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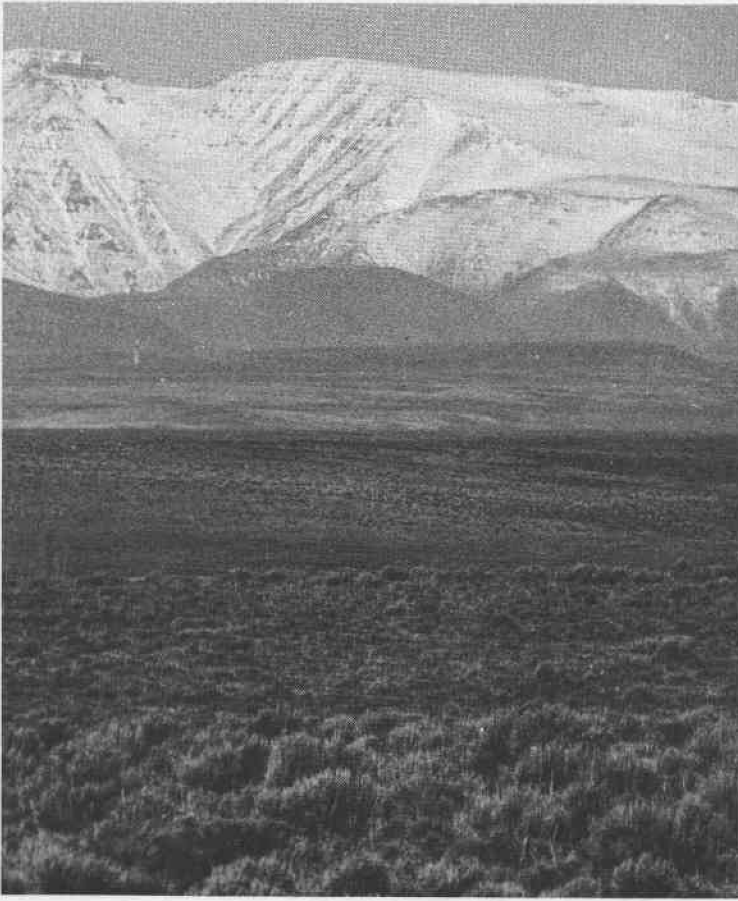June 1991

Management in the Sagebrush Steppe

Agricultural Experiment Station
Oregon State University
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Management in
the Sagebrush Steppe

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FOREWORD

This years Range Field Day will focus on one of the largest ecosystem types in North America, the sagebrush steppe. Sagebrush steppe communities occupy over 100 million acres in the western United States. In Oregon alone this ecosystem type covers 23 million acres.

Increased demands in this semi-arid region for water, forage, minerals, habitat, recreation, and agriculture will continue to increase the challenge of properly managing this resource. Proper management, restoration and use of this ecosystem will depend upon biologically sound and often creative management, and an understanding of how this ecosystem functions.

The purpose of this report is to both increase our understanding of this ecosystem and evaluate several management alternatives in the high desert. This Range Field Day will look at sagebrush ecology, climate, winter and fall grazing, grazing selectivity and diet, and grazing management to control introduced weeds.

-----Richard F. Miller
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A RENEWED COMMITMENT TO MANAGEMENT OF SAGEBRUSH GRASSLANDS

Al H. Winward

INTRODUCTION

If we were to get into a car at Horse Ridge, just east of Bend, Oregon and begin traveling eastward, we could drive hundreds of miles - across the Oregon High Desert, through the Snake River Plains of Idaho, into the northern edge of the Great Basin of Utah, and through much of the Red Desert of Wyoming - and always be within sight of sagebrush. This is the area that some of the early travelers such as Fremont (1845) referred to as the "Sagebrush Desert." Early rangeland managers calculated that over 94 million acres of the western U.S. are dominated by woody species of sagebrush (USDA Forest Service 1936). Tisdale and others (1969) felt that this estimate is too low. Although some of this acreage is now under cultivated agriculture, many millions of acres of sagebrush dominated rangelands remain.

Over 50 years of effort have been spent in trying to improve management of these areas yet, the sagebrush region still is producing far below its potential. Stands that once produced over 800 pounds of air-dry grasses and forbs per acre now produce less than 100 pounds per acre of these understory species. Loss of much of the understory herbaceous species has been accompanied by an increase in size and vigor of the sagebrush and other woody species. Additionally, numerous poison or noxious weedy species, or dense stands of less desirable annuals have manifest themselves and altered the original character and value of these once productive rangelands.

The time has come to reevaluate our past management efforts. Based on current needs, new technology, and especially, updated information, we need to recommit ourselves again to improving the health and productivity of this vast sagebrush-grass ecosystem.

Values of Sagebrush

What are some of the things we've learned about sagebrush-grass rangelands in the past thirty years? Perhaps one of the important things is that sagebrush does have some values. We spent so many years working to "eradicate" sagebrushes because they competed with livestock forage species that we failed to look at some of the good things about this unique group.

There has been considerable effort spent trying to understand more about their value as forage--which ones are preferred and what is their nutritional value, seasonally. Since sagebrush is considered "evergreen" it tends to provide a higher source of protein in the dormant season than most other plant species that occur in these ecosystems.

Additionally, it often is available to foraging animals during the snowy season due to it's upright-shrubby growth form. Several native wildlife species have adapted foraging habits centered around this genus.

There have been some interesting studies on the native insects tied to sagebrush. Not only are some insects tied to certain kinds of sagebrush, but also to certain types of leaves (ephemeral vs persistent) of sagebrush (Jones and others 1983). Presence of certain insects, in turn, influences the types of animals and birds associated with them (Medin 1990). It is of interest to find that the black grass bug (Labops ssp.), which is a native insect that can build to high numbers and damage the native and introduced wheatgrasses, often is held in check if some sagebrush plants are interspersed with the wheatgrasses. Certain insects associated with the sagebrush are parasitic on the black grass bugs. This inter- relationship has been going on for thousands of years and we can upset this balance if we get too involved in our sagebrush eradication projects.

Another value of having a balanced amount of sagebrush in the community ties to total per acre biomass. Sagebrush has both a deep penetrating tap root as well as lateral surface roots. It is able to make better use of the water and nutrients in the soil profile than, for instance, grasses alone--which extract their water and nutrients from the upper 12-18 inches of the soil. In fact, it has been recently discovered, that understory herbaceous production is enhanced if a few sagebrush plants are included in the community composition. This increased production is tied to at least two factors: (1) the sagebrush roots extract nutrients from deep in the soil profile and recycle them to the surface through leaf/litter drop (Mack 1977). The understory species are able to make use of these "extra" nutrients and (2) Sagebrush crowns assist in keeping the winter snows-on-site where the moisture can be more evenly utilized (Sturges 1977). A few scattered sagebrush crowns provide microsites that ameliorate the surface temperatures both in winter and summer. If sagebrush is not too dense, the shade from their crowns is believed to benefit establishment of certain understory plant species such as Idaho fescue (Festuca idahoensis). These crowns also provide food and protective cover for many wildlife species and are especially critical for nesting and wintering sage grouse. Additionally, the crowns provide protection for many understory plant species by providing a barrier to total utilization by grazing animals. Some of our understory species would not have survived the critical grazing pressure at the turn of the century, had it not been for the mechanical protection offered by these shrub crowns.

As we gain a greater understanding of sagebrushes, in general, we also gain a greater appreciation for their presence on our western lands. Future efforts will be geared less to eradication of this plant group and more to keeping it in a balanced supply with it's understory.

Ecological Status:

Let me make a bold statement about the current ecological status of sagebrush grasslands. A statement that I perhaps could not back-up if I were asked for specific figures. But, one that has become readily observable as I have traveled throughout the sagebrush region with my eyes to the ground and my thoughts on sagebrush-grass ecology. Here it is.

"There are more acres of sagebrush-grass lands in the western United States being held in a low ecological status the past decade due to abnormally high sagebrush cover and density than currently is occurring due to livestock grazing."

Now let me explain. One of the remarkable developments we have made in our western grazing lands the past quarter century has been improved rangeland management. Many of us may not have a full appreciation for this since we were not around at the early part of this century to see the western grazing lands during this period of highest rangeland abuse. Much improvement has occurred since the 1930's-1950's. This we can be proud of! Unfortunately, on many acres of rangelands that continue to support an overstory of shrubby species, such as sagebrush, an equal magnitude of improvement has not occurred. During the period of extremely heavy grazing much of the understory species were decimated. This loss of the understory, fine-fuel component, along with fire suppression efforts essentially removed natural fire from the sagebrush-grass setting. These ecosystems, which have developed with an historical 10-40 year fire interval, were dependent on this periodic removal or thinning of sagebrush crowns to maintain their balanced understories. Now, with the understories depleted through grazing, and with the densely established sagebrush crowns competing in an excessive way with new herbaceous seedlings, we are in an almost stagnated setting. A setting with high sagebrush cover and a low cover of the understory species. There essentially is no way we can reestablish a native--or introduced--herbaceous cover without first removing some of the dense sagebrush canopy.

There are a number of instances where exclosures have been erected to allow us to measure vegetation recovery without the grazing impact. In settings where sagebrush densities and cover were high when the exclosures were constructed there has been essentially no increase in understory herbaceous cover--even after over 40 years of protection from grazing. Once sagebrush has become established in dense stands it can be an extremely strong competitor against reestablishment of grass and forb seedlings. Where crowns are dense sagebrush roots occupy all upper soil horizons and compete fiercely with the new herbaceous seedlings. Only when sagebrush crowns are spaced far enough between to allow "open" microsites, do we get successful recovery of the understory.

When are crowns of sagebrush considered dense? In order to answer this question one must consider the particular subspecies involved. Based on numerous observations and studies it appears Wyoming big sagebrush sites have cover values that normally range between 8 to at least 23 percent (Table 1). In my studies those areas with the least disturbance had cover values between 8-11 percent, while those with the highest grazing impacts exceeded 20 percent. Observations indicate there is very little competition between Wyoming big sagebrush and herbaceous species where crown cover is less than 12 percent. Production of understory species remains about the same, or shows a slight increase, where cover values are less than 12 percent. However, somewhere between 12-15 percent cover (depending on specific site features) understory production decreases as canopy cover increases. Many millions of acres of Wyoming big sagebrush presently have canopies above 20 percent and have depleted understories. These are the acres that will require some type of thinning or removal process in order to reestablish a balanced herbaceous component.

Table 1. Density and cover values for three subspecies of big sagebrush

	Subspecies		
	ARTRW wyomingensis	ARTRT tridentata	ARTRV vaseyana
Density[1]			
(plts/Ac)	4,700	5,700	17,000
mean range	2,600-12,000	3,000-8,300	5,100-67,000
Cover[1]			
(line intercept-			
%)	18	24	23
mean	8-23	19-30	14-41
range			

[1] Density and cover of sagebrush are functions of subspecies, habitat type, and ecological condition. Data from A.H. Winward. 1970.

Mountain and basin big sagebrush sites in best condition have cover values between 15-20 percent. Those numerous sites that support cover values in the 30-40 percent category have a much restricted herbaceous production and are essentially closed to recruitment of new herbaceous seedlings. Some type of shrub removal process will be needed before understory forbs and grasses can regain their natural prominence in these communities.

If we are to reestablish a more natural ecological balance in the overstory/ understory in most of our sagebrush ecosystems, we must begin a much greater effort at restoring some of the natural mosaic of sagebrush canopies that existed prior to European settlement of the west. Historical fires naturally burned spotty leaving islands and stringers unburned during any one fire. Those areas which did burn received various intensities of fire. The overall result was an ever-changing mosaic of different densities and ages of sagebrush crowns. In any specific geographic area, a mosaic of ecological settings existed ranging from open temporary prairie types where fires were most recent, to mature, relatively dense sagebrush stands where considerable time had elapsed since the last fire.

Recovery from a burn to a 20 percent canopy can range from 12 years in a mountain big sagebrush type to over 40 years in the drier Wyoming big sagebrush types. Most sagebrush stands now approach 60+ years in age indicating fire intervals have been lengthened to more than twice their natural occurrence.

DISCUSSION

We currently are not beginning to keep pace with the natural increases in sagebrush cover and density. Our prescribed fire programs influence, at most, a few thousand acres each year and almost no mechanical nor chemical programs are being conducted. Natural disease out-breaks, frosts and flooding, along with wildfires remove sagebrush from a few more thousand acres each year. Yet, the acreages influenced yearly is only a minor component of the 96+ million acres classified as sagebrush grasslands. As a result many millions of acres are being maintained in a low ecological status due to presence of excessive sagebrush canopies.

An intensive prescribed fire program could help in the recovery of more natural sagebrush canopies. However, not all acres are suited to burning. Some sites are inherently dry and have such low fuels that fire was probably never very important in maintaining their herbaceous understories. Also on sites where fire tolerant shrubs, especially rabbitbrush, become excessively dominant after burning, prescribed fire may not be appropriate. Other approaches to thinning the sagebrush should be considered.

We must also recognize there are some settings where high sagebrush cover provides special, needed habitat for wildlife such as mule deer and sage grouse. These needs should be considered in any sagebrush management program. However, even in settings such as these it is desirable to have a high enough component of understory species that the overall watershed needs are served. To do this we will need to instigate a long-term program that will allow periodic, patterned removal or thinning of sagebrush. This apparently is the way it was before we became such a dominant modifier of the sagebrush-grass ecosystems. And, it is the way we will have to manage

these areas if we want to maintain all the uses and values that can be associated with sagebrush-grass rangelands.

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DRY-WET CYCLES AND SAGEBRUSH IN THE GREAT BASIN

Richard F. Miller, Paul Doescher and Teal Purrington

INTRODUCTION

The Great Basin, also frequently called the cold desert or high desert, covers most of southeastern Oregon, Nevada, western Utah and extends into parts of northeastern California. Climate for this large region is characterized by cold wet winters and hot dry summers. The primary source of moisture for the northern half of the Great Basin of which 60 percent falls as snow, is from the Pacific Ocean, with low pressure centers moving across the region during fall, winter and spring. Mean annual precipitation for this region is 11 inches, commonly ranging with elevation from 6 to 16 inches, with extremes varying from 3-5 inches in some of the southern valleys to 60 inches in the highest mountain ranges (Flaschka et al. 1987). Annual lake evaporation rates range from 45 inches in the north to 90 inches in the south.

