Special Report 923
June 1993

Eastern Oregon Agricultural Research Center Annual Report, 1993

Agricultural Experiment Station
Oregon State University

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II. ACKNOWLEDGEMENTS:

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Future Mission and Research Direction of the Eastern Oregon Agricultural Research Center

Tony Svejcar and Martin Vavra

Historically the mission of the Eastern Oregon Agricultural Research Center (EOARC) had been to increase production and economic return of range livestock and related industries. The research was focused on livestock management and methods of increasing the productivity of rangelands. However, in recent years the demands for research have expanded well beyond that traditional role. A number of years ago our advisory/liaison committee more-or-less demanded that EOARC devote more effort to ecological issues. At the time, the committee consisted of a rancher from each county in Eastern Oregon. At the request of the original members, the committee has been expanded to include representatives from land management agencies and the environmental community (at the request of the original members). The expanded roles of EOARC was intended to help provide a scientific basis for the management and/or restoration of rangelands.

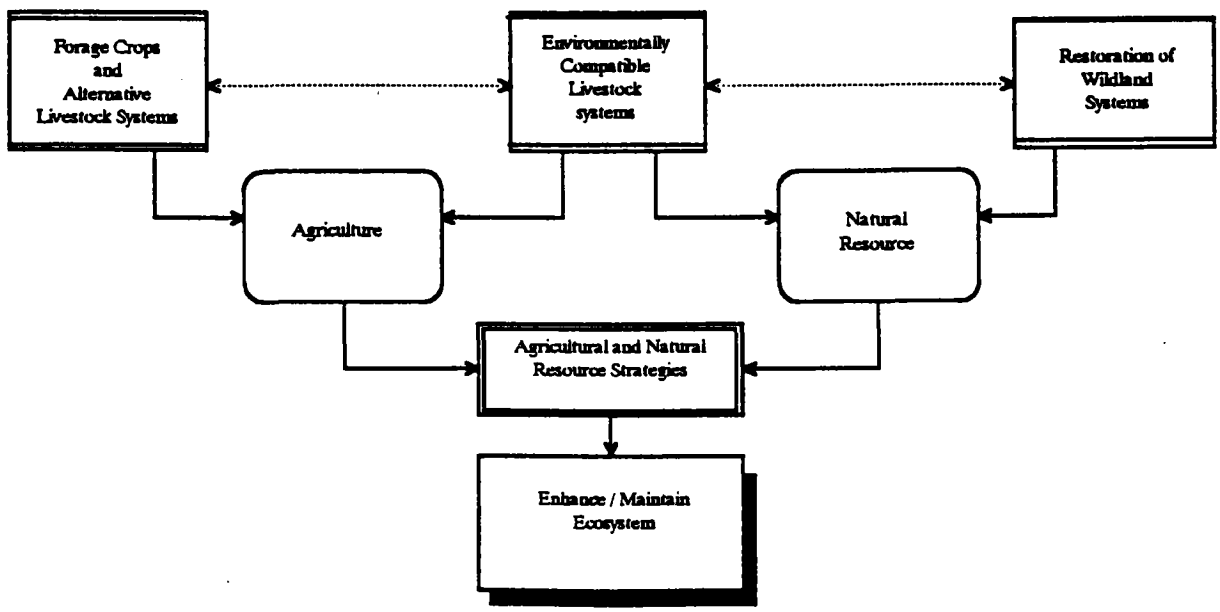
During the past year the EOARC staff rewrote the mission statement, and developed a flow chart that we hope explains the nature of our program and how the pieces fit together (Fig. 1). The natural resource component could involve the development of environmentally compatible livestock systems, or restoration of wildland systems that may or may not involve the use of cattle. We hope to evaluate the utility of using livestock to restore rangeland plant communities. However, there will be cases where restoration may involve no livestock use, either permanently or temporarily. For example, some wetland seeps provide watering points for livestock and wildlife, yet go dry if excessive trampling occurs. In such cases livestock exclusion may make good ecological and economic sense, the loss of a watering point would increase distribution problems. The best and quickest recovery management for some riparian zones may be total exclusion for a given number of years then a planned grazing reentry. Another example is the situation where juniper dominance is in the advanced stages. Such sites may have extremely low levels of forage production. Several years of nonuse or very light grazing after juniper control may be necessary to allow such sites to recover. If we can speed the rate of recovery through nonuse, this decision may be an economically sound one in the long term.

Unfortunately, research and management decisions are often made over relatively short time frames. We need to expand the time period over which we evaluate trends, vegetation responses, etc. beyond the traditional two to three years of a research project. In the past, range improvements centered around drilling seed into the ground and evaluating success or failure at the end of the first growing season. As we look for alternatives to the traditional range improvement techniques, we will need to understand how ecosystems work, and have more patience.

A basic understanding of how rangelands function will also assist us in designing grazing strategies that maintain the productivity of our rangelands and are compatible with the demands of society. On public lands this is an especially critical point. Certainly everyone must realize that public scrutiny of land management will continue to increase. Public land management agencies, as mandated by law and/or policy, must deal

with issues such as threatened and endangered species, biological diversity, and maintenance of ecosystem integrity. Lack of research into what constitutes environmentally compatible grazing will require that decisions be made without a sound scientific framework. There is plenty of research to demonstrate the effects of overgrazing, but considerably less that deals with compatible grazing. The overall emphasis is to maintain or restore ecosystem integrity for a variety of resource products and values such as: water, forage, wildlife habitat, etc.

Finally, there is still a major commitment to forage and livestock production research. Research on heifer development, disease prevention through management, alternative forages or forage harvesting methods, and efficient beef livestock production are ongoing commitments important to long-term improvement of the livestock industry. In fact, non-traditional forages and/or livestock management strategies may be an integral part of developing environmentally compatible range livestock systems. For example, if winter grazing proves to be an important strategy for maintaining productivity of certain types of rangeland, then it will be necessary to provide forage for the period when that rangeland was traditionally grazed. Integrating other non-traditional potential forages, such as grass straw, allows an operation to gain additional flexibility to explore grazing options. There is research underway to evaluate the option of grazing the flood meadows in the spring and still taking a cutting of hay. As everyone in the cow/calf business is painfully aware, cows eat 12 months out of the year. One of our major charges at EOARC is to help in designing year-round management systems that are economically and environmentally sound.



Mission: To Develop agricultural and natural resource strategies that maintain or enhance intermountain forest and shrub steppe ecosystems for the benefit of present and future generations.

Foreword and ... Statistics?

The purpose of the following report is to provide a brief description of recently completed research, ongoing research, and future research projects conducted at the Eastern Oregon Agricultural Research Center. The articles are targeted at a general audience and, in many cases, are summaries of more detailed studies. If additional information is needed pertaining to a specific article or area of interest, the readers are encourage to contact the authors directly.

The Eastern Oregon Agricultural Research Center (EOARC) includes the Northern Great Basin Experimental Range (formerly called "Squaw Butte), the Union Experiment Station and the Burns Experiment Station. Coordinated research projects are also underway in several "off station" locations which include the Steens Mountain, Bridge Creek and the Starkey Experimental Forest. Research efforts encompass the forest steppe regions of the Blue Mountains of northeastern Oregon to the sagebrush-steppe regions of the Northern Great Basin in southern Oregon. Similarly, research focus ranges from animal production and management to strict rangeland ecology for both of these ecosystems. These research efforts and locations are jointly operated and financed by the Oregon Agricultural Experiment Station, Oregon State University and the U.S. Department of Agriculture Agricultural Research Service. We sincerely hope that this publication clearly demonstrates research goals and objectives in place at the EOARC, and by doing so, increases public awareness and involvement in the future operations at the research center.

In most of the following articles the use of statistics will be evident. In science statistics are a necessary tool that allows for making intelligent inferences regarding difference or lack of differences between two subjects. In general, when making comparisons between two livestock diets or two range treatments, statistics are techniques or tools that eliminate guesswork and lend credibility to scientific writing. The following is a brief description of statistics and some of the specific statistical "tools" used in this document.

The variability among individual animals in an experiement leads to problems in interpreting the results. Animals on a treatment x may have a higher average daily gain than those on treatment y, but variability within groups of animals may indicate that the difference between x and y is not the result of the treatment alone. You can never be totally sure that the difference you observe is due to the treatment, but statistical analysis lets researchers calculate the probability that such differences are from chance rather than from the treatment.

In some articles, you will see the notation "P<.05." That means the probability that the observed difference was due to chance is less than 5 percent. If two averages are said to be "significantly different," the probability is less than 5 percent that the difference is due to chance ... or the probability exceeds 95 percent that the difference is true and was caused by the treatment.

Some papers report correlations ... measures of the relationship between traits. The relationship may be positive (both traits tend to get larger or smaller together), or negative (as one trait gets smaller, the other trait gets smaller). A perfect correlation is eigher +1 or -1. If there is no relationship at all, the correlation is zero.

Many animals per treatment, replicating treatments several times, and using uniform animals, all increase the probability of finding real differences when they actually exist. In several instances, you will read where treatments were replicated or blocked several times. This is done to increase the accuracy and sensitivity (ability to detected a "real" difference) of the research. Statistical analysis allows more valid interpretation of the results, regardless of the number of animals in an experiment. In the following research articles, statistical analyses are included to increase the confidence you can place in the results

You may see an average given as 2.5 $\pm$ .1. The 2.5 is the average; .1 is the "standard error." That means there is a 68 percent probability that the "true mean (based on an unlimited number of animals) will be between 2.4 adn 2.6. "Standard deviation" is a measure of variability in a set of data. One standard deviation on each side of the mean is expected to contain 68 percent of the observations.

Due to limited spaces available, most articles do not include experimental design and detailed descriptions of analysis. Again, if addition information is needed, please feel free to contact the authors.

... Timothy DelCurto
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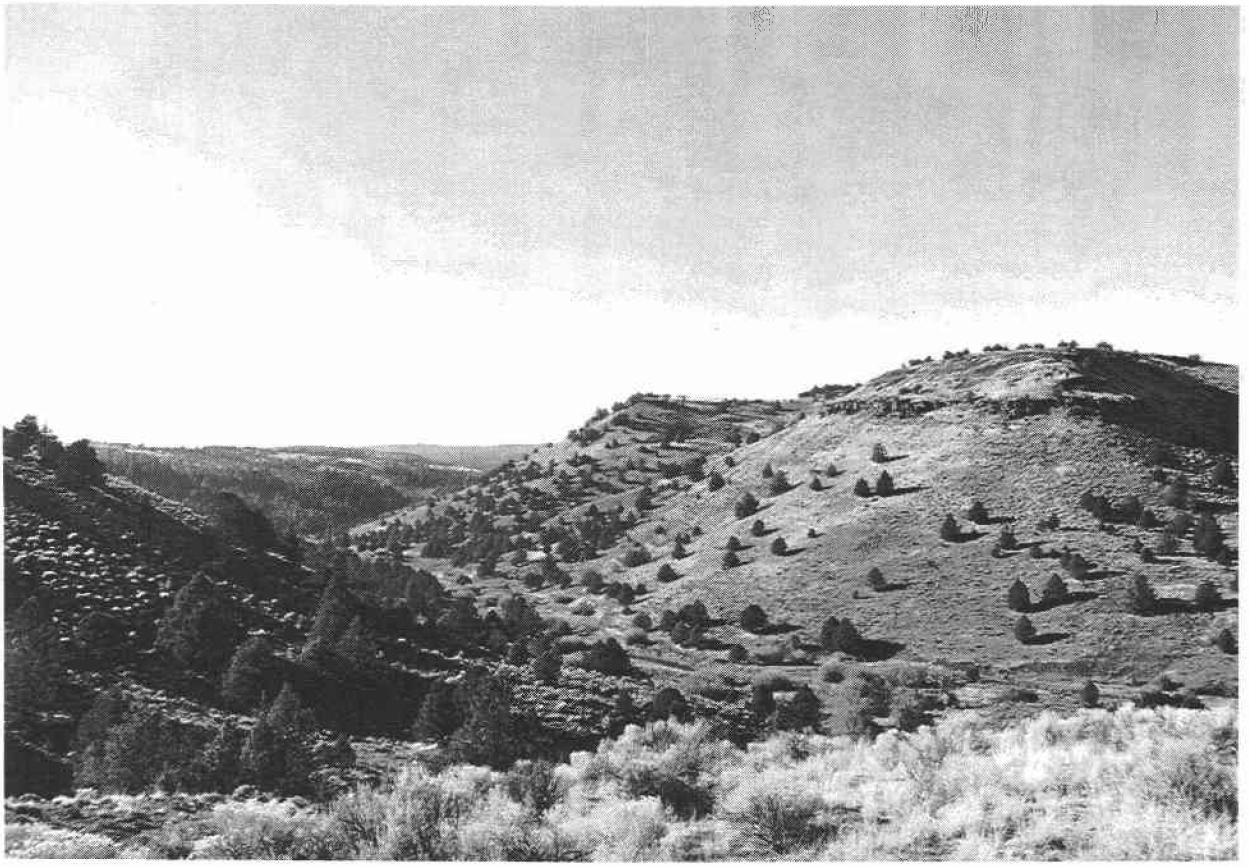
Eastern Oregon Agricultural Research Center

Research Projects:

Restoration of Wildland Systems



Understory Response to Thinning Ponderosa Pine in Northeastern Oregon

Rick Miller, Teena Tibbs and Martin Vavra

SUMMARY: Plant understory production and composition has been monitored over a seven year period following thinning of a ponderosa pine forest in northeastern Oregon. Thinning reduced tree canopy cover by 52 percent and basal area by 59 percent. Understory vegetation did not respond during the first growing season following logging. Four growing seasons after logging, the understory vegetation increased over two-fold. However, during drought conditions, seven growing seasons following logging, understory vegetation was similar in both thinned and non-thinned stands.

