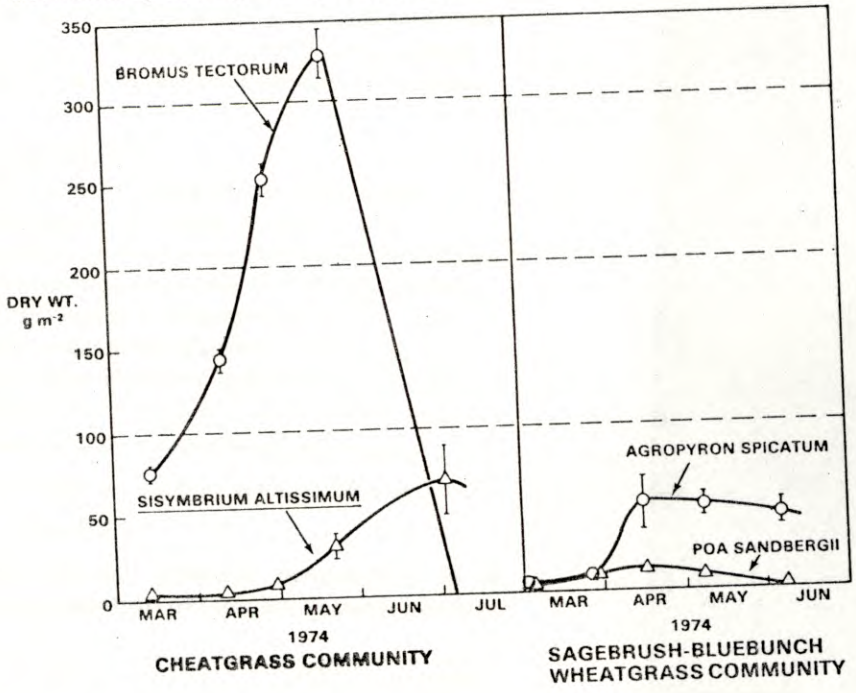
Year	Cheatgrass	Sagebrush-Bluebunch Wheatgrass
1971	15	18
1972	12	14
1973	11	12
1974	30	33
Average	17	20

The cheatgrass community responded to the increased precipitation by showing increased production. The sagebrush-bluebunch wheatgrass community did not respond in a similar fashion.

The response of the two most abundant species, cheatgrass and tumble mustard in the cheatgrass community, and bluebunch wheatgrass and Sandberg bluegrass in the sagebrush-bluebunch wheatgrass community in 1974 is shown in Figure 2. Tumble mustard contributed most to phytomass late in the growing season while Sandberg bluegrass contributed most to phytomass early in the spring.

FIGURE 2.

Comparison of the growth of the two most abundant species in a cheatgrass community with the two most abundant herbaceous species in a sagebrush-bluebunch wheatgrass community during the spring of 1974.



Sagebrush Phytomass

Although sagebrush is the most conspicuous plant in the sagebrush-bluebunch wheatgrass community and contributes yearly growth increments as new leaves, twigs, wood, and flowering stems, these are

inefficiently measured by the plot harvest techniques employed for phytomass estimates of the smaller herbaceous species. The results of a double sampling method of estimating sagebrush phytomass obtained by Uresk *et al.* (1976) is shown in Table 2.

TABLE 2.

Estimated phytomass of sagebrush shrubs during the autumn flowering period; separated into categories.

Category	g m^{-2}*
Leaves	10 ± 2
Live Wood	43 ±10
Flowering Stems	5 ± 3
Dead Wood	8 ± 6
Miscellaneous	2 ± 0.6
Total	68 ±16

*Mean ± SE (n = 20)

Assuming that 50 percent of the leaves and flowering stems weights are produced in the growing season and that 10 percent of the live wood was produced during the current year an estimate of 12 g m^{-2} can be added to net above ground production of the sagebrush-bluebunch wheatgrass community.

Peak Harvest vs Summation of Species Peaks

Plant species mature at different times during the spring growing season, one measurement of productivity made at the end of the spring growing season (peak harvest) is likely to underestimate production (Kelley, *et al.*, 1974). In simple plant communities, i.e., those with few species, this might not be so pronounced as in communities with many species. A summation of peaks for important species in the cheatgrass community is shown in Table 3. Over the 4-year period, the summation of species peaks averaged 249 g m^{-2} as compared to only 226 for peak harvest, a 23 g m^{-2} or 9 percent increase in production estimation.

A single harvest at peak bluebunch production averaged 56 g m^{-2}

TABLE 3.