Climatic variability has always been characteristic of the Great Basin since its' formation. At the Squaw Butte Experimental Range, where mean annual precipitation is 11 inches, precipitation has ranged from 6.5 to 17.5 inches during the past 40 years. During this 40 year period, precipitation has fallen below 70 percent of the mean (8 inches or less) one year in five. In the past 380 years, evidence indicates dry years generally did not occur at random but in cycles.

Evidence of drought over the past 100,000 years indicates that some dry periods lasted several thousand years and caused major shifts in plant and animal species distribution throughout the Great Basin. In this paper we will discuss: (1) the occurrence of dry-wet cycles in the Great Basin during the past 10,000 years; (2) the general effects of dry-wet cycles in this semi-arid ecosystem; and (3) the response of big sagebrush to dry-wet cycles.

Changes in Climate: A Look At The Past

To obtain a better perspective on current climatic conditions it helps to look back to the past. This perspective may also help us predict changes that will occur in the future with global warming. Evidence used to describe past climatic fluctuations include analyzing fluctuations of lakes, glaciers, and snow lines, soil deposition and erosion by water and wind, tree ring widths, pollen cores from lake bottoms, rat middens, the relative abundance of plant and animal fossils requiring wet or arid environments, and in historic time by weather measurements, runoff and lake levels.

Following the last ice age which ended approximately 10,000 years ago, climate throughout the Great Basin continued to fluctuate, with an extreme dry period,

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sometimes called the altithermal, persisting during 7,000 to 4,500 years B.P. (before present) (Figure 1). Following this arid period, climate became more humid, approximately 4,500 years B.P. and then cooler 3,500 years B.P. (Antevs 1938, 1948). Within the last 3,500 years, climate has continued to fluctuate, including a cooling of the Great Basin beginning in the late 1500's and ending in the mid 1800's. This cooling period, frequently called the Little Ice Age, was associated with high volcanic activity around the globe. During the past 3,000 years, however, the general trend in climate has been towards increasing aridity.

Recent Climatic Changes

Since 1650, we can see a distinct pattern of dry-wet cycles, implicated by tree ring data (Figure 2). In general, dry periods have most frequently occurred in clusters of 3 to 10 years. An obvious exception to this is during 1850 to 1917, when drought was infrequent and precipitation was generally above normal throughout the northern half of the Great Basin. We can also observe a trend in Figure 2 towards a gradual increase in drought intensity as we approach the present. By the end of the Little Ice Age (approximately 1850), mountain glaciers reached their maxima. Increased warming, which accelerated glacial melt, and above normal precipitation during the late 1800's and early 1900's increased runoff, elevating lake levels throughout the Great Basin (Antevs 1948). This period coincides with settlement of the region. Expectations of farming and livestock-carrying capacities during this period would have exceeded those had the settlers moved in during another time period. It is also coincidental that settlement occurred after one of the driest periods in the Great Basin, the decade of the 1840's. This wet period, which occurred with settlement from 1850 through 1923, ended with the severest drought since 150 to 650 years in the Great Basin.

From 1900 to 1940 the globe experienced the first major warming trend since the beginning of the Little Ice Age (Neilson 1986). Following the severe drought of the 1930's the globe experienced some cooling in the 1940's and 1950's and an increase of precipitation in the Great Basin (Table 1). In this century periods of below average precipitation occurred in the 1930's, 1970's and since 1985.

Dry-Wet Cycles and Nutrient Availability

Water is considered the most limiting resource for plant growth in the high desert. During years of below-normal precipitation, plants compensate for limited water by reducing their leaf area or canopy. Death also increases, particularly in younger plants (e.g. sagebrush plants three years or younger), and little, if any, recruitment occurs. The overall aboveground effect of drought in a plant community is a reduction in both total plant cover and density.
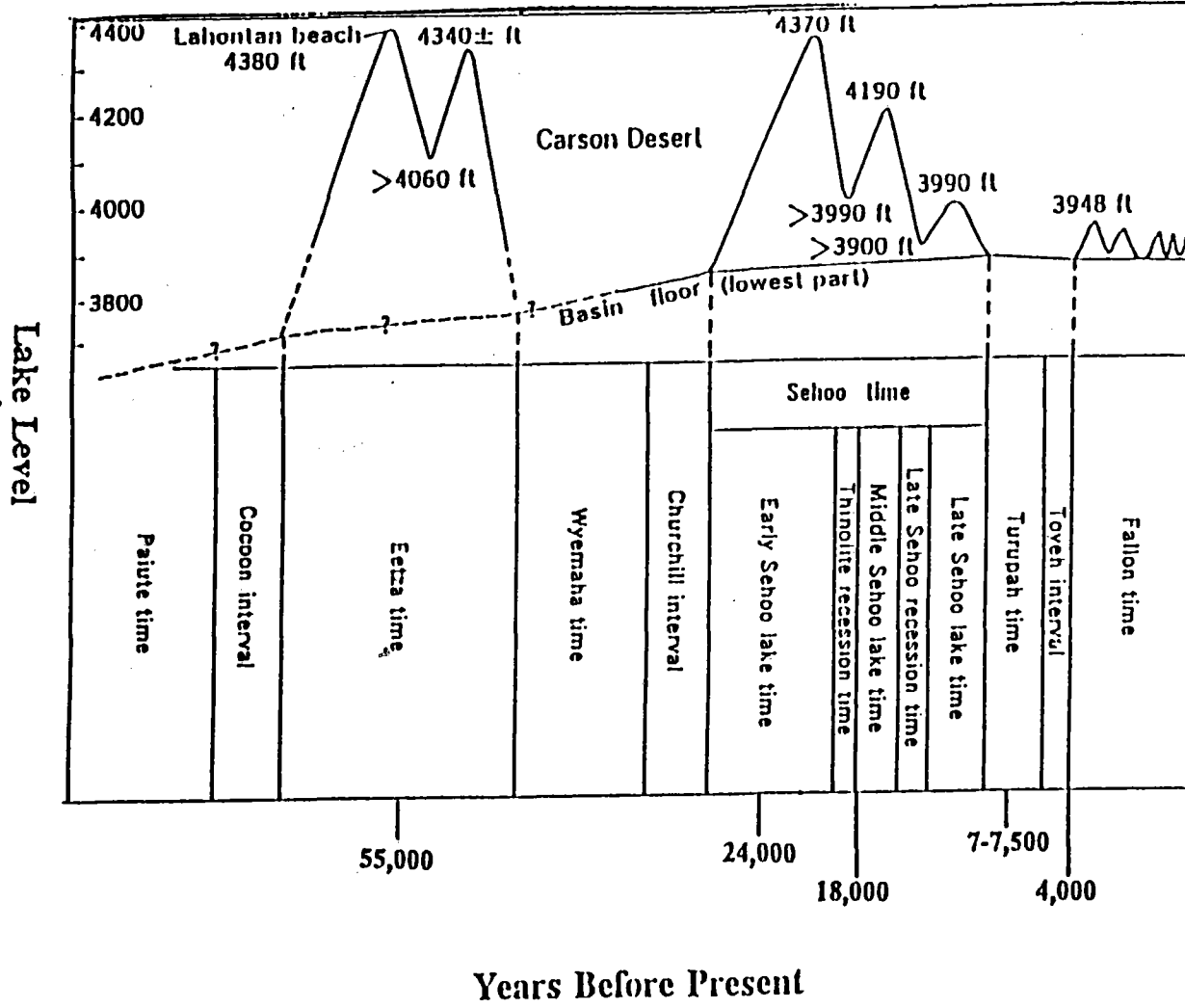
Figure 1. Elevation of Lake Lahontan during the past 100,000 years. The Wyemaha and Turupah time periods were warmer and drier than current conditions and periods of accelerated soil erosion. The Coccoon, Churchill and Toyeh intervals were warmer and wetter than current conditions and were important periods of soil formation in the Great Basin. Periods of elevated lake levels represent cooler and wetter periods than current (adapted from Morrison 1964).
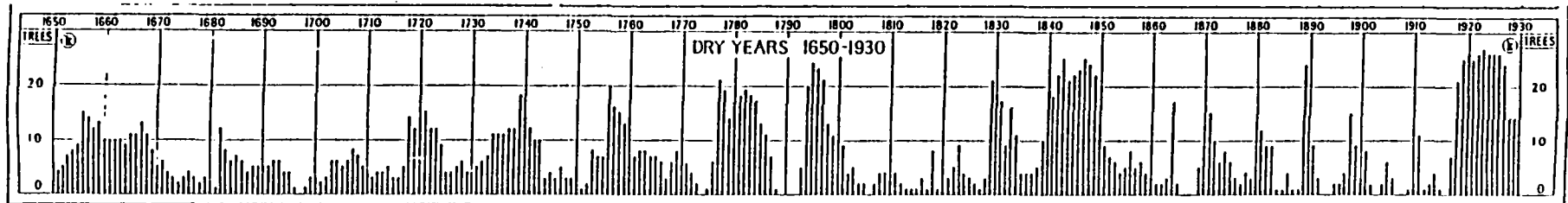
Figure 2. Estimated relative precipitation based on tree ring growth at various locations throughout the northern half of the Great Basin (from Antevs 1938). The Y axis is an index developed using tree ring growth representing wet (0) to dry (≥20) conditions.

Table 1. Mean crop-year precipitation by decade (September thru June) at the Squaw Butte Experimental Range. (Modified from Sneva et al. 1984).

Years	Precipitation (Inches)
1928-1937	6.6
1938-1947	11.0
1948-1957	11.0
1958-1967	10.2
1968-1977	8.2
1978-1984[1]	11.7
1985-1990[2]	7.5

[1] 7-year mean
[2] 6-year mean

Water also affects nutrient availability. Available nitrogen, usually the most limiting plant nutrient in the Great Basin, is dependent upon soil moisture, and is therefore influenced by dry-wet cycles. At the beginning of a wet cycle, increased levels of soil moisture stimulates decomposition of organic matter which transforms nutrients into usable forms for plant uptake and growth. Elevated levels of both water and nutrients stimulates plant growth. However, plant productivity declines in these semi-arid ecosystems following two or more seasons of above average precipitation. This is caused by a reduction in the availability of nutrients which becomes tied up in both live and dead plant material. Increased lignification of cell walls during wet years also reduces the decomposition rate of these plant materials. In 1958 and 1984, both the third year of three consecutive wet years, annual plant production at Squaw Butte declined even though soil moisture was readily available. In 1984, annual plant production was 25 percent less than in 1982 and 1983 even though soil water content was greater during the 1984 growing season. To the contrary, in dry years, available nitrogen levels tend to gradually increase due to limited plant uptake and decreased lignification of plant tissue. At the end of the dry-cycle, both water and nitrogen again become readily available, stimulating vigorous plant growth, including seed production.

Dry-Wet Cycles and Vegetation Composition

Plant species growing in the Great Basin have evolved under highly variable climatic conditions and are well adapted to compensate for dry-wet cycles. However, the competitive balance tends to shift towards one species over another during periods of drought and recovery.

During the past 10,000 years dominance between grasses and shrubs has shifted, coincident with changes in climate. Pollen analysis, rat middens, soil profiles and fossil records indicates grass species were favored during the cooler, wetter periods (e.g. the last 3,500 years) whereas shrubs were favored during the warm arid periods (e.g. 7,000 to 4,000 years B.P.). Pollen data indicate in southeast Oregon cyclic shifts in dominance between sagebrush and perennial bunchgrasses during the past 8,000 years (Mehringer 1986). Vegetation composition covering the landscape, described by the explorers, fur trappers and early settlers in the late 1700's and early to mid 1800's, was established during the cooler, wetter Little Ice Age. A continued trend towards a more arid environment probably favors woody plant species (e.g. big sagebrush) and exotic annuals (e.g. cheatgrass).

Dry-Wet Cycles and Sagebrush

Big sagebrush (Artemisia tridentata), one of the most successful plant species in the Great Basin is probably favored by the reoccurrence of dry-wet cycles. Like most plants, sagebrush greatly reduces its overall growth during drought. For example, limited precipitation in 1990 significantly reduced sagebrush leaf and stem growth, development of flowering shoots, and canopy cover. In 1990, vegetative and reproductive shoot production were only 13 and 20 percent, respectively, of the previous 1989 season (soil water content in 1989 was near average and growing conditions were considered good). During the drought of the 1930's, sagebrush canopy cover declined in the cold desert (Pechanec et al. 1937).

Following drought, we predict big sagebrush will be more opportunistic, recovering more rapidly than associated perennial bunchgrasses on most sagebrush-steppe sites. During the early phase of the recovery period, plant cover and root biomass are low and levels of readily available nutrients are respectively high due to reduced competition and accumulation of available nutrients during the dry period. Big sagebrush has a greater potential growth rate than associated perennial bunchgrasses, allowing it to reoccupy the plant community at a more rapid rate. Research has shown that the addition of nitrogen into a cold desert shrub steppe community allowed the current years' aboveground biomass to increase only 150 percent for a perennial bunchgrass whereas Wyoming big sagebrush biomass increased 340 to 455 percent (Miller et al. 1991). After the 1930's drought, big sagebrush canopy cover increased 76.9 percent in the first year of recovery compared to perennial bunchgrass cover which did not increase during that first year (Pechanec et al. 1937).

We also predict that reproductive effort will increase for many plant species growing in the Great Basin following drought. Increased reproductive effort is probably a response to elevated soil resources, particularly nitrogen. Elevated nitrate levels have been shown to increase big sagebrush flowering shoot growth by 300 percent (Miller et al. 1991). Other researchers in the Great Basin reported the highest densities of big sagebrush closely matched or followed years when plant cover was lowest, that is following a drought (West et al. 1979). Reduced plant canopy cover and elevated nutrient levels following a drought provide an ideal environment for seedling establishment.

CONCLUSION: MANAGEMENT IMPLICATIONS

In conclusion, both long-term and short-term dry-wet cycles in the Great Basin are natural phenomena and will continue. Under the current climatic conditions we expect the sequence of these dry-wet cycles to increase big sagebrush dominance across many landscapes throughout the Great Basin. The ability of established big sagebrush to rapidly increase its canopy size and reproductive effort following a drought makes it extremely competitive. The removal of livestock grazing is unlikely to influence this process. However, excessive livestock grazing is likely to enhance sagebrush invasion by reducing the ability of established perennial bunchgrasses to increase in cover and produce seed crops. Because of the competitive edge of big sagebrush, prescribed fire must play an important role to maintain a balance between woody and herbaceous vegetation. Pre-European settlement fire frequencies, 20 to 30 years in the wetter more productive sagebrush sites and 40 to 80 years on the drier less productive sagebrush sites, allowed herbaceous vegetation to dominate or co-domonimate many of these sites.