Ponderosa pine (*Pinus ponderosa*) forests are widely distributed within the interior mountain ranges of the Northwest. These forests provide timber and forage for livestock and wild herbivores. Ponderosa pine forests are also an important part of watersheds that feed many salmon and steelhead streams and rivers. In the Blue Mountains of northeastern Oregon, ponderosa pine forests comprise much of the economic land base where timber and forage resources are managed for dual or multiple uses. Often these resources are managed independently, rather than simultaneously. Integration of forest and grazing management objectives has the potential to improve returns from both livestock grazing and timber yields on the same unit of land.

Understory production can be increased and species composition changed through overstory thinning, clearcutting, or other methods of harvesting. Commercial thinning of ponderosa pine allows light of greater intensity and duration to reach the forest floor, and increases soil moisture by reducing overstory competition and canopy interception of precipitation. Nutrient cycling is also changed as competition for soil nutrients from the overstory is reduced. The primary objective of this study was to evaluate long term changes in understory production and plant composition following commercial thinning of a ponderosa pine overstory. A second objective was to measure the influence of large herbivores, both domestic and wild, on plant composition within thinned and non-thinned ponderosa pine stands. This report will only discuss the effects of thinning on understory vegetation.

MATERIALS AND METHODS

The study was conducted on the Hall Ranch of the Eastern Oregon Agricultural Research Center, located approximately 12 miles southeast of Union, Oregon. The Hall Ranch is in the southern foothills of the Wallowa Mountains in the northeastern corner of the state at an elevation varying from 3,300 to 4,000 feet. The climate is continental with cold wet winters and hot dry summers, with occasional thunderstorms. Mean annual precipitation is 24 inches, most of which occurs between November and May in the form of snow.

The three study sites selected were in a ponderosa pine/snowberry (*Pinus ponderosa/Symphoricarpos albus*) community type. Ponderosa pine dominates the overstory, but can co-dominate with Douglas-fir (*Pseudotsuga menziesii*). Snowberry, elk sedge (*Carex geyeri*), pinegrass (*Calamagrostis rubescens*) and heartleaf arnica (*Arnica cordifolia*) dominate the understory. Sites were selectively logged before 1936; since then there has been no logging.

The three major soil series occurring on the pine stands are Hall Ranch, Klicker and Tolo. Surface texture ranges from silt loam to silty clay loam, and depth varies from 12 to greater than 36 inches. All series, originated from pumicite parent material ejected from Mt. Mazama 6,600 years ago.

Three 12 acre blocks, located within a half mile of each other, were selected for this study. Half of each block (6 acres) was commercially thinned in the winter and early spring of 1986, and the remaining half left undisturbed (control). Stands were thinned from a density of 140 to 60 trees/ac. The pine sites were relatively homogeneous in overstory species composition and stand structure, however, understory vegetation differs slightly among blocks. Tree diameters at breast height (dbh) averaged 12.5 inches with the larger trees approaching 53 inches.

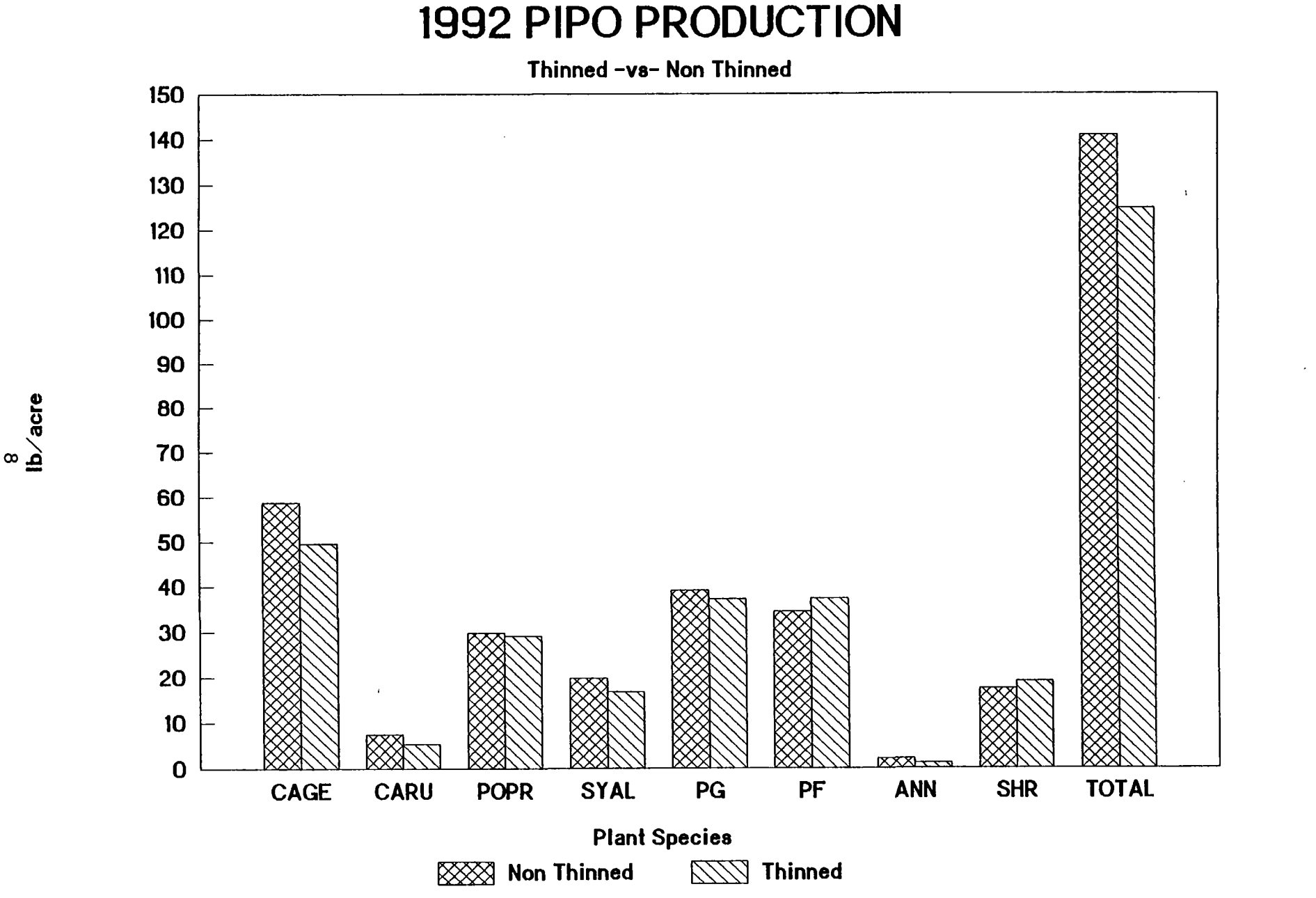
In 1986 (first year following thinning), 1989, and 1992 understory production was measured in both the thinned and non-thinned pine stands across three grazing treatments; cattle plus big game, big game only, and both cattle and big game excluded. One hundred 5.4 ft^2 areas were clipped to a 1 inch stubble height within the thinned and nonthinned plots in each of the 3 blocks. Species groups separated out were elk sedge, pine grass, Kentucky bluegrass (*Poa pratensis*), other perennial grasses, snowberry, perennial forbs, and annual and biennial forbs. Plots were clipped near peak annual production and data are averaged across grazing treatments.

RESULTS AND DISCUSSION

Thinning reduced tree canopy cover by 52 percent and basal area by 59 percent. Light reaching the understory was 2.2 times greater, and air temperatures 10 percent higher in the thinned versus non-thinned stands. Precipitation in crop years 1986, 1989, and 1992 (September - August) were 96, 111, and 71 percent, respectively, of the long-term average.

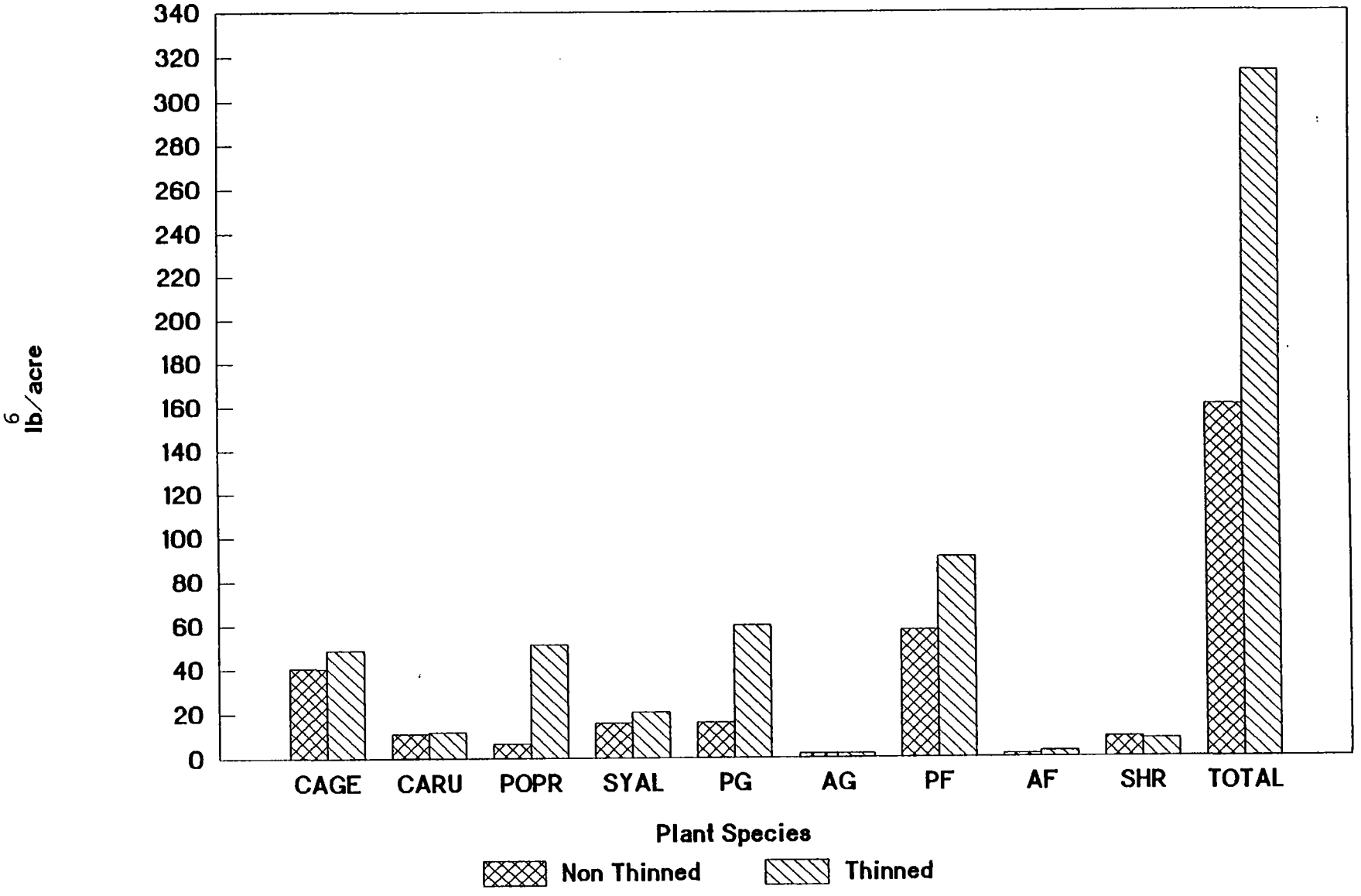
During the first growing season, immediately following logging, understory vegetation was not different between thinned and non-thinned pine stands (Fig. 1). In the fourth growing season following thinning, understory production was two times greater in the thinned stand compared with non-thinned (Fig. 2). Grasses (with the exception of pinegrass), sedges, and perennial forbs increased by the greatest magnitude. Annuals and shrubs did not respond to thinning. During the 1992 growing season no difference occurred in understory production between logging treatments.