Estimation of net above ground primary production in a cheatgrass community by summation of species at peak harvest values g m^{-2} dry weight.

Taxa	1971	1972	1973	1974	Average
Bromus tectorum	189 ± 12	132 ± 7	166 ± 12	328 ± 16	206
Sisymbrium altissimum	17 ± 4	1.7± 0.7	67 ± 15	68 ± 18	38
Poa sandbergii	3.2± 2.8	0.2± 0.2	0	8.4± 5.3	3
Miscellaneous	2.0± 2.0	0.2± 0.2	5.3± 3.7	1.4± 1.4	2
Summation Total	220	134	238	406	249
Peak Total	211	132	205	358	226

A single harvest at peak bluebunch production averaged 56 g m^{-2} (Table 4), a summation of species peaks yielded 70 g m^{-2} or a 14 g m^{-2} increase. This amounted to about a 20 percent increase in the estimate of net production.

TABLE 4.

Estimation of net primary above ground herb production in a sagebrush-bluebunch wheatgrass community by summation of species at peak harvest values g m^{-2} dry weight.

Categories	1971	1972	1973	1974	Average
Perennial Grasses					
Agropyron spicatum	42 ± 6	44 ± 7	40 ± 6	44 ± 10	42
Stipa thurberiana	0.8 ± 0.6	1.0 ± 0.7	0.5 ± 0.4	1.7 ± 1.2	1
Poa sandbergii	7.1 ± 0.7	5.2 ± 0.3	4.0 ± 0.4	11.6 ± 1.2	7
Poa cusickii	4.9 ± 1.7	3.0 ± 1.2	2.0 ± 1.8	4.2 ± 3.8	4
Sub Total	55	53	46	61	54
Perennial Forbs	3.3	5.2	4.0	4.7	4
Annuals	0.4	1.2	0.4	5.5	2
Half-Shrubs	12.9	13.2	11.0	4.2	10
Sub Total	16.6	19.6	15.4	14.4	16
Summation Total	72	73	61	75	70
Peak Total	45	65	50	65	56

Perennial Forbs: *Lupinus, Astragalus, Calochortus, Brodiaea*
Annuals: *Draba, Descurainia, Bromus, Festuca*
Half-Shrubs: *Erigeron, Phlox, Antennaria*

Discussion

Two methods of estimating net above ground productivity were used. The summation of species peaks yielded higher values than the single value obtained by harvest at peak yield. The single harvest is most useful in plant communities with a short growing season, such as Arctic and Alpine tundra where growth is limited by temperatures. The summation of species peaks is more appropriate in regions with long growing seasons where different species respond to different parts of the growing season, such as the warm and cool season grasses of great plains grassland communities. Although summation of species peaks increases the production estimate, the harvest method still does not account for losses due to shedding or to herbivory (Kelly *et al.*, 1974), so that the values are best regarded as minimum estimates.

Clearly, the cheatgrass community produced more dry matter than the sagebrush-bluebunch wheatgrass community. The superior performance of the cheatgrass community suggests that it is a more efficient user of available soil water. Grassland Biome studies suggest that evaporation from bare ground is a major contributor to low water use efficiences in desert

ed 56 g m^{-2}
$^{-2}$ or a 14 g m^{-2} rasslands (Van Dyne *et al.*, 1975). Cheatgrass communities
in the estimate haracteristically provide a closed plant canopy while the plants of the
agebrush-bluebunch wheatgrass community are widely spaced with much
are ground between clumps. This suggests that evaporation losses may be
least partly responsible for the poor production performance of the
agebrush-bluebunch wheatgrass community. Another explanation may be
oat there is more below ground production, i.e., roots and crowns, in
gebrush-bluebunch wheatgrass communities and harvest data tend to
pport this contention, although estimates of the amount of below
ound phytomass produced annually are not highly reliable because of
e high variance associated with root estimates obtained from soil cores.

production in
by summation

1974	Average
44 ±10	42
1.7 ± 1.2	1
11.6 ± 1.2	7
4.2 ± 3.8	4
61	54
4.7	4
5.5	2
4.2	10
14.4	16
75	70
65	56

, Brodiaea

Probably the most surprising finding of these studies was the failure of
uebunch wheatgrass to respond to the more favorable moisture year in
974. This suggests that there are factors that constrain the growth of
uebunch wheatgrass independently of precipitation patterns. This
vestigation in itself yields no insight as to what these constraints might
e; however, experiments could be designed to elucidate possible
onstraints such as simulated rainfall (sprinkler irrigation) in conjunction
ith burning to eliminate shrub competition and phytotoxins.

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