If an accelerated warming trend does occur in the Great Basin (Global Warming), accompanied with a decrease in precipitation, we can expect, based on past events, an increase in dominance of woody plants, a decrease in total plant cover and an increase in soil erosion. An increase in exotic annuals, such as cheatgrass, are also likely to increase in dominance. Reduced water yields will also fall far short of projected future demands in the Great Basin.

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USING PAST CLIMATIC DATA TO ESTIMATE EFFECTS OF PREDICTED CLIMATE CHANGE ON TEMPERATURE AND PRECIPITATION IN SOUTH CENTRAL OREGON

Patsy Miller

Levels of atmospheric carbon dioxide (CO_2) have increased from preindustrial levels of 275-285 ppm in the early 1800's to the current level of 350 ppm. The largest input of carbon dioxide into the atmosphere is through the burning of carbon stored in fossil fuels and in tropical rain forest vegetation. Seasonal variations in atmospheric carbon dioxide reflect increased uptake of carbon dioxide by vegetation during the summer and reduced plant activity during the winter.

Carbon dioxide and other greenhouse gasses (methane, nitrous oxide, chlorofluorocarbons, and lower atmosphere ozone) trap incoming, short-wave solar radiation from the sun and do not allow the reflected, long-wave radiation from the earth to pass out through the atmosphere. By acting like a greenhouse to trap heat from the sun, increasing concentrations of these gasses cause the earth to become warmer. Carbon dioxide accounts for about 50 percent of the warming, methane 20 percent, and the other gasses account for the remaining 30 percent of the temperature increase.

The effect of increased greenhouse gasses on temperature is generally agreed upon. With a doubling of present levels of atmospheric carbon dioxide, which is predicted to occur within 50 to 100 years, mean annual global temperatures are predicted to increase 3 - 4°C (5.4 - 7.2°F) at the equator and 8 - 10°C (12.8 - 18°F) in the Arctic. The mean annual global temperature has already 0.6°C (~1°F) in the past 30 years. Six of the 10 warmest years in the 130-year record of mean annual global temperature have occurred since 1978.

Precipitation patterns and amounts are predicted to change with global warming, but changes in precipitation for a given region are difficult to predict using global climate models because of the scale of model resolution. For example, all of Oregon, parts of Washington, Idaho, Nevada, California, and some of the Pacific Ocean are lumped together as one data point in the National Atmosphere and Space Administration (NASA) global climate model.

Another approach to understanding the effects of increased temperature on precipitation is to look at past climatic records for an area. The National Ocean and Atmospheric Administration (NOAA) has compiled a data set of mean monthly temperature and monthly precipitation for a 94-year period from 1896 to 1990 for Division 7 in south central Oregon. The data set is currently based on 34 reporting

stations in Crook, Lake, Deschutes, Wheeler, Grant, Harney, Jefferson, and Klamath counties (Figure 1).

From 1896 to 1991 the composite mean annual temperature for all the reporting weather stations in south central Oregon was calculated as 7.86°C (46°F). Only seven water years, October 1 to September 31, have had mean annual temperatures more than 1°C (1.8°F) above the 94-year, long-term, composite mean (1917-1918, 1925-1926, 1933-1934, 1939-1940, 1986-1987, 1987-1988, and 1990-1991). And only one year, 1933-1934, was 2°C (3.6°F) warmer than the long-term mean temperature. It is interesting to note that three of the last four water years are among the seven warmest years recorded since 1895 in south central Oregon (Figure 2). Previous warm years were separated by intervals of 7, 7, 5, and 45 years. The recent warm period with current levels of atmospheric carbon dioxide may be coincidental or may be a foreshadowing of future trends.

The long-term mean annual precipitation for south central Oregon is 30.6 cm (12.1 inches). Five years (1923-1924, 1930-1931, 1938-1939, 1954-1955, 1976-1977) have had precipitation <66.6 percent of the long-term mean (Figure 3).

To understand how precipitation might be affected by increases in temperature, individual months with a mean temperature 2°C (3.6°F) above the long-term mean monthly temperature were selected from the long-term record. The number of months used in the analysis varied from four in July to 17 in February. Analysis indicated that months with a mean monthly temperature 2°C above the long-term mean monthly temperature had precipitation 5 percent, 13 percent, and 11 percent above the mean during November, December, and February. However, precipitation for October, January, March, April, May, June, July, August, and September was, respectively 88, 77, 99, 87, 65, 55, 70, 71, and 62 percent of long-term monthly precipitation (Figure 4).

The composite mean annual precipitation for months with temperatures >2° above the mean monthly temperature was 27 cm (10.6 inches) compared to the measured long-term mean annual precipitation of 30.6 cm (12.1 inches). This reduction in mean annual precipitation was for a composite year with a mean annual temperature of 10.6°C (51.1°F), which is 2.74°C (4.9°F) above the measured long-term mean annual temperature of 7.86°C (46.1°F) (Figure 5).

The 94-year weather record for south central Oregon cannot be used to statistically predict precipitation with an increase in annual temperatures 3 - 4°C (5.4 - 7.2°F) above the mean annual temperature. Such warm temperatures are outside the existing data set. Although it is tempting to predict precipitation with temperatures warmer than those measured in the past, it is dangerous to do so because the relationship between precipitation and temperature may change at air temperatures warmer than those measured in the past.

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Only one year, the water year of 1933-1934, had a mean annual temperature 2°C (3.6°F) above the long-term mean. However, the current pattern of decreased precipitation with increased temperatures indicates a strong possibility that eastern Oregon will become significantly drier if mean annual temperature increases by 4°C (7.2°F) in response to higher concentrations of greenhouse gasses in the atmosphere.

If (with predicted climate change) warmer, drier conditions become the new norm for south central Oregon, patterns of above and below-ground resource acquisition of carbon dioxide, light, water, and nutrients may be altered, and the ability of range plants to photosynthesize, absorb water and nutrients, and grow may change. If resource capture by a species is disadvantaged compared to resource capture by other species in the community, populations of the disadvantaged species will decline. If perennial grasses and forbs are less able to adapt to the new climate than are sagebrush and western juniper, the amount of available forage for livestock and wildlife may decline. On the other hand, long-lived shrubs and trees may be at a disadvantage during a period of rapid climate change. If all species are equally disadvantaged by climate change, community composition should not change.

Research is needed to measure the relative abilities of western juniper, sagebrush, rabbitbrush, and perennial grasses to capture above and below-ground resources with conditions that mimic expected increases in temperature and reductions in precipitation. Such research would allow prediction of changes in community composition. If sagebrush and western juniper are more successful in acquiring resources than are perennial grasses under conditions of increased air temperature and decreased precipitation, present levels of domestic livestock grazing may not be possible if perennial grasses are to be maintained in eastern Oregon. If information on the response of rangeland plants to climate change is available before anticipated global climate change is realized, necessary adjustments in grazing on public and private lands can be made to define alternative grazing strategies and reduce dislocation of permittees while retaining perennial grasses in the ecosystem.
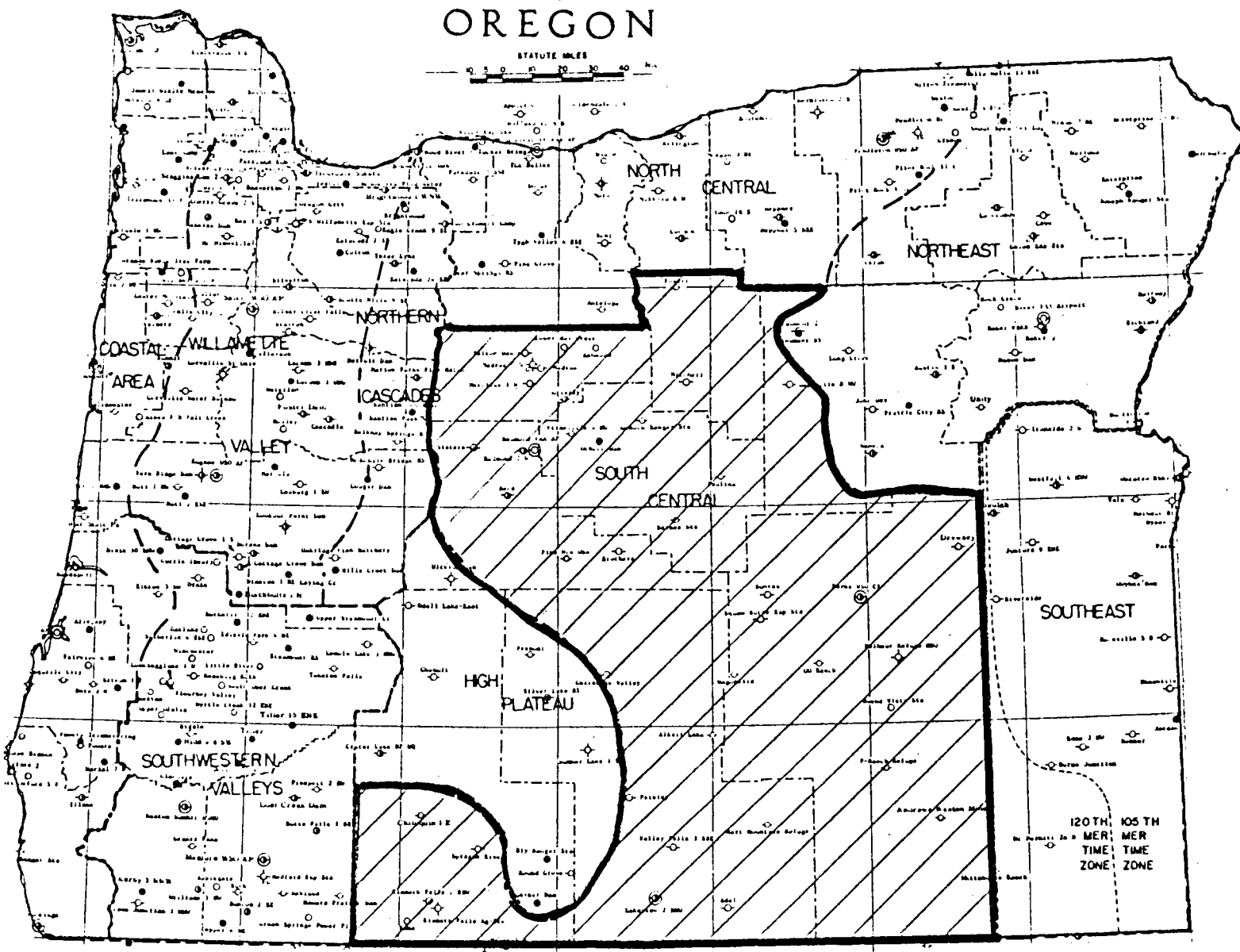
OREGON

Figure 1. Division 7 in south central Oregon with 34 reporting weather

Air Temperature
South Central Oregon

Figure 2 .

Mean Annual Temperature, C

Mean Annual Temperature, F

Water Year (Oct. - Sept.), 1896 - 1990
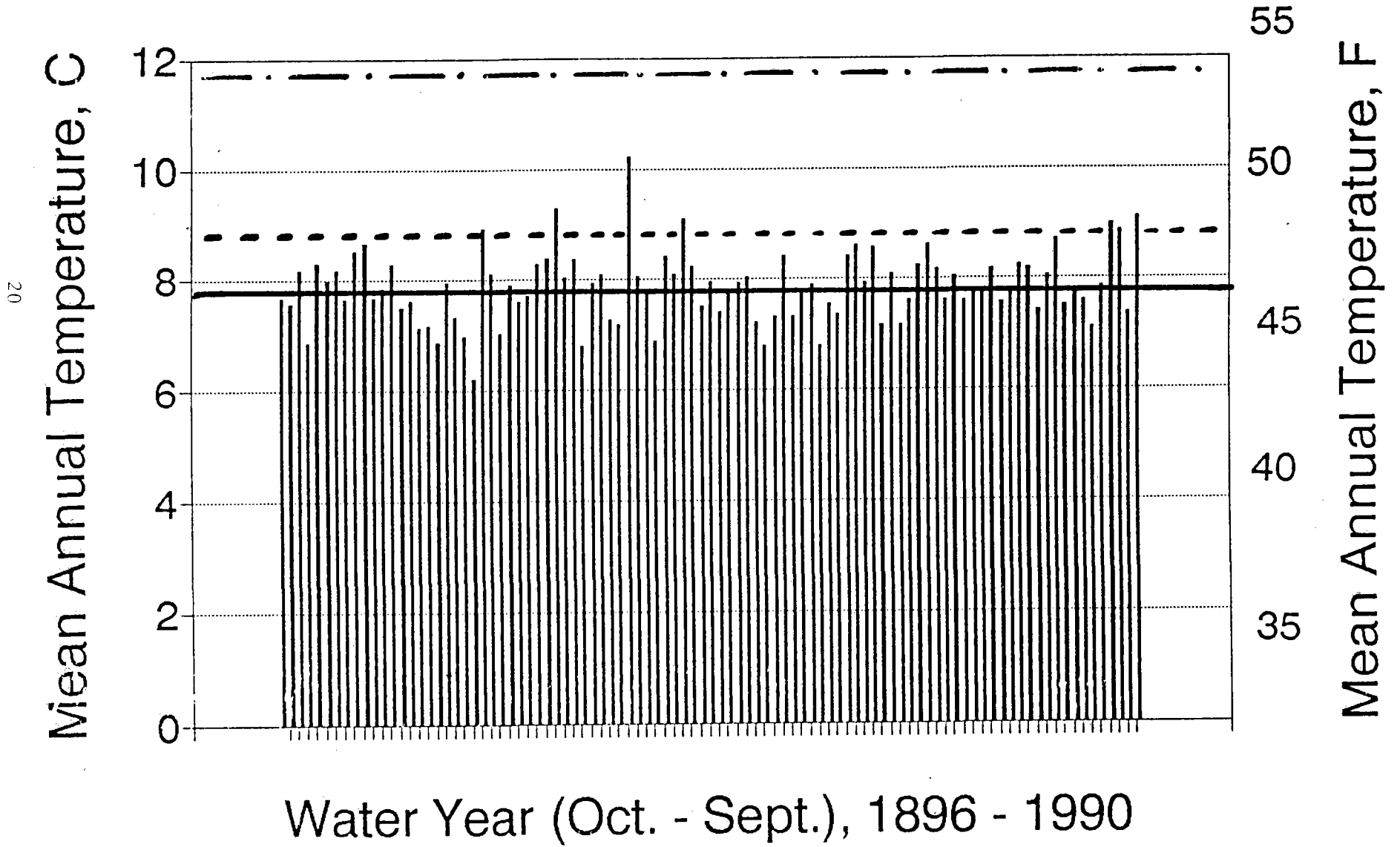
Figure 3.