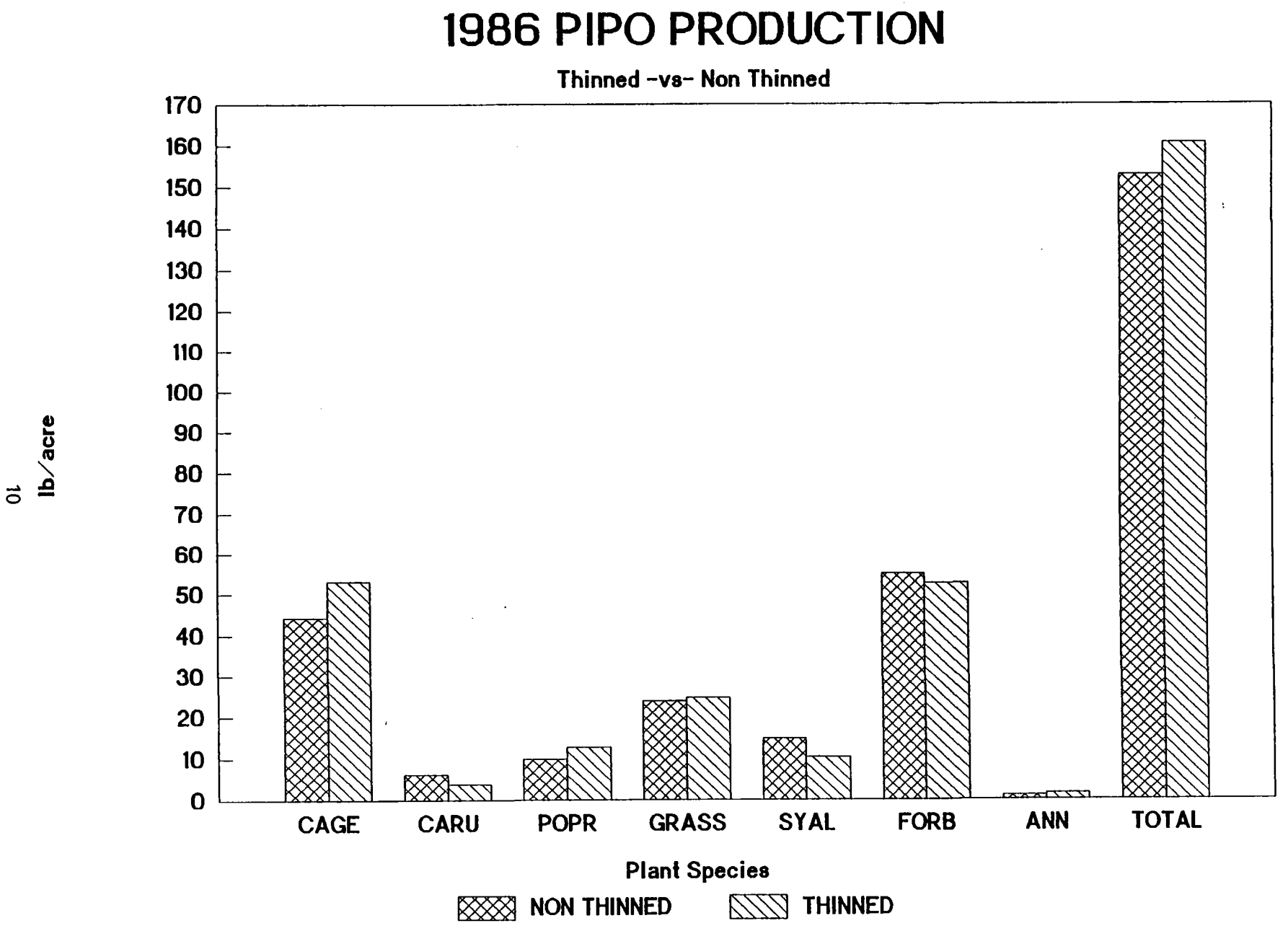
Understory production in the non-thinned pine stands changed little across the three growing seasons regardless of annual precipitation amounts, varying from 71 to 111 percent of average. Understory production only ranged from 125 to 150 lbs/ac in these three years. In the thinned stands, however, understory production varied 2.5 - fold. Logging occurred during the winter and spring just prior to the 1986 production sampling. Data suggest little response from understory vegetation can be expected during the first growing season following logging. This may in part be due to surface disturbance from logging. However, during the fourth growing season following logging and in a year of above normal precipitation, understory production was 2.5 times of the 1986 production. This response did not continue in 1992, seven growing seasons following logging. The lack of response in 1992 may have been related to low crop year precipitation, or interspecific competition between understory and overstory returning to pre-cut levels. During drought conditions, increased shading and lower midday temperatures in the non-thinned stand may partially compensate for increased below-ground competition for water and nutrients. Data collection will continue on this study, which will hopefully help us better interpret the lack of response in 1992. Tree growth data is also being collected in both logging treatments and will be addressed in next years annual report.


1992 PIPO PRODUCTION
Thinned -vs- Non Thinned
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
8
lb/acre
CAGE
CARU
POPR
SYAL
PG
PF
ANN
SHR
TOTAL
Plant Species
Non Thinned
Thinned

1989 PIPO PRODUCTION

Thinned -vs- Non Thinned




1986 PIPO PRODUCTION
Thinned -vs- Non Thinned
lb/acre
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
CAGE
CARU
POPR
GRASS
SYAL
FORB
ANN
TOTAL
Plant Species
NON THINNED
THINNED

Wyoming Big Sagebrush: Coping With Drought

Teal Purrington, Rick Miller, Paul Doescher and Jeff Rose

SUMMARY: The effects of drought on Wyoming big sage brush were evaluated. Plant water status, water use, growth, and nitrogen content were measured during two growing seasons. Response was measured at two locations, both representing a Wyoming big sagebrush/Thurbers needlegrass habitat type. One site had been seeded to crested wheatgrass. The second location contained an understory of native species. Precipitation was 106 and 67 percent of the long term mean during the 1989 and 1990 crop years, respectively. Limited soil water availability in the drought year decreased plant water status, water use, and nitrogen content in big sagebrush. The ability of big sagebrush to cope with drought was expressed through morphological plasticity. Under drought stress, Wyoming big sagebrush partitioned more biomass to vegetative versus reproductive shoots, leaves versus stems, and perennial versus ephemeral leaves. Limited soil water also greatly reduced secondary ephemeral leaf and lateral shoot development.

The drought tolerant shrub, big sagebrush (*Artemisia tridentata* Nutt.) is the dominant shrub characterizing the Intermountain Sagebrush Steppe. In the past 120 years, sagebrush abundance has increased two to four-fold at the expense of the herbaceous understory. Uncontrolled livestock grazing of the herbaceous understory has been described as one of the primary factors contributing to the increase in sagebrush density and cover throughout the sagebrush steppe. Drought has also been attributed to increased density of sagebrush.

Drought is a common phenomenon throughout the Intermountain Sagebrush Steppe, with precipitation falling below 70 percent of the mean one year in five. Drought can influence plant community dynamics in these cold desert ecosystems. Sagebrush density often increases following drought. Morphological and physiological plasticity of plants in response to highly variable water supplies in semi-arid and arid ecosystems has been shown to be important in determining the ability of a plant to survive and reproduce during and following drought. The semi-deciduous habit of sagebrush, which produces the relatively larger ephemeral leaves in the spring and the smaller perennial leaves in the summer, allows this species to take advantage of cool moist conditions in the spring and continue growth during the prolonged summer drought conditions.

The overall goal of our study was to evaluate the direct effects of drought on growth, nitrogen content, and water relations of a cold desert shrub, Wyoming big sagebrush (*Artemisia tridentata* spp. *wyomingensis* Beetle). Our initial hypothesis was that sagebrush would reduce leaf area, reproductive shoots, ephemeral leaf development, and nitrogen uptake during drought.

MATERIALS AND METHODS

The study was conducted at the Eastern Oregon Agricultural Experimental Range in southeastern Oregon, located 40 miles southwest of Burns. The station lies in the far northern portion of the Great Basin, and is representative of shrub-steppe rangeland ecosystems dominated by sagebrush. The climate is cool, semi-arid desert, characterized by large seasonal variations in temperature and moisture. Winters are cold and wet, summers hot and dry. The mean winter temperature is 31°F, with a daily minimum of 23°F. During summer, temperatures average 64°F, with daily maximum of 80°F. Mean annual precipitation is 11.1 inches (39-year mean), of

which 80 percent occurs October through June, the majority as snow.

The study was located in a Wyoming big sagebrush/Thurbers needlegrass habitat type, at an elevation of 4,520 ft. Soils are coarse to fine sandy loam, frigid Orthidic Durixerolls of the Milcan Series. The soil is well drained and is underlain by a duripan at 20 to 40 inches. The study was laid out in two adjacent locations, one containing native vegetation, the second seeded vegetation. The native site contained a 14 percent canopy cover of sagebrush with an understory of Thurbers needlegrass, Idaho fescue (*Festuca idahoensis* Elmer), bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith) and Sandbergs bluegrass (*Poa sandbergii* Vasey). The seeded site contained a 5 percent canopy cover of sagebrush with an understory of crested wheatgrass (*Agropyron desertorum* Schult.), planted in the 1960s.

Forty 34 ft^2 circular plots, with a single sagebrush plant in the center, were selected randomly within each location. Criteria used for plot selection were that sagebrush plants had full vigorous canopies greater than 6 inches tall. Precipitation and air temperature were obtained from a U.S. Weather Bureau Station located about 0.6 miles from the study site. Soil water content was measured throughout both growing seasons down to 16 inches. Plant water status (xylem pressure potential), water use (leaf conductance) and leaf nitrogen content were also measured throughout both growing seasons. Plant growth parameters measured were length and dry weight of vegetative terminal and lateral stems and reproductive stems, and dry weight and number of leaves. Perennial, primary ephemeral and secondary ephemeral leaves were separated (Fig 1).

RESULTS AND DISCUSSION

Precipitation during 1988-1989 and 1989-1990 crop years (September - August) was 106 percent and 67 percent respectively, of the long term mean. Soil water content in 1989-1990 was limited in the upper 8 inches, and not available at anytime during the growing season below 8 inches. Sagebrush expressed structural plasticity between the two growing seasons with contrasting levels of soil water availability. Not only did varying water supplies between years influence plant water status, water use, and nitrogen content at peak leaf growth in sagebrush, but also the proportion of different plant structures developed. Water availability during the two growing seasons influenced the partitioning of growth between vegetative and reproductive shoots, leaves and stems, and ephemeral and perennial leaves.