Precipitation
South Central Oregon

Water Year (Oct. - Sept.), 1896 - 1990
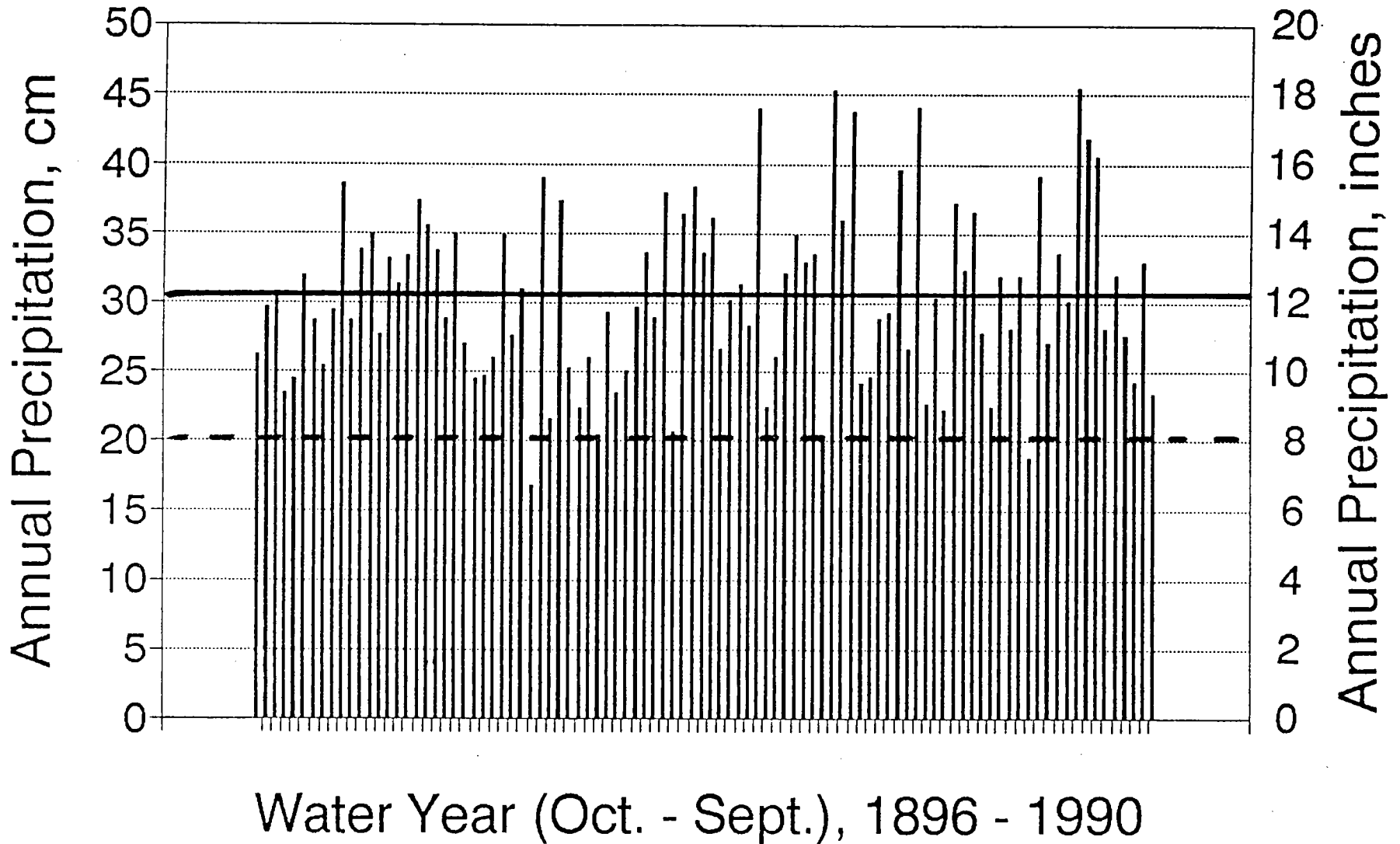
Figure 4.

Mean Monthly Precipitation 1896 - 1990 ▨
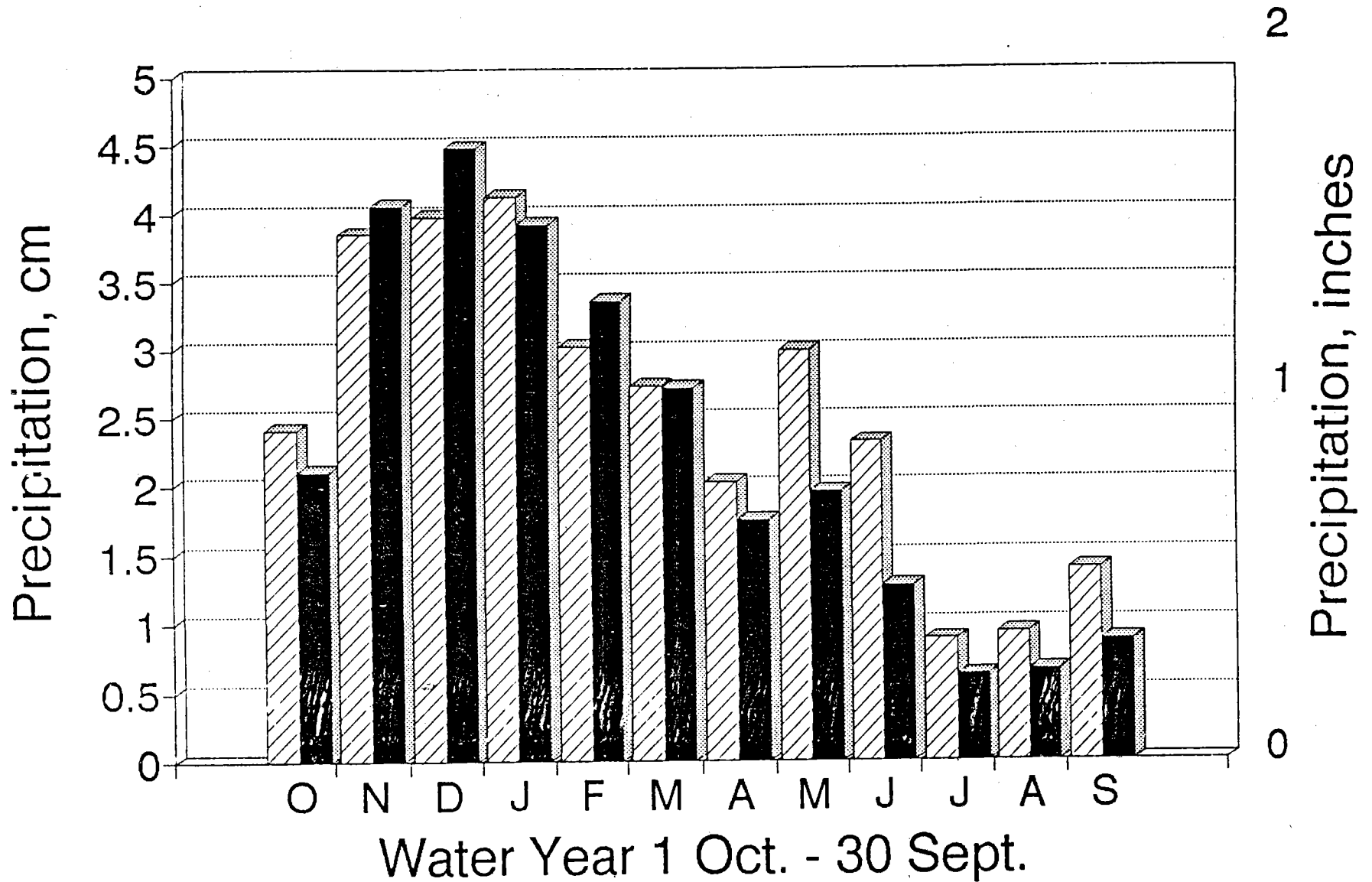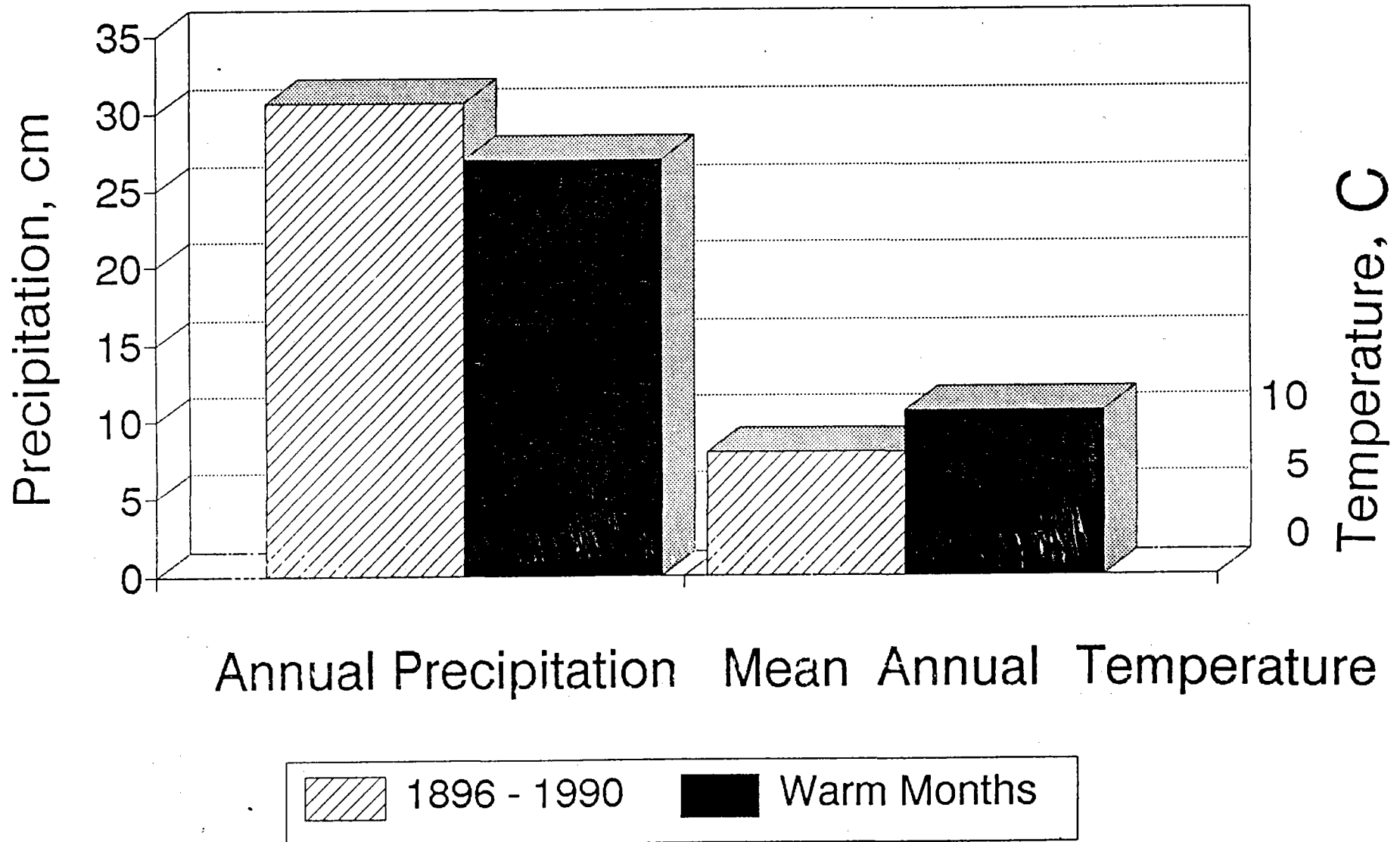# Warm Months Precipitation 1896 - 1990 ◼

Figure 5.

Precipitation and Temperature 1896-1990
Warm Month Precipitation & Temperature

GRAZING MANAGEMENT STRATEGIES TO CONTROL WEEDS

Michael L. McInnis, Larry L. Larson, and Richard F. Miller

INTRODUCTION

Large herbivores influence their environments in many ways. Selective grazing alters the vigor and competitive abilities of plant species and can change vegetative composition and structure. Trampling alters soil characteristics. Dunging and urination influences nutrient cycling. Animals can enhance distribution of plants by carrying seeds in their feces.

Each of these "primary" animal impacts can result in deterioration of plant communities and may have detrimental impacts on vegetation diversity and sustained productivity of rangelands. However, these same primary animal impacts can be exploited by managers to facilitate desirable and positive ecosystem processes leading to ecologically stable and diverse communities. For example, selective grazing by livestock has been used to control poisonous plants (Sharrow and Mosher 1982), improve the quality of winter forage for elk (Anderson and Scherzinger 1975), increase available browse for wintering deer and elk (Urness 1990), and promote establishment of conifer plantations (Krueger 1985, Doescher et al. 1987).

Researchers at Oregon State University have embarked on a series of studies broadly defined as "facilitative grazing management" in which primary animal impacts are used as tools to promote rangeland improvement. This paper describes preliminary results of a study in which grazing was examined as a method to help control whitetop (Cardaria draba (L.) Desv.).

THE PROBLEM

Whitetop is a creeping perennial introduced from Eurasia during the 1800's. A single plant can produce as many as 4,800 seeds, of which over 80 percent are viable (Selleck 1965). One plant growing in the absence of competition can spread over an area of 10 feet in diameter and produce 455 shoots the first year of establishment (Mulligan and Findlay 1974). Whitetop currently infests thousands of acres in eastern Oregon and is capable of replacing desirable forage species (Larson et al. 1990).