In the drought year, there was a proportionally greater reduction in biomass allocated to reproductive shoots than vegetative shoots on both sites. Biomass allocated to reproductive shoot growth was 8.5-fold greater in 1989 than 1990 for both sites. In another study, supplemental watering in mid summer increased sagebrush inflorescence growth four-fold. Others have also found that perennial plants subjected to environmental stress, including drought, sacrifice reproductive development in favor of maintaining vegetative production.

Plants also allocated a larger proportion of resources for leaf growth than stem growth during the drought; that is, there was a greater reduction in stem development than leaf development for both reproductive and vegetative shoots. For example, leaf biomass decreased 79 percent compared to a 90 percent reduction of stem weight. Lateral stem (Fig. 1) development was non-existent during the drought year. Leaves may have been preferentially developed over stems to increase the energy return on carbon invested. The result of increased leaf:stem ratios in the drought year was that canopies were more densely arranged. This could lead to reduced air movement and increase humidity within the canopy, and thus reduce transpiration during the drought year. The increase in proportion of perennial versus ephemeral leaves on vegetative stems of shrubs on the seeded site would also reduce water loss during the drought year. Drought conditions decreased perennial leaf biomass by 25 percent compared with a 34 percent reduction in ephemeral leaves. In 1989, secondary ephemeral leaf (Fig. 1) development was 11 to 12-fold greater than during 1990. Ephemeral leaves are not as water-efficient as

perennial leaves, so the preferential allocation to perennial to leaves would seem a good strategy for water conservation. Changes in resource allocation patterns to different plant parts is an important mechanism for drought avoidance.

Tissue nitrogen concentration in current years' growth was 29 percent less on the seeded site and 18 percent less on the native site in 1990 than in 1989. Others have shown that tissue concentrations of nitrogen declined by as much as 40 percent in water stressed plants compared with well-watered plants. Reduced root growth and nitrate uptake by the root membrane, and reduced nutrient mobility in dry soils limits nitrogen availability.

Response to dry conditions appeared to be different between the seeded and native sites. Stem and leaf growth, and reproductive shoot production were reduced by a greater magnitude on the seeded site than native site during the drought. Stand structure on the seeded site was characterized by a 5 percent sagebrush canopy cover with many sagebrush seedlings entering the stand. The native site contained a 14 percent canopy cover of sagebrush and what appeared to be an even-age stand based on size. No seedlings were observed entering the native stand. The greater reduction of plant growth parameters on the seeded site than the native site were of greater magnitude when water availability was reduced, suggesting that resources other than water were more limiting on the native site. However, although the decline in the relative proportion of growth during drought was greater on the seeded site, growth still exceeded that of the native site in 1990. Increased resource limitation on the native site may be due to increased intraspecific competition and a larger proportion of nutrients tied up in above and below ground biomass on the native site.

CONCLUSION

Drought during the second year did have some predictable effects. Sagebrush water status and use, plant growth and nitrogen content were all less in the drought year compared to the previous year. However, reduced water availability also resulted in sagebrush plants exhibiting a high degree of morphological plasticity. In the drought year compared to the previous year, there was an increase in proportional allocation of resources to vegetative versus reproductive development, in number of perennial versus ephemeral leaves, and in leaf versus stem development. In favorable years, sagebrush is able to increase acquisition of resources by increasing ephemeral leaf area, particularly through secondary ephemeral leaf development, and increasing leaf area through the development of lateral shoots. The potential to rapidly develop leaf area in the spring would increase the ability of sagebrush to compete for resources during optimal growing conditions. It is important for a plant species to maximize its leaf area as early as possible during the growing season to make the most beneficial use of water.

Drought is a common occurrence in the Great Basin. As such, it is important for land managers to understand the specific response of sagebrush to low soil moisture conditions. The reduction in allocation to reproductive shoots seen in the current study indicates that dry years may not be important for sagebrush seed production. However, future research on seed production and viability is necessary to determine the actual contribution sagebrush makes to the seed bank under varying climatic conditions. The findings in this study illustrate several specific adaptations sagebrush possesses that enable it to survive in a semi-arid environment. The ability to alter the amount of biomass allocated to various plant parts in response to drought increases sagebrush's ability to compete successfully with other species for limited soil resources.

Figure 1

Artemisia tridentata vegetative shoot; (1) primary ephemeral leaf, (2) secondary ephemeral leaf, (3) perennial leaf, and (4) lateral shoot.

The Historic Expansion of Western Juniper in Southeastern Oregon

Rick Miller and Jeff Rose

SUMMARY: Prior to settlement, densities of western juniper were relatively stable. Initiation of the recent expansion of juniper on Steens Mountain began in the 1880's. As densities of trees reaching maximum potential seed production age increased, establishment of new juniper trees has been proceeding at a geometric rate.

Juniper and pinyon-juniper woodlands are one of the major vegetation types characterizing the Intermountain Region. These woodlands, sometimes described as pygmy forests, currently occupy over 40 million acres in this region. Western juniper is considered the Northwest representative of the pinyon-juniper zone in the Intermountain Region. Western juniper occupies over 2 million acres in eastern Oregon, southwestern Idaho and northeastern California. Western juniper is found primarily north of the polar front gradient (near and parallel to the Oregon and Nevada border) where temperatures are cooler, summer precipitation decreases and winter precipitation increases.

Relict juniper woodlands, tree-age class ratios, fire scars, and historical documents indicate western juniper woodlands were open, savannah-like, or confined to rocky ridges prior to Euro-American settlement. Western juniper began increasing in both density and distribution in the late 1800s. Even though western juniper is long lived, less than 3 percent of the woodlands in Oregon are characterized by trees over 100 years old. In 1825, Ogden observed only occasional junipers (reported as cedars) growing on the hillsides, while traveling through the Crooked River drainage in central Oregon. Today, these hillsides are covered by dense juniper woodlands. In a nearby area, J.W. Meldrum's 1870 survey notes describe a gently rolling landscape covered with an abundance of perennial bunchgrasses and a wide scattering of juniper trees. Today, juniper densities on this site range between 50 and 100 trees per acre.

Our primary objective was to describe the chronology of western juniper expansion during the past two centuries in southeastern Oregon. Secondary objectives were to evaluate height age relationships across different plant communities, determine the effect of plant canopy and interspace on juniper seedling establishment, and evaluate the relationship of tree age and reproductive potential.

METHODS

The study area was located on Steens Mountain in southeastern Oregon, approximately 50 miles south of Burns. This isolated volcanic fault-block, which lies in the extreme northwest Basin and Range Province is about 50 miles long oriented in a northeast direction. The elevation of Steens Mountain varies from 4,100 to 9,700 ft with a steep east facing escarpment and a gentle west facing slope. The climate is cool and semi-arid, characteristic of the northern Great Basin. Annual precipitation averages 9 to 11 inches at the lower elevations and 20 inches or more at the higher elevations. The majority of moisture is received as snow in November, December and January, and as mostly rain March through June.

The juniper woodlands on Steens Mountain form a discontinuous belt between 4,700 and 6,600 feet. Early observations on Steens Mountain describe a landscape that contained only scattered stands of juniper. Severe winter conditions probably restrict juniper from expanding into higher elevations while the lower limit is controlled by temperature inversion layers (cold air sinks) and drought conditions. Western juniper

cover varies from fairly open with a dominate shrub steppe understory to a well developed woodland (25 to 35 percent cover). Canopy cover in woodlands that have formed on the mesic aspen sites approach 100 percent.

Twenty-two, 1 acre plot locations were selected in an attempt to characterize juniper woodlands on the west slope of Steens Mountain. Old stands on the rocky outcrops were not measured. These plots represented several maturity classes of dispersed, scattered, and closed juniper stands. Dominant understory vegetation in the scattered and dispersed stands were mountain big sagebrush (*Artemisia tridentata* spp. *vasyana*) and Idaho fescue (*Festuca idahoensis*), and on the rocky shallow soil sites, low sagebrush (*A. arbuscula*) and Idaho fescue. Understory vegetation in the closed stands was composed of a few remanent deep- rooted perennial grasses and 70 percent bare ground.

Juniper density, height, two canopy diameter measurements, and basal area were recorded. Tree canopy cover was estimated by adding crown area measurements for each plot. Current years juniper seedlings were not measured. Position of trees less than 20 inches tall; beneath a juniper canopy, sagebrush canopy, or in the interspace; was also recorded. Reproductive status was determined for each tree by designating one of three classes for berries or cones: (1) berries and/or cones scarce; (2) berries and/or cones obvious but not abundant; and (3) berries and/cones abundant. Ten trees were randomly selected within five size classes. Trees were cut at the base, cross-sectioned and aged.

RESULTS AND DISCUSSION

Prior to settlement western juniper populations appeared to be relatively stable during the past century. We encountered old trees on the rocky outcrops, in several low sagebrush sites, and only a few in mountain big sagebrush communities. The remains of old stumps on most of these sites suggested very open stands of juniper. Densities of juniper over 110 years old on two low sagebrush sites were two per acre. In 1991, juniper densities on these two sites are 94 and 180 per acre. Canopy cover in the newly formed juniper woodlands averaged 22 percent, ranging form 18 to 28 percent. Density of adult trees on these sites varied from 88 to 201 trees per acre with a mean of 120 trees per acre. Juvenile trees ranged from 88 to 496 per acre. The open juniper stands with a strong understory component of sagebrush and perennial grasses were generally characterized by a canopy cover of less than 10 percent, and adult tree density of less than 50 trees per acre. Densities of juvenile trees in these stands ranged from 40 to 488 trees per acre with a mean of 272 trees per acre.

The first evidence of increased regeneration occurred in the 1880s, with relatively steady establishment ensuing into the 1950s (Fig. 1). In the 1960s juniper establishment began occurring at a geometric rate. Expansion of western juniper in the late 1800s coincided with ideal climatic conditions for seed development and establishment, and reduced fire return intervals. Overgrazing, which reduced the fine fuels, and the reduction fires started by Native Americans dramatically altered the role of fire in these ecosystems.

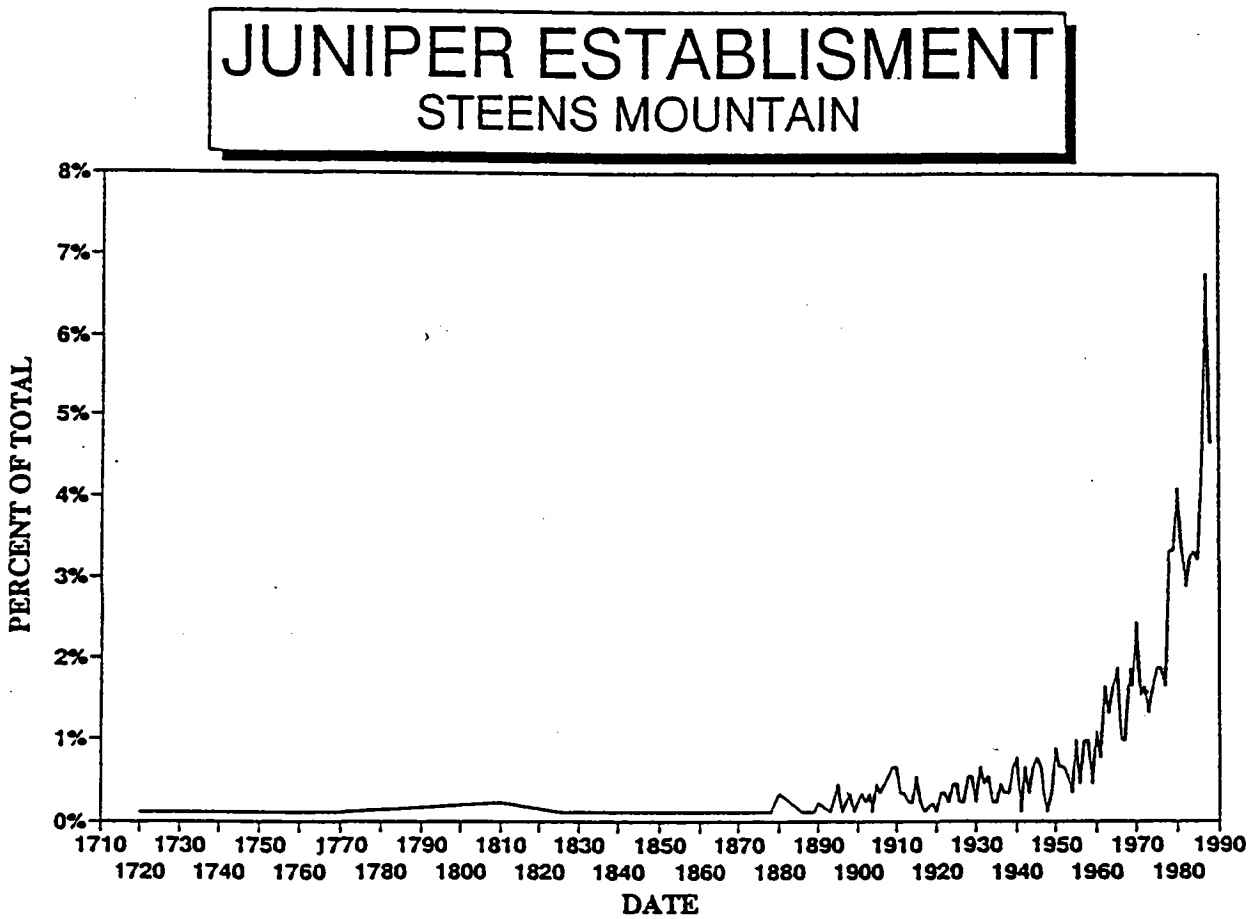
The largest proportion of juniper seedling establishment occurred beneath the canopies of juniper and sagebrush, with a small percentage establishing in the interspace. In the woodlands, 86 percent of the juveniles were located beneath the canopy of an adult juniper. In sagebrush grassland communities 55 to 64 percent of the juveniles were located beneath sagebrush canopies. Growth rate of young juniper trees growing beneath a sagebrush canopy, was 144 percent greater compared with growth rates beneath a juniper canopy or in the interspace. Based on growth rates of over 200 trees between 10 and 20 years of age, 90 percent of these trees, were or will be, less than 40 inches tall at the age of 15 (64 percent will be less than 20 inches tall). As trees matured, growth rates beneath sagebrush canopies increase from 1.8 to 3.1 inches per year. As tree canopy cover approached or exceeded 20 percent, tree growth rates declined to 2.2 inches per year.