Conventional control of whitetop consists of applying 2 lb/acre of 2,4-D at early bloom. However, the effectiveness of this treatment is variable because herbicide often does not penetrate the dense canopy. Furthermore, the phenology of individual stems may not be uniform at any given calendar date, so when some stems have reached the early bloom stage, others have achieved a growth stage less affected by herbicide.

Applying herbicide to plants on any given day may affect stems that have reached early bloom, but may not be as effective on others.

The objective of our study was to manipulate height and phenology of whitetop regrowth with livestock to make it more susceptible to subsequent application of herbicide. Whitetop is not a highly palatable species, but observations suggest sheep will consume it early in the year. In this study, we wanted to learn what impacts grazing would have on height, phenology, and reproductive effort of whitetop. Therefore, we simulated grazing using a gas-powered string clipper to defoliate plants at ground level (100 percent utilization) during three phenological stages: bolting (April 29), early flowering (May 14), and full flowering (May 26). The study was conducted on a whitetop-infested field near Keating, Oregon, and study plots were 10 X 40 ft in size. We allowed regrowth to occur following defoliation, and recorded the following measurements of whitetop plants at the end of the growing season (August): (1) above-ground biomass; (2) maximum height; (3) number of vegetative and reproductive stems; (4) number of seeds produced; and (5) percent germination of seeds.

RESEARCH RESULTS

Plants defoliated early in the year will regrow if soil moisture is sufficient. Regrowth of clipped whitetop plants was not as tall, produced less above-ground biomass, fewer reproductive and vegetative stems, fewer seeds, and seeds lower in viability than untreated plants. Phenology of regrowth was more uniform at any given date than that of the control. Plants clipped during later phenologic stages were less tall and produced fewer seeds with lower seed viability than plants defoliated earlier in the season.

ABOVE-GROUND BIOMASS: Untreated plots (control) produced 2,865 lbs/acre of whitetop (dry matter), and 695 lbs/acre of associated vegetation (mostly annual species). Average biomass on defoliated plots was 385 lbs/acre of whitetop, and 1,173 lbs/acre of associated vegetation. There were no significant differences in biomass production of whitetop or associated vegetation resulting from timing of defoliation.

MAXIMUM HEIGHT: Whitetop plants growing in the control plots averaged about 17 inches in height. Height of plants clipped during the bolting and early bloom stage averaged about 7 inches. Height of whitetop plants clipped at full bloom was about 3 inches.

NUMBER OF STEMS: Since whitetop sprouts from underground shoots, we expected a large increase in the production of shoots from defoliated plants. However, there was no significant difference in total stem density among treatments, which averaged about 429 stems per square yard. The later the date of defoliation, the fewer reproductive stems were produced. Observed numbers of stems with seedheads (stems per square

yard) were: control (426); defoliation at bolting (7); defoliation during early flowering (1); and defoliation during full flowering (0).

SEED PRODUCTION: Seed production on control plots averaged 491 seeds per stem and more than 200,000 seeds per square yard. Regrowth of plants clipped while bolting averaged 137 seeds per stem and about 1,000 seeds per square yard. Seed production of regrowth from plants defoliated during early flowering was 112 seeds per stem and about 112 seeds per square yard. We found no seeds produced from regrowth of plants clipped at full flowering.

SEED GERMINATION: Fifty whitetop seeds collected from each treatment plot were germinated in a growth chamber at constant temperature and moisture. After 20 days, total percent germination for each treatment was: control (83 percent); defoliation at bolting (63 percent); and defoliation at early flowering (23 percent). No seeds were produced from regrowth of plants clipped during full flowering.

APPLICATION OF RESULTS

While defoliation alone is not expected to be an effective long-term control of whitetop, we believe properly-timed grazing or mowing can be used in combination with other methods to help control this weed. In our study, regrowth of defoliated plants was not as tall and more uniform phenologically than nondefoliated plants and should be more susceptible to subsequent herbicide applications. Properly timed defoliation can stress plants physiologically, and render them less vigorous. Therefore, regrowth of defoliated plants should be less resistant to herbicides. Pre-conditioning weeds by defoliation may require lower rates of herbicides to accomplish effective control. This would be a desirable environmental goal and should lower the cost of herbicide applications. Regrowth of defoliated whitetop plants produced fewer seeds than nondefoliated plants. Although this weed spreads from below-ground shoots of established plants, it is distributed to new areas by seeds. Any reduction in this potential would be beneficial.

The concept of facilitative grazing management as explained above must include concern for the profitability of utilizing animals to accomplish environmental goals. Studies should focus not only on environmental impacts of defoliation, but also on nutritive content and anti-quality components of target plant species as sources of animal feed. Further, palatability trials are needed to determine the best species of animal and timing of use to accomplish the desired environmental objective. The future of livestock production on rangelands not only will be the continued conversion of plant material to useful products for humans, but will include the thoughtful application of primary animal impacts to help solve ecological problems.

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SEASON EFFECTS ON CATTLE DIET QUALITY

Raymond F. Angell, Martin Vavra and David Ganskopp

INTRODUCTION

Cattle grazing native rangelands in eastern Oregon are limited by nutritional inadequacies during much of the year. The length of time when forage quality is adequate for livestock is limited in part because annual precipitation is low, and summer drought is typical. Livestock producers, and others concerned with maintaining adequate livestock performance on native rangeland need to know what seasonal variation in diet quality to expect. Such knowledge will permit them to devise management plans which minimize nutritional deficiencies, and enhance animal performance with proper supplementation. Previous work at this location (Raleigh and Wallace, 1964) has demonstrated that supplementation of yearling cattle during summer can provide increased profits. Further information is needed on fall and winter diet quality because of increasing interest in dormant season grazing.

This research was initiated in March 1986, and continued through February 1989. Objectives were to develop a nutritional profile for cattle, and to determine expected extremes of diet quality from the peak in spring to the minimum in fall or winter. Diet samples were collected from esophageally fistulated steers every other week for the three years of the study. At each collection period, three to five steers were released to graze for 30 minutes in pastures occupied by the main cow herd. Samples of ingested forage were collected in screen-bottomed bags. Samples were stirred, subsampled, and placed in plastic bags. Later samples were dried, ground, and analyzed for percentages of crude protein, cell walls, and organic matter digestibility. Precipitation was measured at the weather station located at headquarters.

RESULTS

Monthly precipitation was highly variable during the study, which is typical for this region (Figure 1). Winter and spring precipitation determines the amount of forage growth expected during the growing season, and also affects the length of the growing season. In each of the three years, winter and spring precipitation was adequate to provide good spring growth. However, summer and fall precipitation was highly variable among years, with no measurable rain in September 1987, July 1988, and October 1988. As will be seen later, August and September precipitation has significant impact on forage quality in fall.
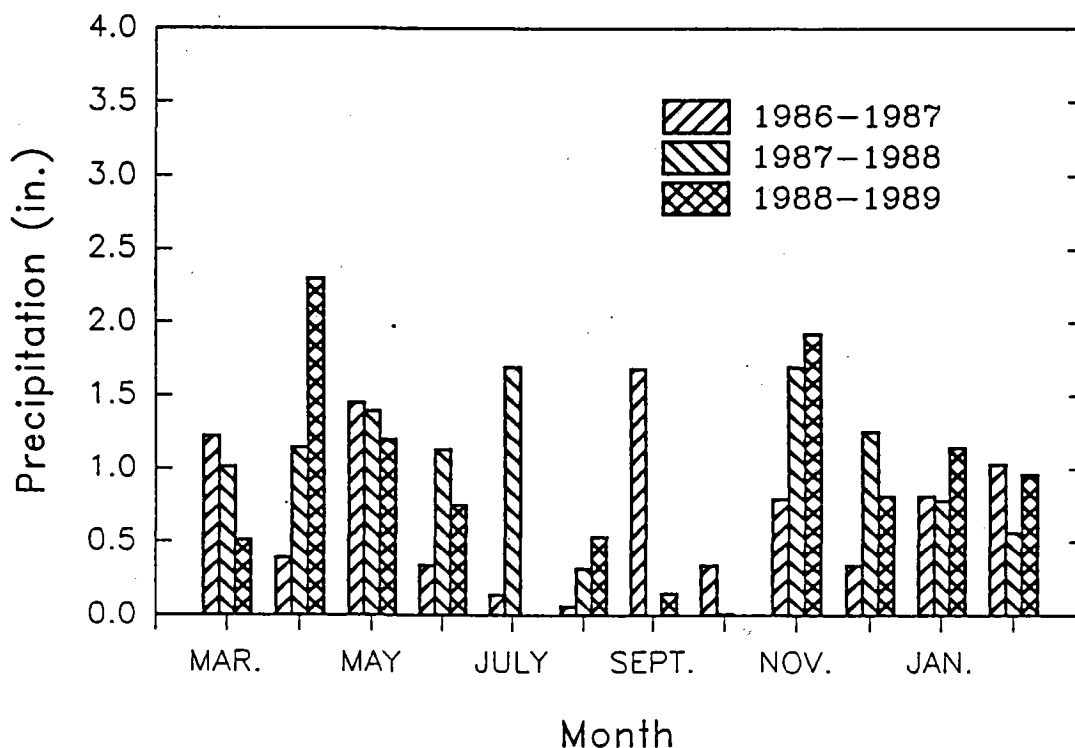
Figure 1. Precipitation received during the three year study at the Squaw Butte
Experimental Range.

Diet composition of samples was analyzed for the first year of the study. Cattle
diets were dominated by grasses, but forbs became important when available in spring
and summer (Table 1). Changes in diet composition demonstrate the ability of livestock
to dynamically shift their diets in response to changing forage conditions. Cattle did
consume small amounts of sagebrush during winter. Cattle were located on lower
elevation pastures dominated by Wyoming big sagebrush (*Artemisia tridentata* ssp.
wyomingensis during winter. This subspecies is generally considered to be of low
palatability, so the low level of consumption of sagebrush is not surprising. Cattle were
observed consuming dead sagebrush stems, mainly during high stress periods when snow
cover restricted availability of dormant grasses. Seasonally, cattle shifted from Sandberg
bluegrass in early spring, to generally equal mixtures of bluegrass, bluebunch wheatgrass,
squirreltail, and Thurber needlegrass in May. During summer, Idaho fescue was a
major component of cattle diets. At that time cattle were on higher elevation pastures
with access to north facing slopes. In fall, cattle were moved to lower pastures
dominated by bluebunch wheatgrass. Initially they selected mainly bluebunch
wheatgrass but later shifted to Thurber needlegrass in November and December.

Table 1.   Composition of diet samples from fistulated steers grazing sagebrush rangeland during 1986-1987.

| | Month | | | | | | | | | | | |
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Grasses	96	93	98	98	55	73	50	90	78	99	98	97
Forbs	2	4	1	2	45	26	50	10	22	1	2	3
Browse	2	3	1	0	0	1	0	0	0	0	0	0

In March, crude protein content in the diet was highly variable among years because of the year effect on plant growth initiation (Figure 2). In 1986, growth began in late February, and cattle diets in March that year were very high in protein. This high level of protein would indicate that although old growth was available, cattle were actively selecting early growth of Sandberg bluegrass. Growth was delayed in 1987 and 1988, resulting in lower nitrogen concentration in cattle diets during March.
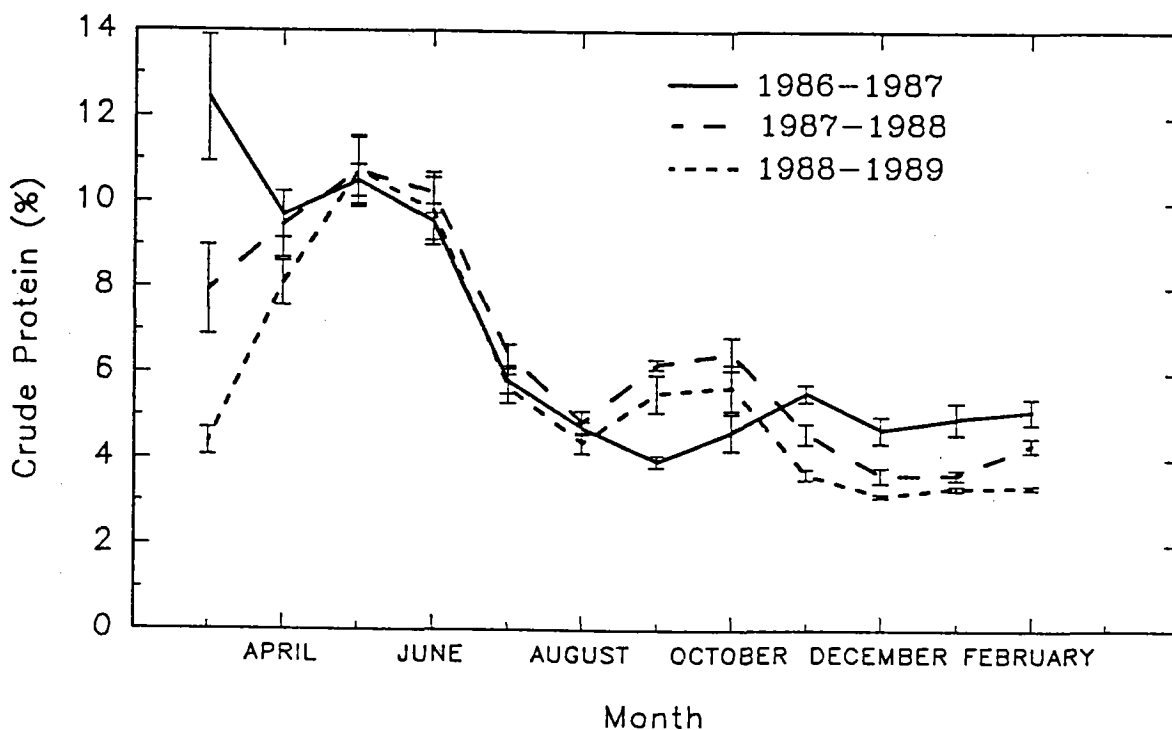

Figure 2. Crude protein content of diet samples obtained from steers grazing sagebrush rangeland. Vertical bars represent 1 standard error of the mean at each date.

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In all three years, seasonal declines in protein concentration from May to August were very consistent. This pattern reflects the normal decline associated with increasing plant maturity. From these data, it appears that crude protein in cattle diets will generally peak at about 10 to 15 percent in May, and decline to about 6 percent in July. Over the three year study, the highest level of protein observed in May was 15 percent. In the fall, crude protein concentration was less consistent. It is interesting to note the differences among years in September. These curves show how late summer precipitation can effect changes in protein concentration by stimulating new forage growth. For instance, protein concentration was lowest in 1986, even though September rainfall that year was the greatest of the three years. Rain in August 1986 was low, and most of the September 1986 rain occurred at the end of the month, so increases in forage quality were not noted until later, in October and November. Ranges which are grazed in early spring, and then rested the remainder of the growing season would be able to provide good quality forage for late fall grazing because they would contain a mixture of old and new growth.

Cell wall content and digestibility of diet samples was primarily affected by seasonal changes in plant maturity (Figure 3). The typical inverse relationship between cell wall content and digestibility is readily apparent. Over the three years, forage digestibility generally peaked in April at about 65 percent, and then steadily declined to about 57 percent in August. However the data do show that forage digestibility tended to increase slightly in fall if precipitation was adequate to stimulate growth. During this study, forage quality was consistently lowest in mid winter. Two probable reasons for the declines noted in January and February were that cattle had consumed the higher quality forage in November and December, and that weathering had decreased the quality of the remaining dormant forage. Forage digestibility was generally increasing by March, in response to early forage growth.

SUMMARY

Knowledge of the effects of season on forage quality allow a rancher to modify management practices to optimize livestock gain. Pasture rotation, early weaning, supplementation and even time of calving can be modified to make the most of available nutrients and improve the return to stockmen.
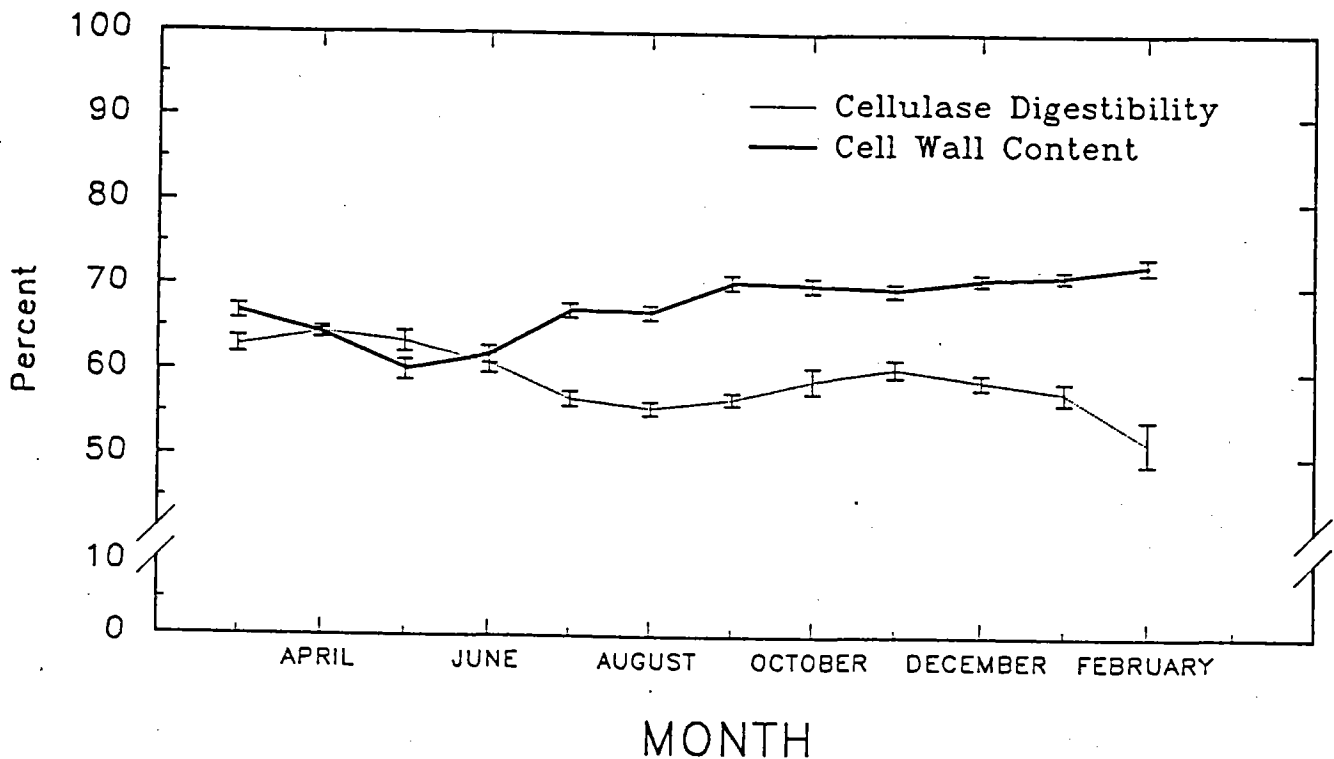
Figure 3. Average cell wall content and organic matter digestibility of diet samples from steers grazing sagebrush rangeland. Vertical bars represent 1 standard error of the mean at each date.

Nutritional status of cattle grazing sagebrush rangeland will decrease quickly in late spring, and by mid summer crude protein content of the diet will generally be below 6 percent. Growing cattle require greater nitrogen concentration than this level in their diet, and other research at this station has demonstrated the benefits of supplemental protein during summer. Summer declines in forage quality appear to be consistent. Fall precipitation, however, can significantly improve diet quality. In this study, we reserved forage produced in spring for use in fall. The results show that this forage, coupled with fall growth, can significantly enhance diet quality in late summer and fall. A program of early weaning, coupled with pasture management designed to improve forage quality in fall could help to maintain condition of cattle going into the winter.

Diet quality in winter was consistently low during this study, with crude protein in winter usually below 5 percent, and digestibility at about 57 percent. January and February are critical months because forage quality is low while environmental stress is high. It is apparent from these results that supplementation will be required if a successful system of winter grazing is to be developed. Grazing in fall and winter is receiving increased interest because it can reduce requirements for harvested hay. Additionally it can provide an alternative to grazing during the growing season, allowing plants to rest and gain vigor. Based on the interest in winter grazing and the results of

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this preliminary study, we have initiated another study designed to investigate the response of cattle to protein supplementation during the winter. Results from that study are presented elsewhere in this report.

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ALFALFA SUPPLEMENTATION OF BEEF CATTLE GRAZING WINTER SAGEBRUSH-STEPPE RANGE FORAGE

Tim DelCurto, Raymond Angell, Roxane Barton, Jeff Rose and Shane Bennett

INTRODUCTION

Several studies have been conducted or are planned in the near future to evaluate the efficacy of wintering beef cattle on rangelands in the Northern Great Basin. This research directive is designed to evaluate alternatives to traditional winter management of beef cattle, as well as, alternatives to managing private and public sagebrush-steppe rangelands. The overall objectives are: 1) to determine if grazing cattle during the winter months represents a viable alternative to traditional hay feeding management systems; 2) to evaluate winter grazing as an alternative use of public rangelands within multiple use goals and 3) to define supplementation strategies optimizing cattle performance with efficient use of dormant range forage resources. For all supplementation studies, minimizing supplement inputs (costs and labor) and maximizing the use of the range forage with an acceptable level of beef cattle performance will be the research goals.

EXPERIMENTAL DESIGN

Our research is currently in the second year of a two-year study evaluating graded levels of supplemental alfalfa on beef cattle performance and utilization of the dormant range forage resource. In year 1 (winter of 1989-90), 48 mature gestating Hereford x Angus cows were stratified by age and body condition and allotted randomly within stratification to one of the following treatments: 1) control, no supplement; 2) 1.5 kg supplemental alfalfa pellets (3.31 lbs); 3) 3.0 kg supplemental alfalfa pellets (6.61 lbs) and 4) 4.5 kg supplemental alfalfa pellets (9.92 lbs). In year two (winter of 1990-91), 72 mature gestating Hereford x Angus cows were allotted in the same manner and to the same treatments as year 1. For both years, cows were gathered daily at 0900 to 1200 hours and individually fed their corresponding treatment supplements. Chemical composition of the alfalfa pellet supplement is listed in Table 1. Individual feeding of the cows began in early November and continued through February 21 (year 1) and January 15 (year 2). The second years study was shortened due to a lack of available forage and concern over the health of the unsupplemented control cows. A free-choice trace mineralized salt with vitamin A was provided during both years.

Cow body weights were monitored on a 28-day basis throughout the winter grazing period. Likewise, cow body condition was monitored on a 28-day basis using a one to nine scale (1 = extremely thin, 9 = extremely fat; Neumann and Lusby, 1986). Additional cow weight, body condition and calf weights were (year 1) and will be (year 2) obtained at calving, just prior to breeding and mid-summer.

In addition to cow performance measures, esophageal steers were used to monitor diet quality throughout the winter grazing periods. Four consecutive days of collections were made at the beginning of December, January (for year 1 and 2) and February (year 1, only). Forage intake is being estimated by dosing chromic oxide sustained release boluses to determine fecal output and an internal marker estimate of digestibility. Intake estimates correspond to the same time periods as the esophageal collections during both years. In addition, vibracorders and digital pedometers were used to estimate the influence of graded levels of alfalfa on time spent grazing, pattern of grazing and distance traveled. Results corresponding to forage intake and beef cattle behavior have not been analyzed and, as a result, will be presented at a later date.

Table 1. Chemical composition of supplement and diet selected by beef steers during the winter supplementation period (Year 1).

Item[a]	Alfalfa Supplement	Quality of diet selected			
		December	January	February	SE[b]
Organic matter, %	91.5	73.9	77.7	77.5	1.7
Acid detergent insoluble nitrogen, %	18.9	48.9	50.5	55.3	2.7
		-----% of forage organic matter-----			
Crude protein, %	19.0	6.82	6.28	5.43	.24
Neutral detergent fiber, %	41.3	81.5	79.1	79.0	.84
Acid detergent fiber, %	32.0	72.2	67.1	70.5	.91
Acid detergent lignin, %	6.11	7.81	7.29	9.09	.16

[a]Acid detergent insoluble nitrogen is expressed as percent of the total nitrogen.

[b]SE = standard error of the means (n = 6).

RESULTS

Year 1. Protein concentration and potentially digestible protein declined throughout the winter grazing period (Table 1). Crude protein decreased 20 percent from early December to early February. In addition, acid detergent insoluble nitrogen (ADIN; an estimate of nondigestible nitrogen) tended to increase throughout the winter grazing period and represented as much as 50 percent of the total nitrogen in the selected forage. In contrast, fibrous components of the diet remained relatively stable during the winter grazing

period with the exception of an elevated lignin component during the February sampling period.

Cow weight changes responded in a curvilinear fashion with nonsupplemented cows losing over 60 lbs of body weight during the 112-day supplementation period (Figure 1). In contrast, cows receiving supplemental alfalfa pellets gained weight during the supplementation period with increasing gain with increasing quantities of supplemental alfalfa pellets. The magnitude of gain, however, decreased with increased quantities of supplement above 1.5 kg (3.31 lbs). Cow body condition changes also responded in a curvilinear fashion. Nonsupplemented control cows lost over 1.2 units of body condition, whereas, supplemented cows maintained body condition throughout the winter grazing period (Figure 2).
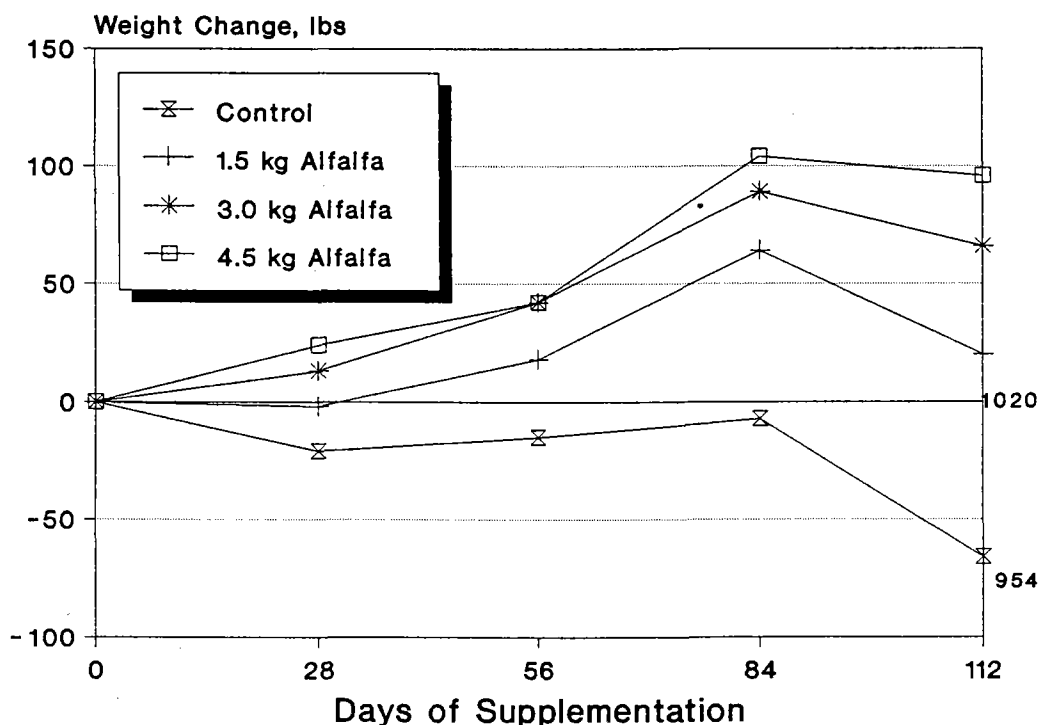

Figure 1. Influence of graded levels of supplemental alfalfa pellets on beef cattle body weight changes during the winter grazing period (Year 1).