The largest proportion of trees

producing berries or cones were over 50 years old. Trees producing crops of berries and cones between 20 and 25 years old accounted for only 10 percent of the population. Trees producing berries or cones less than 20 years old were rare. Approximately 75 percent of the trees producing heavy crops of berries or cones were over 50 years old. Ratios of male:female trees were varied with dominance of trees on the site.

In conclusion, the expansion of western juniper on Steens Mountain began during the late 1800s when fires became less frequent and climate was ideal for seed production and seedling establishment. The dramatic increase in tree establishment rates since the 1960s is probably due to lack of fire and a large increase in seed production. Data suggest seedling establishment beneath sagebrush canopies, where growth rates and distribution of seedlings is greater, is a primary mechanism for juniper establishment within shrub grassland communities. Full reproductive potential for most junipers is not reached until trees are over 50 years old.

Figure 1. Years in which all trees measured on Steens Mountain were established (sample size = 1400).



Growth, Plant Water Relations and Carbon Allocation of Heart-Podded Hoary Cress (Cardaria draba (L.) Desv.)[1]

Rick Miller, Tony Svejcar, Jeff Rose and Mike McInnis

SUMMARY: The noxious weed heart-podded hoary cress, also known as whitetop, has been expanding from cultivated fields to adjacent sagebrush steppe communities. Control measures are often not effective in prohibiting the expansion of this species. Plant water status, carbon allocation, and growth were measured on two sites to attain more information on the biology of heart-podded hoary cress. Leaves developed in the fall but did not survive winter. However, terminal buds just below the surface did survive winter, initiating new leaves in the spring. Below-ground biomass in the upper 24 inches was 3 times greater than above-ground biomass. Maximum translocation of carbon to below-ground tissue occurred during full flowering. Although production of heart-podded hoary cress was greater on the potential arable terrace site, this species also appeared to be adapted to the more arid, shallow soil, upland site.

Heart-podded hoary cress (*Cardaria draba* (L.) Desv.), also commonly know as whitetop, is a noxious, introduced weed. It is a deep rooted perennial, capable of reproducing by both seed and vegetative shoots originating from underground stems. Since its introduction from Europe in 1862, this species has invaded cropland and rangeland in British Columbia, Alberta, Saskatchewan, Washington, Oregon, Idaho, northern California, and Nevada. One of three species of hoary cress, heart-podded hoary cress is the most abundant species in Oregon and has the widest distribution in the United States. It grows in open areas and is adapted to alkali soils.

Heart-podded hoary cress can produce large numbers of viable seed and vegetative shoots, allowing it to rapidly invade cultivated and disturbed areas. It can gradually dominate stands of alfalfa and can have a major economic impact on agronomic crops. Movement of heart-podded hoary cress from cultivated fields to adjacent semi-arid upland big sagebrush (*Artemisia tridentata* Nutt.) communities is also common. Its recent movement into the big sagebrush ecosystem in the northwestern United States on a rather large scale is cause for concern. In eastern Oregon, heart-podded hoary cress occupies over 250,000 acres. It grows in big sagebrush communities in different seral stages and in communities seeded to crested wheatgrass (*Agropyron desertorum* Schult.). Shrubs are the most effective competitors with heart-podded hoary cress whereas grasses are less effective competitors.

Chemical and biological control of hoary cress species has been studied. Chemical treatments usually have to be repeated several times, or combined with farming practices for successful control. Thus, treatments are often prohibitively expensive on rangelands. The effectiveness of chemical control also has been highly variable and unpredictable. To date, biological control methods have not been effective.

Variability of effectiveness among control treatments indicates that more information on the basic biology of this species is needed. Thus, the goal of this study was to measure plant water relations, carbon allocation, and growth of heart-podded hoary cress. We also compared phenology and plant water relations of this species growing on an arable deep soil site with an adjacent big sagebrush upland site.

[1]Funding for this project was partially provided by the USDA Integrated Pest Management Project and Baker County Livestock Growers.

MATERIALS AND METHODS

The study site is on the south slope of the Wallowa Mountains, approximately 3 miles north of Keating, Oregon, which is situated 15 miles northeast of Baker City in northeastern Oregon. Soils are of granitic origin. Climate throughout this area is maritime with cold wet winters and hot dry summers. The growing season typically begins in early March and ends about mid-June. The nearest weather station with a similar geographic position is 22 miles east in Richland, Oregon. Although weather varies across short distances in this area, precipitation throughout this region was below normal during the 1987-1988 crop year (Sept-June), and near normal during the 1988-1989 crop year. In Richland, Oregon, crop year precipitation for 1987-1988 and 1988-1989 was 46 percent and 82 percent of the mean, respectively. Temperatures in the region were 7 percent warmer during the 1988 than 1989 growing seasons.

Two sites were sampled consisting of an upland and an adjacent terrace site. The upland site was located approximately 30 feet above the terrace site, on a 15 percent west facing slope with a sandy loam soil averaging 20 inches in depth. The plant community was dominated by Wyoming big sagebrush (*Artemisia tridentata ssp. wyomingensis* Beetle) and crested wheatgrass. A few remnant plants of bluebunch wheatgrass (*Agropyron spicatum* Rybd.) and Thurber needlegrass (*Stipa thurberiana* Piper) were present. The level terrace contained soils deeper than 48 inches. The plant community was dominated by basin big sagebrush (*Artemisia tridentata ssp tridentata* Nutt.) and crested wheatgrass. A few giant wildrye (*Elymus cinereus* Scribn. and Merrill) plants were present in the understory. The experiment was repeated during the 1988 and 1989 growing seasons.

Soil water content was measured to bedrock on the upland site, and to 48 inches on the terrace site throughout both growing seasons. Plant measurements recorded were phenology, above-ground and below-ground biomass, plant water status, and carbohydrate allocation to above and below-ground plant parts.

RESULTS AND DISCUSSION

Although heart-podded hoary cress did not develop the density or biomass of shoots on the upland site compared with the terrace site, it appeared to be adapted to the Wyoming big sagebrush site. In both years, plant water status decreased earlier in the growing season on the upland site than the terrace site. Although plant water status was lower (more stressed) on the upland site during the later half of the growing season, phenology was similar between sites. In 1988, heart-podded hoary cress flowered in mid-May and developed seeds in early June, although soil water content was very limited on the upland site. The ability of plants to complete growth through seed development on the upland site may partially be attributed to greater growth activity early in the season than on the terrace site, based on leaf development and water use. The ability of heart-podded hoary cress to adjust to limited soil water conditions also allows this plant to complete growth and seed production.

Leaves began to grow during the fall on the terrace site. These leaves did not survive winter. However, the upturned buds on which these leaves were attached survived the winter directly beneath the soil surface producing leaves and above-ground shoots the following spring. Early development of leaves in the spring from rhizomes directly beneath the soil surface probably contributes to the competitiveness of heart-podded hoary cress.

Growth of heart-podded hoary cress on both sites was primarily from underground shoots. Although, heart-podded hoary cress can produce large amounts of viable seed, no seedlings were observed in the permanent plots. However, we did observe heart-podded hoary cress seedlings growing on disturbed soils adjacent to badger holes and gopher mounds on both sites in 1988 and 1989. A recent study indicated that heart-podded hoary cress seedling establishment was greatest in annual communities and on disturbed soil surfaces. Few if any seedlings established on undisturbed soils.

Approximately 76 percent of heart-podded hoary cress biomass was located below-ground (Table 1). Similar values have

been reported for a number of rhizomatous forbs. The high degree of biomass allocation to roots and rhizomes provides heart-podded hoary cress a competitive root system, a large food storage capacity, and extensive below-ground buds, capable of developing above-ground shoots. Root biomass was concentrated in the upper 8 inches of the soil profile. Similarly, perennial grasses usually have the largest proportion of their root biomass in the upper 8 to 12 inches. This overlap in root distribution probably increases the intensity of interspecific competition between heart-podded hoary cress and other herbaceous species. Food storage (sugar) was greater in roots located in the 12 to 24 inch soil layer compared with roots in the upper 12 inch layer. Root distribution and sugar content may indicate a difference in root function. The upper roots may be primarily feeding roots, whereas roots at 12 to 24 inches may be for both feeding and food storage. Based on root distribution, heart-podded hoary cress probably has a greater capacity than perennial grasses, to extract soil water and nutrients at greater soil depths. Fall growth and plant water status indicated that roots were able to effectively acquire deep soil moisture. In another study the roots of globe-podded hoary cress (*Cardaria pubescens* [Mey.] Jarm.) were traced to the water table, 21 feet below the surface. On the upland site, rooting depth was restricted by shallow soils (20 inches), precluding acquisition of deep soil moisture.

Carbon uptake, assimilation, and translocation to roots and rhizomes occurs in less than 24 hours. In both years the greatest degree of carbon uptake and retention of newly assimilated carbon in aboveground plant tissue occurred during the rosette stage. The rapid uptake of carbon during the rosette stage may result from: 1) favorable microclimate during that labeling period, and/or 2) high carbon demand during this rapid growth phase. The comparatively low enrichment during the seed stage probably is a result of reduced physiological activity as plants approach dormancy, and soil content becomes depleted. Plant water status and water uptake were relatively low during seed set in mid-June.

Respiration can account for a large fraction of carbon translocated to roots. However, in the present study there was relatively little decline in newly assimilated carbohydrates in the roots and rhizomes after the peak at 24-h. The greatest decline of newly assimilated carbon occurred during the rosette stage when root and rhizome growth was probably at its peak, and growth respiration rates may also have been relatively high. In the present study, the patterns of carbon allocation clearly depended on phenological stage.

The greatest absolute enrichment of newly assimilated carbon in the roots and rhizomes, and the greatest proportional flow of carbon to roots and rhizomes occurred during the flower stage. Enrichment of carbon in the roots and rhizomes is considerably less at both the previous and subsequent stages of phenology. Prior to flowering, carbon demand by above-ground organs may be greater due to rapid shoot elongation and leaf development. During flowering, leaves and shoots are fully developed, possibly decreasing the demand for carbon in aboveground parts. Following flowering, leaves begin to senesce and soil water content becomes limited, reducing carbon assimilation. The period of maximum carbon allocation to below-ground structures was not associated with maximum plant growth. Not surprisingly, past work has shown that chemical control of heart-podded hoary cress was most successful during the flower stage. The narrow window of maximum carbon allocation to roots and rhizomes, and variation of phenology within a given area may account for the difficulty associated with chemical control of this species.

MANAGEMENT IMPLICATIONS

Heart-podded hoary cress is an effective colonizer, invading open, disturbed ground by seed, and then colonizing adjacent undisturbed sites by vegetative reproduction. When unimpeded by competition, this species has the capacity to rapidly spread and occupy a site. This emphasizes the importance of reestablishing desirable plant species

	Aboveground	Belowground	Above: Belowground Biomass
Biomass (lbs/ac)	3,390	11,034	0.31
		Soil Depth (mm)	
	0-200	200-400	400-600
Root:Rhizome	1.41	0.33	0.40
% Biomass[1]			
Roots	0.73	0.16	0.11
Rhizomes	0.40	0.38	0.22

[1]Values are percentage of total root or rhizome biomass occurring at the various depths.

immediately following heart-podded hoary cress control. However, control of this species is difficult. Inconsistent chemical control can probably be attributed to variable phenology, short time period of maximum carbon flow to below-ground organs, and a large reserve of below-ground dormant buds. Application of foliar herbicides should be applied during maximum translocation of carbohydrates to belowground parts. The large proportion of biomass located below-ground, and deeply established rhizomes also makes this species both difficult and economically prohibitive to control with cultivation on rangelands. Past work indicated three consecutive years of cultivation were required to attain effective control of all three hoary cress species. Although heart-podded hoary cress is most abundant on potentially arable sites, this species appeared to be adapted to the drier shallow soil on the Wyoming big sagebrush site.

Simulation of Leaf Conductance and Transpiration in Western Juniper

Raymond F. Angell and Richard F. Miller

SUMMARY: Western juniper is a conifer species well adapted to semi-arid rangelands in portions of the western United States. Water relations of mature western juniper trees were observed, and soil temperature, soil water, air temperature, vapor density deficit (D_a), and solar radiation were recorded. A daily soil water budget was maintained by coupling the conductance model with the hydrology component of the model SPUR (Simulation of Production and Utilization of Rangelands). Results indicate that the model successfully simulated seasonal conductance trends. Conductance was strongly affected by soil temperature and D_a in spring, while soil water potential and D_a were important during summer. Western juniper transpired 5.6 inches of water, 47 percent of the total evapotranspiration for the site and 44 percent of total annual precipitation. Simulated western juniper conductance increased whenever environmental conditions moderated in late winter and spring. Juniper withdrew 1.5 inches of water between January and May, suggesting it has potential to significantly alter watershed value and site productivity.

Western juniper (*Juniperus occidentalis* Hook.) is a conifer species well adapted to semi-arid rangelands in portions of the western United States. It occurs throughout eastern Oregon, eastern Washington, northeastern California and southern Idaho. During the last 100 years this species has increased in density, actively invading adjacent sagebrush-grass communities. The conversion of shrub steppe communities to juniper woodlands has influenced ecological processes on the landscape. As western juniper increases on a site, understory production decreases, subsurface flow decreases, and sediment production increases.

Because of western juniper's increased presence on semi-arid uplands, information is needed to evaluate the effects of these woodlands on the hydrologic cycle. Models have been developed for other conifers, however little work has been reported for western juniper. Recent water relations research has investigated relationships between western juniper conductance rates and environmental conditions, and this information provides the necessary data to develop a physiologically based conductance model for a western juniper woodland. In the present study we developed a conductance model for western juniper and estimated water use of an entire stand.

MATERIALS AND METHODS

Study Site. The leaf conductance model was developed using data collected at the Squaw Butte Experimental Range located in the northern Great Basin, in southeastern Oregon. The study site was in an *Artemisia tridentata* ssp. *vaseyana/Festuca idahoensis* habitat type at 4,420 ft elevation. Western juniper encroachment began on the study site just after the turn of the century. Soil is a Typic Haploxeroll, varying from loam texture at the surface to gravelly loam at lower depths. Soils are underlain by columnar bedrock at approximately 44 inches. Average annual precipitation (39-yr mean) is approximately 11 inches, most of which is received as snow between September and June. During the study, precipitation was above average, with about 14.6 and 12.5 inches received in 1983 and 1984, respectively. March, 1983 was much wetter than average in

both years, and the entire soil profile was at or near field capacity during early spring.

Data Collection. Data for model development and testing was obtained by measuring western juniper stomatal conductance (g_l) ($cm*s^{-1}$) during two growing seasons, between January, 1983 and September, 1984. Environmental data included precipitation, air and soil temperature (°C), vapor density deficit (D_a) ($g*m^{-3}$), gravimetric soil water content (%), and solar radiation ($cal*cm^{-2}*s^{-1}$). Leaf conductance was measured with a steady state porometer (LiCor, Li-1600) fitted with a cylindrical chamber. Juniper total leaf area (LA) (m^2) was estimated from basal circumference, and leaf area index (LAI) was derived based on LA per tree and $trees*ha^{-1}$. All plant measurements were collected on mature trees. Analysis of data collected in 1983 indicated that solar radiation, soil temperature, soil water pressure (ψ_s) (MPa), and D_a were important factors that could be used to predict diurnal patterns of g_l.

Model Overview. The model JUOC operates at an hourly time step. At the start of each day, precipitation, diurnal temperature extremes (°C) and daily solar radiation ($cal*cm^{-2}*d^{-1}$) are input (Figure 1). JUOC simulates g_l for a moderate density (50-60 trees/acre), even-aged stand of western juniper growing in the northern Great Basin. Transpiration (J) ($\mu g*cm^{-2}*s^{-1}$) is calculated based on g_l and D_a. Descriptive parameters for the juniper stand are input at the beginning of the simulation, and do not change. Stomatal conductance is based on current soil temperature at 4 inches, soil water pressure in the wettest layer, and overnight minimum temperature. Stomatal conductance is set to the maximum potential rate just after sunrise. As the day progresses, ambient temperature and D_a rise toward a diurnal maximum, and conductance rate declines. Hourly J is summed to get total daily transpiration per unit LA. Stand transpiration is estimated at the end of the day and reported as mm of water. At the end of the day, soil water is uniformly removed from the soil profile, down to the maximum rooting depth. In this study we assumed a rooting depth of 35 inches, and a 39-inch

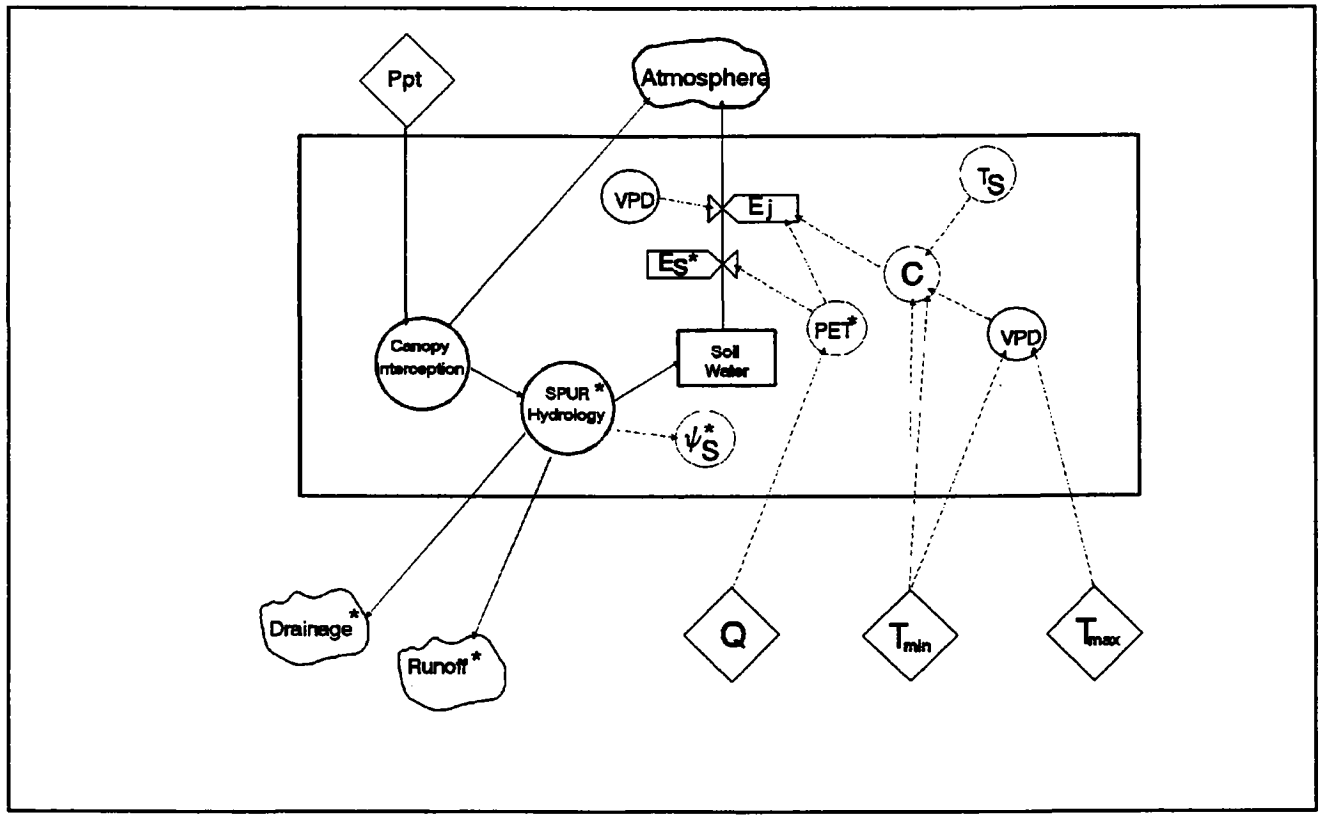


Figure 1. Flow chart for JUOC, a conductance model for western juniper, showing inputs and outputs for the model.

depth of profile.

Daily soil water balance is maintained by coupling the conductance model, JUOC, with the upland hydrology component of SPUR - Simulation of Production and Utilization of Rangelands. SPUR hydrology controls water routing to snow storage, snowmelt, runoff, soil storage, or deep percolation.

RESULTS AND DISCUSSION

Model Development and Testing. We used actual precipitation and temperature data from 1983, which were collected at a weather station 1.25 miles from the study site. Simulations began on January 1, and continued through the end of the year. Simulated g_h in 1983 (Figure 2) was generally within 1 SD of measured seasonal averages. Residual standard deviation (RSD) of model versus measured values was low (0.029).

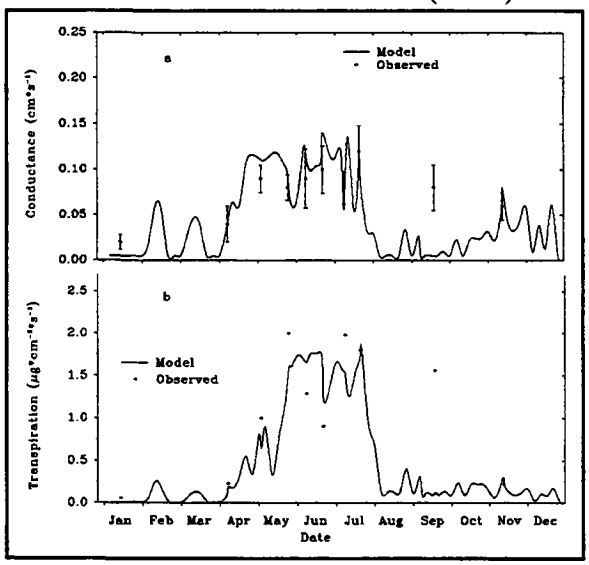


Figure 2. Conductance (a) and transpiration (b) of western juniper in 1983.