The nutritional status during the supplementation period did impact subsequent cow and calf performance. From the end of the supplementation period (day 112, February 21) to calving (avg calving date = April 8), previously unsupplemented cows displayed a compensatory gain in body weight and maintenance of body condition. Cows who had previously received supplemental protein continued to lose weight and body condition. At calving, calf birth weights tended to increase with dams who received increasing levels of supplemental alfalfa pellets (82, 87, 89 and 91 lbs for control, 1.5, 3.0 and 4.5 kg alfalfa

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supplement treatments, respectively). In addition, calf average daily gain (first 68 days postpartum) tended to increase linearly with dams who received increasing levels of alfalfa pellets (1.97, 2.07, 2.20 and 2.23 lbs/head/day, respectively).
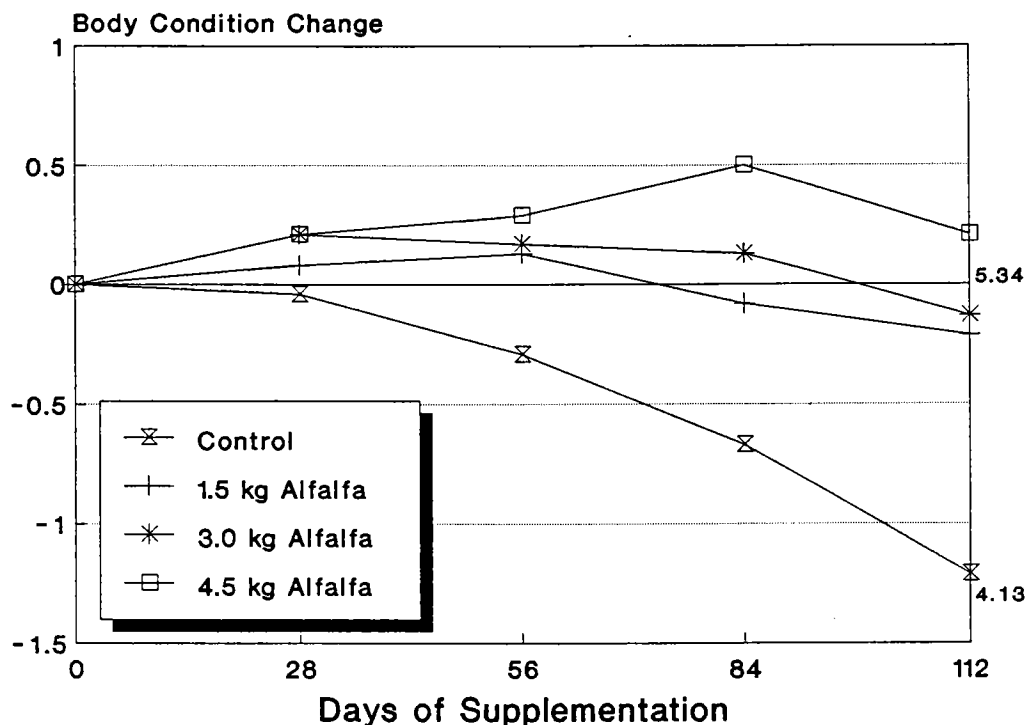

Body Condition Change

Legend:
- Control
- 1.5 kg Alfalfa
- 3.0 kg Alfalfa
- 4.5 kg Alfalfa

5.34

4.13

Days of Supplementation

Figure 2. Influence of Graded Levels of Supplemental Alfalfa Pellets on Beef Cattle Body Weight Changes During the Winter Grazing Period (year 1).

Year 2. Similar to year 1, cow body weight changes responded in a curvilinear fashion, however, the magnitude of weight loss was greater than year 1 (Figure 3). Nonsupplemented cows lost 138 lbs, whereas supplemented cows were more able to maintain body weight during the 70-day supplementation period (-34, 12 and 26 lbs gain for 1.5, 3.0 and 5.0 kg supplemental alfalfa treatments, respectively). Body condition changes also responded in a curvilinear fashion with control cows losing over 2 units of body condition during the 70-day supplementation period (Figure 4). In addition, cows receiving 1.5 kg of alfalfa supplement lost .8 units of body condition, whereas, cows receiving 3.0 and 4.5 kg of supplemental alfalfa were able to maintain body condition within .2 units of their initial body condition.

Data pertaining to subsequent beef cow performance and calf performance are currently being collected and will be presented at a latter date.

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Difference between beef cattle performance in year 1 versus year 2 may be due to a number of factors. In year 1, a greater amount of forage was available and substantial fall regrowth occurred prior to the winter grazing period. Therefore, the forage may have been more readily available and of higher nutritional quality than year 2. In addition, the winter grazing period of year 1 was unseasonably mild with little or no measurable precipitation. In contrast, year 2 was marked by extreme cold temperatures particularly during the December grazing period (day 28 to 56).
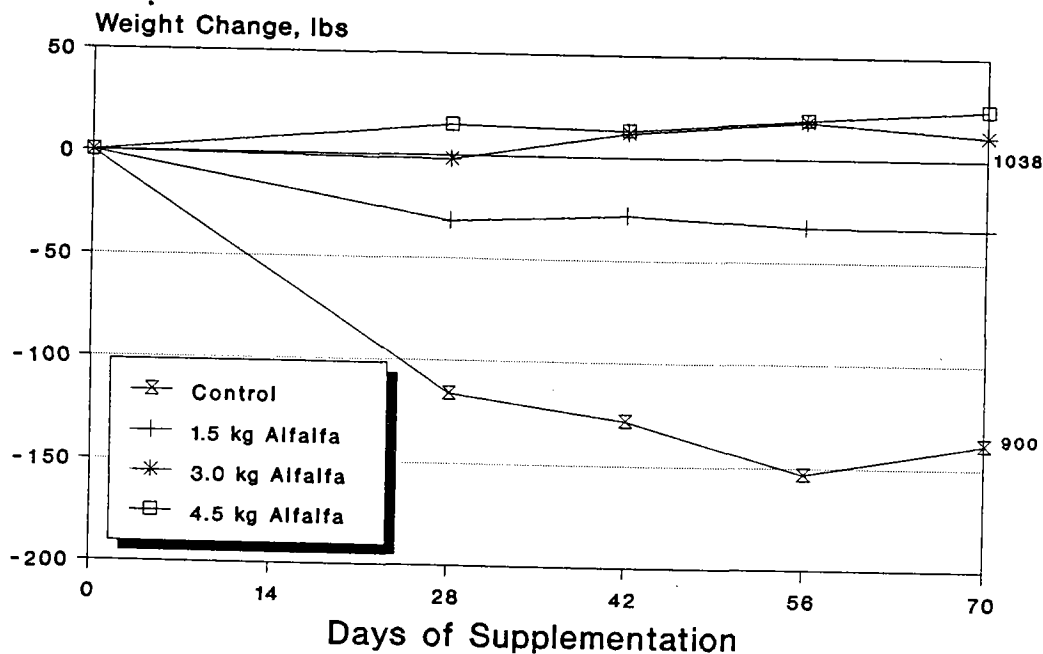

Figure 3. Influence of Graded Levels of Supplemental Alfalfa Pellets on Beef Cattle Body Weight Changes During the Winter Grazing Period (year 2).

DISCUSSION

Responses to supplemental protein are usually observed when the crude protein content of the forage are less than 6 to 8 percent (Campling, 1970; Kartchner, 1981). In addition, the digestibility of the forage and, specifically, availability of the crude protein modify this estimate (Allden, 1981). Results from this study suggest that beef cattle grazing winter sagebrush-steppe range forage are deficient in protein. Crude protein concentrations of the selected diets were less than 7 percent and declined throughout the winter grazing period. In addition, approximately 50 percent of the crude protein was found in the nondigestible ADIN fraction.
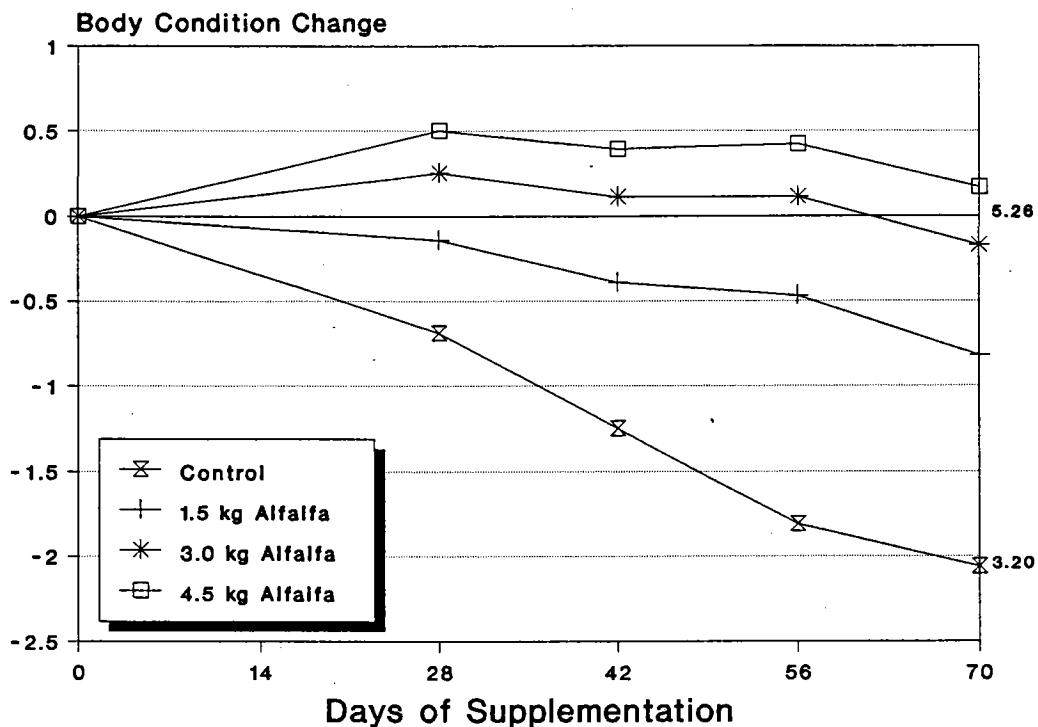
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Body Condition Change

Figure 4. Influence of Graded Levels of Supplemental Alfalfa Pellets on Beef Cattle Body Weight Changes During the Winter Grazing Period (year 2).

Beef cow body weight and condition changes displayed a dramatic response to alfalfa supplementation during both years 1 and 2. The largest improvements in body weight and condition were noted for the 1.5 kg (3.31 lbs) supplementation level relative to nonsupplemented control cows. Cows supplemented 3.0 or 4.5 kg of alfalfa displayed smaller benefits relative to body weight and condition changes during the winter feeding period. This curvilinear nature of the cow performance data suggest that forage intake and digestion is optimized at the lower levels of alfalfa supplementation. High levels of alfalfa supplementation may have actually reduced the quantity of forage consumed. Data corresponding to this hypothesis will be available at a latter date.

Numerous researchers have observed increases in beef cattle performance with the addition of supplemental protein to high fiber, low-quality roughage diets. With mature cows, the benefits are often observed as decreased loss in body weight and condition during the winter feeding or grazing period (Clanton and Zimmerman, 1970; Lusby and Wetteman, 1988; DelCurto et al., 1990a and b). Adequate maintenance of cow body

weight and condition, in turn, tends to promote greater reproductive efficiency and calf weaning weights (Clanton, 1982; Wallace, 1987).

Due to the limited number of cows used in these studies, data pertaining the reproductive efficiency cannot be accurately measured. However, with cattle in moderate body condition prior to the winter grazing period (i.e. condition score 4 to 6), losses greater than one body condition unit during the winter grazing period can have detrimental effects on subsequent reproductive efficiency. Specifically, cows with body conditions less than 4 will often display delayed onset of estrus and lower milk production relative to cows with body conditions greater than 4 units. Therefore, the nonsupplemented cows should be expected to display reduced reproductive efficiency, in addition to, depressed calf ADG.

In summary, this research suggest that supplementing alfalfa pellets is important in maintaining beef cattle weight and body condition during the winter grazing period. Supplementing 1.5 kg (3.31 lbs) of alfalfa pellets appears to be the most effective in optimizing range forage utilization with an acceptable level of beef cattle performance during the mid trimester and early portion of the third trimester of gestation. Supplementation above 1.5 kg may be warranted as cows approach calving due to the declining availability of forage protein and the increased protein demands of the developing fetus.

FUTURE RESEARCH

Research tentatively planned for the winter of 1991-92 will evaluate both long stem alfalfa hay verses sun-cured alfalfa pellets and feeding daily verses alternate days. The treatment structure will be a 2x2 factorial contrasting the following treatments:

1) Long stem alfalfa hay fed on a daily basis
2) Long stem alfalfa hay fed on a alternate day basis
3) Sun-cured alfalfa pellets fed on a daily basis
4) Sun-cured alfalfa pellets fed on a alternate day basis

The alfalfa supplements will be derived from the same cutting of alfalfa and, on a alternate windrow basis, harvested as sun-cured pellets or long stem alfalfa hay. All cows will be fed the equivalent of 5 pounds of supplement per day. Cows will be gathered daily and individually fed their corresponding treatment supplements. Measures of interest will be the same as those described in the previous studies.

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HOW FINICKY ARE CATTLE ABOUT WOLF PLANTS?

DAVID GANSKOPP

"Wolf plants" in our sagebrush bunchgrass environment are typically thought of as individual bunches of any grass species that have dense accumulations of last year's reproductive stems still standing in the crown. Livestock typically avoid wolf plants while foraging, probably to avoid the extra effort required for sorting the palatable and unpalatable portions, and unless some event occurs to remove the cured material these plants may go ungrazed for years.

Many things can lead to the evolution of wolf plants. These include: 1) selective grazing by cattle in mixed species pastures; 2) typically under stocking a pasture to such a degree animals do not get around to all plants in the pasture; 3) above normal precipitation years following drought when plants produce exceptional growth and high numbers of reproductive stems; 4) or animal avoidance of plants receiving recent depositions of fecal material. What ever the case, substantial amounts of available forage can go unused if wolf plants exist in high numbers. Additionally, remaining uncontaminated plants may be forced to bear more and more of the grazing load as they are repeatedly defoliated by livestock or wildlife over the season. The result may be a stand of overgrazed and ungrazed plants within the same area or pasture.

This problem is especially prevalent with grasses producing large numbers of persistent seed stalks. Some representative species in this area include: crested wheatgrass (Agropyron desertorum), bluebunch wheatgrass (Agropyron spicatum), and basin wild rye (Elymus cinereus). We have speculated that the presence of small amounts of cured material are sufficient to begin the evolution of a wolf plant, but have never investigated this possibility in a controlled environment. The objective of this research was to determine just how sensitive cattle are to the previous season's reproductive stems in standing forage and whether they were equally sensitive at different stages of plant growth.

MATERIALS AND METHODS

This project was conducted on the Squaw Butte Experiment Station in crested wheatgrass seedings established approximately 18 years ago. The area was heavily grazed the previous fall to insure removal of nearly all standing forage and subdivided into 9 separate pastures with the aid of electric fence. Within each pasture 20 plants were assigned to each of seven treatments. Treatments consisted of artificially stocking plants with either 0, 1, 2, 3, 6, 9, or 12 seed stalks that had been gathered the previous fall. We punched holes in the soil within the crown of each plant and simply dropped the seed stalks into the holes, so the stems were not firmly attached to the plants in any way.

Three stages of plant growth were sampled with three pastures being used at each stage. These included: vegetative - when plants supported only leafy growth; flowering - when flowering stems were fully elevated and all current year's leaves and stems were still green; and dormant - when all current year's leaves and stems had turned brown. Cattle were then placed in each pasture and allowed to forage until 75 to 80 percent of all plants in the pastures had been grazed (4 to 5 days). We then counted the number of plants in each treatment that been grazed and estimated the amount of material that had been utilized or removed from each plant.

RESULTS AND DISCUSSION

Cattle appeared to be more sensitive than anticipated to cured stems when forage was green but more or less oblivious to their presence after leaves and stems had turned brown. Responses to treatments were identical during the vegetative and flowering stages of growth, so data from these periods are pooled and referenced as "green forage" for the balance of this discussion.
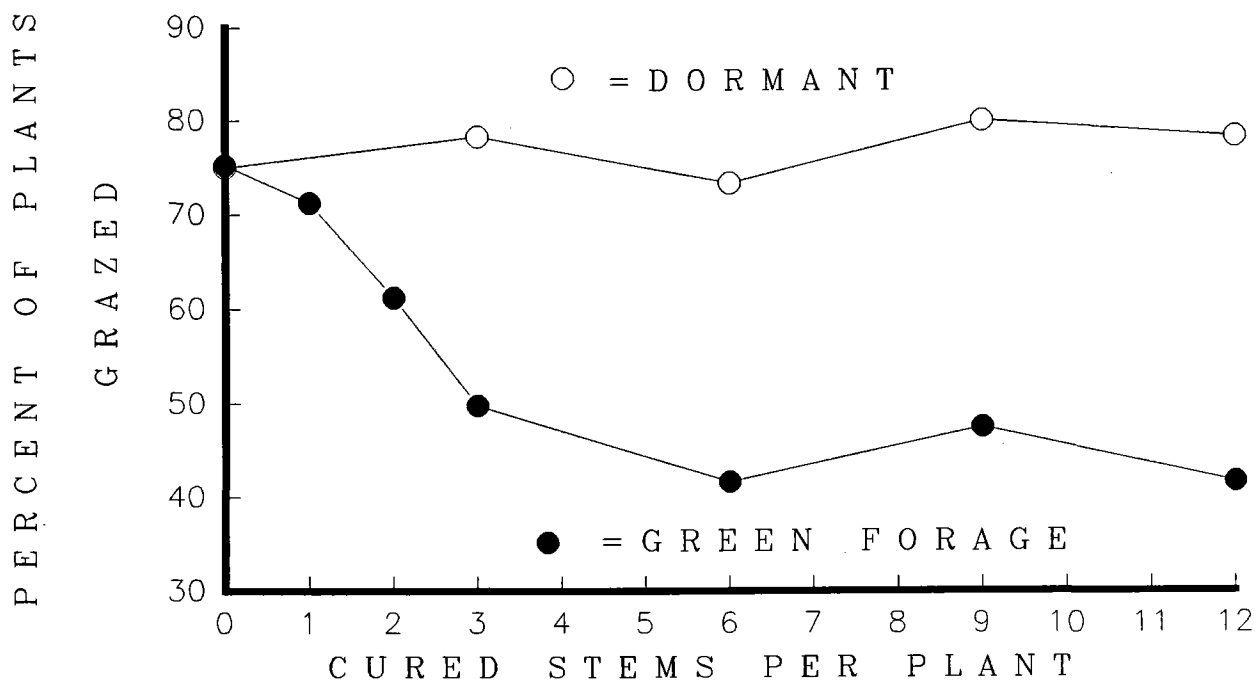

Figure 1. Number of cured seed stalks per plant and percent of plants grazed by cattle during green and dormant stages of growth in crested wheatgrass at the Squaw Butte Experiment Station in 1989 and 1990.

During the green forage periods approximately 75 percent of plants with no cured stems were grazed, while plants with 1, 2, or 3 stems were progressively less acceptable (Figure 1). The 3 stem treatment appeared to approach the level of tolerance by cattle as no differences occurred among the 3, 6, 9, or 12 stem treatments. Only 45 percent of the plants in these treatments received some level of grazing, indicating there is roughly a 30 percent less chance a plant will be grazed if it contains 3 or more dead stems.

Cattle did not appear to have a discriminating eye after all forage had turned brown, as each treatment was grazed at roughly the 75 percent level. We suspect that they responded to the visual presence of cured stems during the green forage periods as no greater effort would have been required to harvest the free standing, cured stems along with the green forage. Lack of response during dormancy also suggests that grazing animals might be more successful in cleaning up a pasture containing large numbers of wolf plants if grazing is postponed until all forage has turned brown. This would best be accomplished by high numbers of mature animals (preferably dry cows or bulls) in the pasture for a short time, as one would not wish to leave animals on poor quality forage for an extended period.

In closing we suggest that pasture and livestock managers avoid the proliferation of wolf plants by obtaining uniform levels of forage utilization. Our findings indicate the presence of 1 to 3 residual stems will lower the likelihood of a plant being grazed in the subsequent year if grazing occurs when forage is green and growing. If conditions do get out of hand and one wishes to clean up the pasture with grazing animals, success is much more likely if grazing is delayed until all forage has matured and turned brown. Other alternatives are burning or brush beating which might also aid in woody plant control. This problem might also be avoided to some degree if leafy selections or species with less persistent seed stalks are used in pasture revegetation programs.

RESPONSE OF CRESTED WHEATGRASS (Agropyron desertorum) GROWTH AND CARBON ALLOCATION TO FALL DEFOLIATION

Richard F. Miller and Jeff A. Rose

INTRODUCTION

Tiller recruitment predominately occurs in the fall for some cool-season perennial grasses. Several researchers in the sagebrush-steppe have reported the majority of tillers for crested wheatgrass and bluebunch wheatgrass present in the spring were produced the previous fall following late summer or fall precipitation. In eastern Oregon, precipitation is generally adequate to initiate tiller growth in September or October. Over a five-year period in this area, 80 to 90 percent of all crested wheatgrass tillers present in the spring were produced the previous fall. Under dry fall conditions tiller recruitment occurred in November. Fall tillers can become physiologically active, producing sugars in the winter if conditions are suitable. Crested wheatgrass leaves are capable of photosynthesis and carbohydrate production at temperatures near freezing. Early photosynthetic activity in fall-produced shoots may reduce demands for stored carbohydrates during initial spring growth. The presence of green leaves early in the growing season may also provide a competitive advantage for acquisition of soil water and nutrients.

Development of new shoot tissue in the fall provides a source of high quality forage for many wild and domestic herbivores prior to winter. Very little work, however, has focused on the defoliation of active leaf tissue in the fall. Our goal was to ascertain the effects of defoliating photosynthetically active replacement tillers in the fall. We wanted to know if fall defoliation of new replacement tillers would: (1) increase winter tiller mortality, (2) decrease root growth and carbon allocation to the roots, and (3) decreases peak standing crop during the following growing season.

DISCUSSION

The decline in tiller recruitment was the only consistent response to fall defoliation over the two-year period (Table 1). If we account for both the increase in tillers in the control plots and the decline in the fall defoliated plots, fall defoliated plants produced 25 and 21 percent fewer tillers than control plants in 1988-1989 and 1989-1990, respectively. However, the decline in tillers was not a result of an increase in winter mortality. The primary cause was the cessation of tiller development immediately following fall defoliation. Fall defoliation did not affect individual shoot weight, reproductive shoot density, or peak standing crop during the following growing season.

Table 1. Performance of crested wheatgrass under two fall defoliation treatments during the fall and spring of 1988-1989 and 1989-1990, at the Squaw Butte Experimental Range.

	Control	Defoliated
Tiller Density ($\#/ft^2$)		
1988-1989		
Fall	254	229
Spring	284	190
% Change	11.3[a]	-14.8[b]
1989-1990		
Fall	275	240
Spring	281	207
% Change	2.7[a]	-18.0[b]
Mortality (%)		
1988-1989	8.7[a]	9.4[a]
1989-1990	9.0[a]	10.0[a]
Reproductive Shoots ($\#/ft^2$)		
1989	129[a]	127[a]
1990	0	0
Grams/Tiller 1990	0.054[a]	0.060[a]
Biomass (lbs/ac)		
1989	200[a]	192[a]
1990	180[a]	175[a]

Means followed by similar lower case letters are not significantly different between treatments ($p \leq 0.05$).

During fall tiller development, carbohydrates were produced in the leaves and translocated to the roots in both years. Carbon uptake by leaves and allocation to roots in the fall was significantly greater in 1988 than in 1989 (Figure 1). Soil moisture and temperature conditions were more optimal for growth in the fall of 1988 as compared to 1989. Defoliation significantly reduced carbohydrate allocation to the roots under the wetter and warmer growing conditions in the fall of 1988. Carbohydrate allocation was not altered by defoliation in 1989.
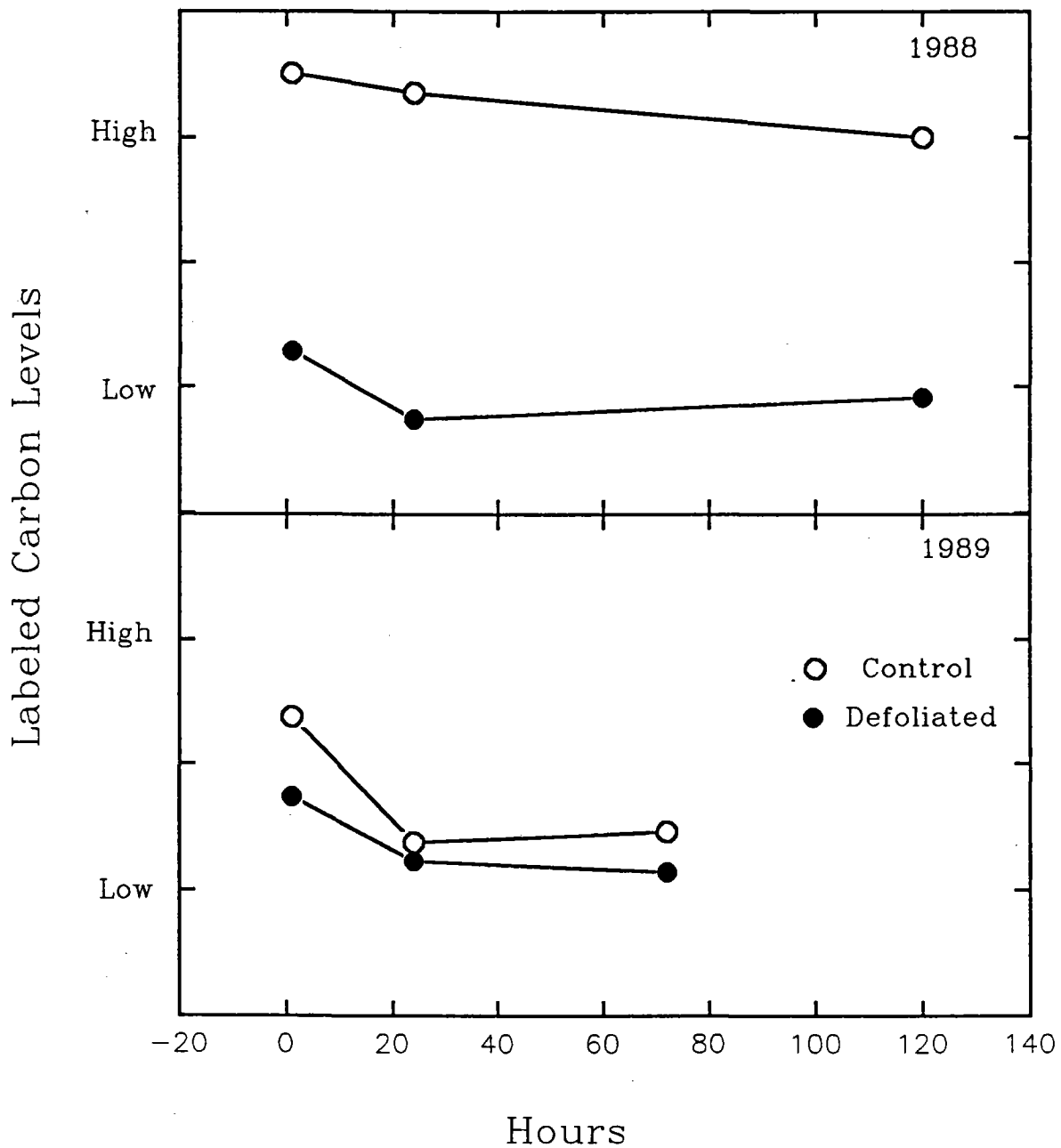
Figure 1. The relative amount of assimilated carbon translocated to the root following defoliation. Plants were labeled with C_{13}, 24 hours following defoliation. Samples were collected 1, 24, 72 and 144 hours following labeling in 1988 and 1989.

Root growth during the fall of 1989 and into the following spring was not affected by defoliation of newly recruited tillers. Continued allocation of carbon to the roots and a reduced above-ground carbon sink, due to the discontinuation of tiller development, may lessen the affect of fall defoliation on root development. However, fall defoliation did reduce carbon flow to the roots in the fall of 1988, when carbon uptake and allocation to the roots was significantly greater than the fall of 1989. Fall defoliation may influence root growth under more ideal growing conditions, reducing the ability of crested wheatgrass to compete for soil resources. However, root growth data for the wetter 1988 fall were not available.

CONCLUSIONS

Our work showed fall defoliation had little effect on subsequent above-ground biomass, root growth, winter mortality of tillers, and the density of reproductive shoots. For a bunchgrass to maintain its position in a plant community it must replace each tiller with one or more new tillers. Although defoliation of fall-initiated tillers in October 1988 decreased tiller numbers by the following spring, it did not appear to effect the tiller numbers initiated the following fall. Two consecutive years of fall defoliation did not appear to detrimentally effect crested wheatgrass.

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