During optimum environmental conditions, modeled maximum potential J is 1.9 $\mu g*cm^{-2}*s^{-1}$, at D_a=20.9 $g*m^{-3}$. Soils were at field capacity in spring and J was primarily affected by soil temperature and evaporative demand. May 1983, midday transpiration increased to about 1.8 $\mu g*cm^{-2}*s^{-1}$ and fluctuated with daily changes in D_a until early July when ψ_s of the wettest layer decreased to about -0.3 MPa. By that time soil water pressure in the upper profile was at or below -1.5 MPa. As noted above, the model predicted stomatal closure in September, because of decreased ψ_s, resulting in a difference of about 1.4 $\mu g*cm^{-2}*s^{-1}$ between measured and modeled values.

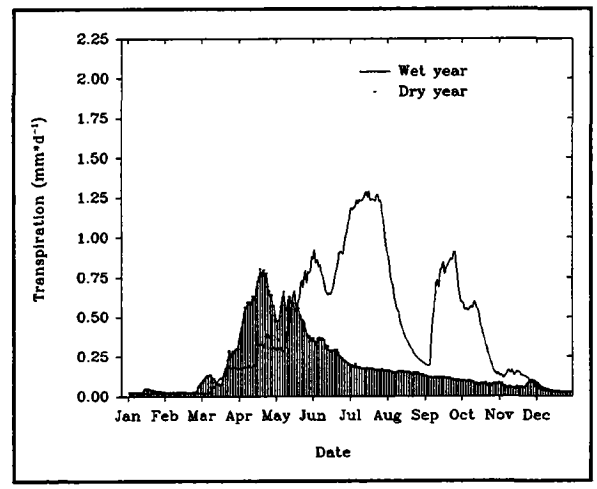


Figure 3. Modeled daily transpiration by western juniper in a dry year (1990) compared to a wet year (1984).

Wet Year vs. Dry Year. One use of our simulation model is to investigate a variety of weather profile effects on water budgets. We set up a one-year drought simulation using actual precipitation, temperature, and solar data from 1990. Total precipitation was 6.9 inches, and available soil water on January 1 was 50 percent of field capacity. Results, shown in Figure 3, compare the drought transpiration profile with the profile for 1984, which was wetter than normal. As expected, transpiration declined quickly as soil water was depleted. Early in the growing season (May 15), maximum potential g_h was 0.13 $cm*s^{-1}$, but one month later maximum g_h declined to 0.08 $cm*s^{-1}$ because ψ_s in the wettest layer had already decreased below the threshold of -0.25 MPa. Springtime air and soil temperature increased earlier in the drought year, and western juniper began active transpiration, resulting in early depletion of stored soil water. Others have reported that western juniper growth increases under mild wet winters and cool wet springs. Early increases in J have important

implications for understory herbaceous species that are just initiating growth. Drought effects on the understory may be intensified by western juniper's early withdrawal of soil water. Additionally, as western juniper stand density and/or LAI increases on a site, additional soil water will be withdrawn early in the year, altering western juniper seasonal g_l patterns, which may help explain reported decreases in production of associated species.

CONCLUSIONS

The conductance model, JUOC, successfully simulated seasonal leaf conductance patterns for western juniper. The model demonstrates how well western juniper is adapted to the environment of the northern Great Basin, where most of the annual precipitation is received as winter snow. The model closely matched observed springtime conductance. In spring, when soil water is highest, western juniper will begin active transpiration as soon as soil temperature increases, and this effect may be enhanced in dry years when fewer cloudy days occur.

During model development, we simulated a site stocked with 30 trees per acre, and 1.6 LAI. Even at this relatively moderate level of density and cover, western juniper was able to extract 1.9 inches of water during May and June, and transpired 5.6 inches during a wet year. This response illustrates one of the adaptations that makes western juniper so competitive once it establishes on a site. Because it is an evergreen, it can draw on available soil water any time environmental conditions are favorable. Based on the drought year simulation, even moderate density juniper stands appear to have the potential for significant impact on site hydrologic processes. By beginning active growth early in spring, soil water is depleted rapidly and development of understory species will be even further restricted. The model suggests that in dry years, western juniper could significantly impact growth and development of understory species by depleting soil water early in the year.

This model provides resource managers with important new information about the impact of developing western juniper woodlands on water use in the watershed, based on stand density, basal area, and environmental conditions. This information can be used to make stand management decisions such as what stand density is acceptable, and whether some control measure is justified. Further research needs include comparing model predictions with measured transpiration data on widely differing sites and for different climatic conditions.

Research Projects:

Environmentally Compatible

BLACK-TAILED JACKRABBIT SELECTION OF 8 FORAGES AVAILABLE FOR RECLAIMING GREAT BASIN RANGELANDS

Dave Ganskopp, Bill Meyers[1], and Scott Lambert[2]

SUMMARY: Our objective was to establish the growing season relative preferences of jackrabbits for eight selections of grasses available for reclamation of Great Basin rangelands. The percent of plants grazed and utilization levels of two crested wheatgrass cultivars were nearly twice those of the other grasses. Two cultivars of basin wildrye and one selection of Russian wildrye were avoided by jackrabbits, while two cultivars of bluebunch wheatgrass and one selection of thick-spiked wheatgrass were passively foraged upon. Seedings of unpalatable cultivars are suggested to discourage jackrabbit presence in right of ways where they pose a danger, to reduce competition between jackrabbits and livestock for forage, or moderate potential damage to ground cover or forage resources in critical areas during jackrabbit population peaks.

Black-tailed jackrabbits (*Lepus californicus*) frequent North American range and croplands from Washington, east to the Dakotas in the United States, and extend south into Mexico. When high populations occur, jackrabbits can compete with wild and domestic herbivores for forage, and many feel that high populations of these animals affect stature and composition of rangeland vegetation through selective grazing

Agricultural crops and reclaimed rangelands, particularly crested wheatgrass (*Agropyron desertorum* (Fischer ex Link) Schultes) seedings, are often preferred by black-tailed jackrabbits. Jackrabbits select grasses in early spring and summer, forbs in late summer and fall, and shrubs during winter months. The spring and early summer period coincides with the late-boot and early anthesis stages of phenology of our caespitose grasses, a period when severe defoliation may significantly affect vigor or health of these plants.

We evaluated the relative preferences of black-tailed jackrabbits for eight selections of grasses adapted, to and available for reseeding areas in the arid Great Basin. Selections were: two cultivars of basin wildrye (*Elymus cinereus* Scribner & Smith), Magnar and Trailhead; two cultivars of bluebunch wheatgrass (*Agropyron spicatum* Pursh), Secar and Goldar; thick-spiked wheatgrass (*Agropyron dasystachyum* (Hooker) Scribner & J.G. Smith), selection #9021076; the Bozoisky cultivar of Russian wild-rye (*Elymus junceus* Fischer); Nordan crested wheatgrass (*Agropyron desertorum* (Fischer ex Link) Schultes); and a crested wheatgrass cross called Hycrest II, a product of *Agropyron desertorum* and *Agropyron cristatum* (L.) Gaertner). Our objective was to identify selections that might be attractive to, or avoided by, black-tailed jackrabbits.

MATERIALS & METHODS

The study was conducted on the Northern Great Basin Experimental Range 43 miles west-southwest of Burns, OR. With the exception of Hycrest II, from USDA-ARS Logan, UT, seed was acquired from the SCS

[1]Soil conservation Service, PO Box 848, Hines, OR

[2]Soil Conservation Service, U.S. Court House Rm 360, West 920 Riverside, Spokane, WA 99201

Pullman Plant Materials Center, Washington. Seedlings were established in tubes in a green house during the winter and transplanted to plots in early April 1990. Crop-year precipitation for 1990 was 74 percent of average, but because plants were growing essentially free from competition, they tillered prolifically. Planting design was a randomized complete block with eight treatments (cultivars) and nine replications. A replicate contained 98 plants of each selection (total/replicate = 784 plants).

Trails, frequent sightings, and jackrabbit scat on nearly every square meter of our plots gave us confidence that black-tailed jackrabbits were the main herbivores. Jackrabbits from surrounding terrain had free access to the plots from early June until 10 July 1990. Most foraging was nocturnal, and we did not census the animals. One would, however, typically encounter a jackrabbit for every 50 to 75 yards of day-time travel in the adjacent sagebrush/bunchgrass vegetation.

During the period the jackrabbits had access to plots, plants were in the vegetative and early-boot stages of phenology. The latter stage is the time when severe defoliation most negatively affects subsequent vigor and production of cool-season grasses. Diameters of individual plants ranged between 1 and 5 inches. After hares were excluded from plots by fencing, each plant was scored for presence or absence of any sign of defoliation, indexed as either a 0 or a 1, and degree of utilization as indexed by scores ranging from zero to three. Scores, based on appearance of plants, indicated: 0) no utilization, 1) 1-20 percent herbage weight removed, 2) 20 to 40 percent weight removed, and 3) more than 40 percent weight removed. Scores (n=98) for both response variables were summed by cultivar (n=8) within each replication (n=9) with the totals functioning as single observations (n=72) in randomized-complete-block analyses of variance. Data were converted to percentages after analyses.

Mean separations and preference ratings were accomplished with Least Significant Difference (LSD) procedures (P=0.05). Selections scoring greater than than 1 LSD above the mean were viewed as "preferred", those less than 1 LSD below the mean were recognized as "avoided", and those within plus or minus 1 LSD of the mean, were considered to be "passively" foraged upon by jackrabbits.

RESULTS & DISCUSSION

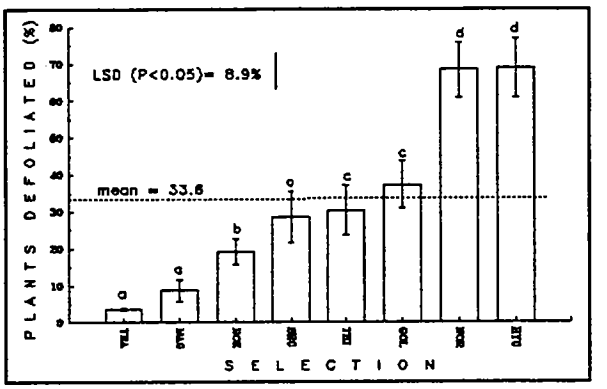


Figure 1

Approximately 34 percent of all plants received some degree of defoliation with the range extending from 4 percent for 'Trailhead' basin wild-rye to 69 percent for 'Hycrest II' crested wheatgrass. Mean percentages of plants defoliated and levels of utilization by black-tailed jackrabbits differed significantly among selections with nearly identical interpretations derived from both response variables (Figure. 1 and 2). The crested wheatgrass cultivars

(Nordan and Hycrest II) were clearly preferred forages. Percent of plants defoliated and levels of utilization for both cultivars were nearly two times greater than scores of the other selections, and approximately 6 percent of these plants were actually killed by overgrazing. The two bluebunch wheatgrass cultivars (Secar and Goldar), and the thick-spiked wheatgrass were foraged upon at roughly mean levels and were assigned a passive rating. The Bozoisky Russian wild-rye and two basin wild-rye cultivars, Trailhead and Magnar, were lightly foraged upon and ranked as avoided.

Our results suggest these cultivars could be used as management tools to either discourage or encourage black-tailed jackrabbit use of an area. For example, plantings of the wildrye cultivars might avoid

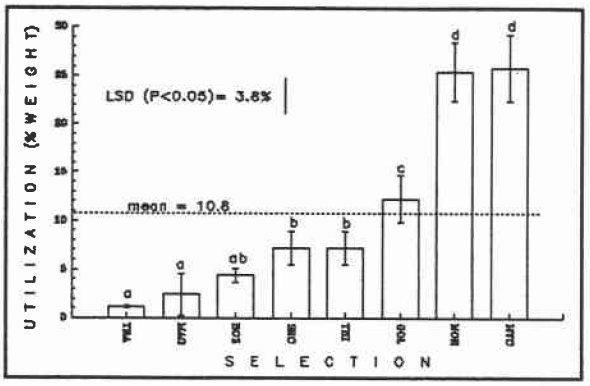


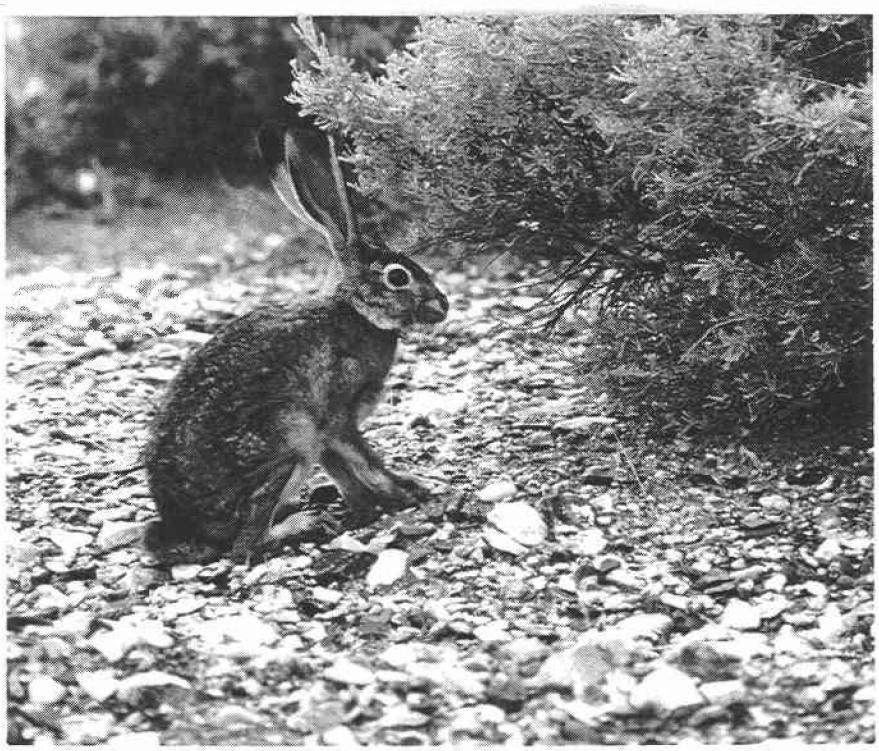
Figure 2

attraction to road or aircraft runway right of ways. In a similar vein, the basin and Russian wild-rye cultivars might function as protective buffers around more valuable crops or as alternative livestock forages less likely to be consumed or damaged by black-tailed jackrabbits. Conversely, plantings of crested wheatgrass cultivars might lure jackrabbits away from more valuable, but less palatable, crops or critical areas. Efficacy of buffer strips for crop protection has not been tested, however, and additional research is needed to address applicability of this hypothesis.

In the sagebrush-steppe, black-tailed jackrabbits typically inhabit shrub dominated areas during daylight and make feeding forays into areas offering higher quality forage, but less overhead cover at night. Research has detected significantly less use of palatable feed by jackrabbits when distance from cover was only 5 to 10 yards. Under more applied conditions, in large seedings, and with high populations, black-tailed jackrabbits typically forage within a 300-yard band adjacent to protective cover.

CONCLUSIONS

Our findings clearly demonstrate selective grazing by black-tailed jackrabbits. Having identified favored and avoided cultivars, we suggest planting avoided selections in areas prone to frequent outbreaks of black-tailed jackrabbits. Possible benefits include minimizing potential damage to growing forage or arid land ground cover during its most susceptible stage of phenology, reducing competition with livestock or other wildlife for forage, and perhaps discouraging immigration and/or encouraging emigration of these hares to other areas.



WOLF-PLANTS : HOW FINICKY ARE CATTLE ABOUT OLD GROWTH IN STANDING FORAGE?

Dave Ganskopp, Ray Angell, and Jeff Rose

SUMMARY: Accumulation of wolf-plants in pastures frequently results in waste or incomplete utilization of high quality forage by cattle. The objectives of this research were to determine: whether cattle were aware of small numbers of old stems in standing forage, the seasonality of effects, and the degree that use of contaminated forage by cattle was affected. Cattle were aware of even one cured stem in green crested wheatgrass plants. When grass was green and growing, cattle removed 76 percent less material from plants containing old stems than from uncontaminated plants. Cattle were oblivious to old stems after standing forage had cured. These findings demonstrate that cattle will harvest forage more completely and efficiently if densities of wolf-plants are minimized. Also, grazing can be effectively used to clear pastures of wolf plants if postponed until standing forage has cured.

When bunchgrasses remain ungrazed throughout a growing season, residual straw and stems begin to accumulate. The result is that both wild and domestic animals are less likely to forage upon these "wolf-plants." If wolf-plant numbers become high in a pasture, selective grazing may result in wasted forage as well as focus undue grazing pressure on the remaining uncontaminated plants.

Research in other regions has shown that cattle forage less rapidly when feeding on plants contaminated with the previous year's stems. Typically cattle forage from the top down on grasses. When grazing plants containing old stems or straw, however, they either reach in from the sides toward the base of the plant or push their noses down through the stems and attempt to selectively remove leafy material.

There were three objectives to this research. These were: determine how much old material must be present in bunchgrass before cattle exhibit a selective response; determine whether selective responses varied from season to season; and determine whether responses were continuously expressed by cattle as pastures were progressively grazed down.

MATERIALS & METHODS

This research was conducted in 1990 and 1991 on the Northern Great Basin Experimental Range. In 1990 a crested wheatgrass (*Agropyron desertorum* [Fischer ex Link Schultes]) range was subdivided into nine 1.5 acre pastures with electric fencing. Three pastures were sampled when the crested wheatgrass was green and leafy, three when plants were green and seed stalks were flowering, and three in late summer when plants were dormant and all forage was brown. Before cattle turn in, 100 plants in each pasture were selected and randomly assigned to one of five treatments for a total of 20 plants per treatment per pasture. Treatments involved the placement of either 0, 3, 6, 9, or 12 cured crested wheatgrass seed stalks in each plant. Holes were punched in the soil within the crown of each plant with a metal pin and the appropriate number of seed stalks simply dropped into the holes. Five additional plants for each treatment were also augmented with stems and harvested to evaluate treatment effect on forage quality, and the percent of plant material contributed by stems.

Two yearling steers were placed in each of the three pastures where they grazed until roughly 75 percent of all plants in the pasture received some degree of use (4 to 5 days). Steers were removed and treatment plants were evaluated for presence or absence of grazing and, if grazed, the percent of plant weight that had been removed by the steers. Based on the 1990 results, a slightly different design was used in 1991. In 1991 only four 1.7 acre pastures were used with the trial conducted only when plants were green and leafy. Treatments included additions of either 0, 1, 2, or 3 seed stalks to plants, and patterns of plant use by

cattle were evaluated each day over a six day grazing trial. Other aspects of the project were similar to the 1990 efforts.

RESULTS & DISCUSSION

1990 Results. When forage was green and growing cattle made significantly ($P<0.01$) less use of plants containing cured seed stalks than plants without any dead material (Figure 1). This selective grazing did not occur, however, after crested wheat plants became dormant, and all standing forage was brown.

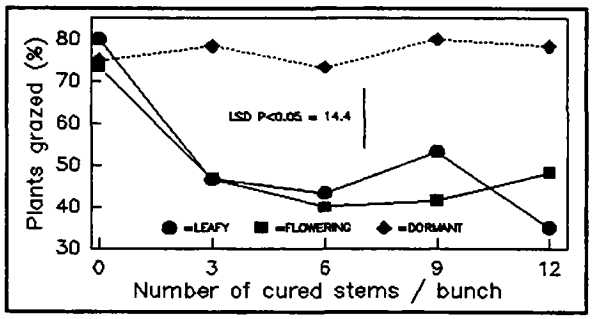


Figure 1

When the forage was green and growing (leafy and flowering) the steers did not discriminate among treatments containing cured stems. That is, they showed the same aversion to plants with three cured stems as they did to those containing 12. With green forage, the probability a plant with no cured seed stalks would be grazed was about 75 percent. The probability of grazing for plants with stems was about 45 percent, regardless of the number of plants present. The overall chance then that a plant with stems would be gazed was about 60 percent of that expected for uncontaminated bunches.

Measures of how much material was removed from plants in the various treatments painted a similar picture. During the leafy and flowering stages of growth approximately 25 percent of the plant's weight was removed from bunches that were free of cured stems (Figure 2). On average, only about 8 percent of the plant's weight was harvested from bunches augmented with stems. This translates to over a 60 percent decrease in amount of material removed from the stemmy plants.

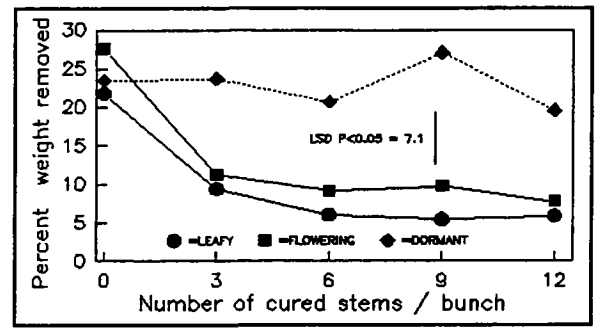


Figure 2

Again, the range in the number of seed stalks present appeared to have little effect. That is, plants with three stems were viewed with the same disdain by cattle as bunches containing 12 cured seed stalks.

In retrospect, our treatments did not have sufficient resolution to establish any lower level of tolerance by cattle for old stems in standing forage. The differences detected in cattle responses among the three stages of growth, however, demonstrated that cattle were not as selective when forage was dormant, and that cattle will most effectively rid a pasture of wolf plants if grazing is postponed until all forage has cured.

1991 Results. The goals of our 1991 efforts were to evaluate cattle reactions to lower numbers of stems (0, 1, 2, and 3 per plant), in hopes of establishing a threshold of response, and to see if grazing behavior changed as pastures were gradually grazed down.

Again measures of number of plants grazed and percent of plant weight removed resulted in similar interpretations. As cured stems were progressively added, cattle grazed fewer of the augmented plants and removed less material from augmented plants that were defoliated (Figure 3). After the first day, 25 percent of the plants with no stems were grazed and only 5 percent of those with stems were grazed. After the 6th day, respective values for these treatments were 95 and 76 percent. Differences among overall treatment means indicated cattle could not discriminate between treatments differing by only 1 stem. Comparisons involving treatments differing by 2 or more stems, however, were significantly different.

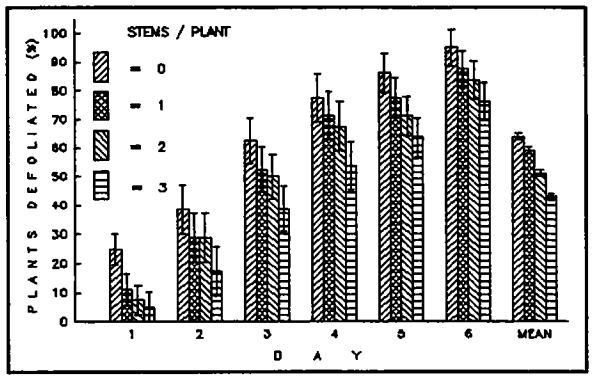
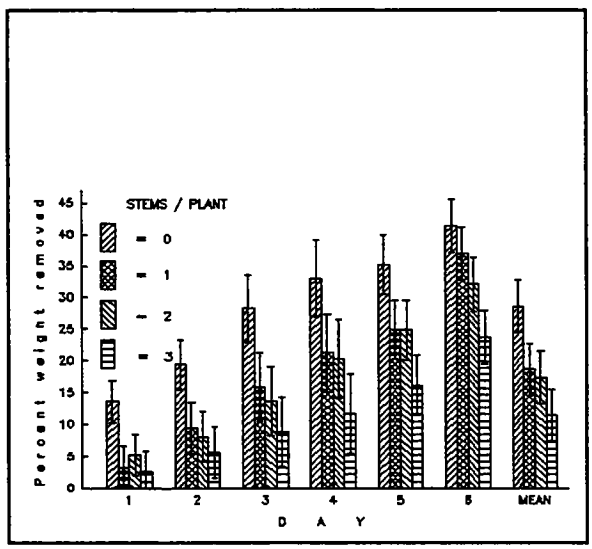


Figure 3

Utilization data implied cattle were aware of even a single cured stem in bunches of crested wheatgrass. With no stems present, roughly 29 percent of plant weight was removed by cattle. Addition of one stem lowered utilization to 19 percent, and three stems reduced it to 11.4 percent (Figure 4). This translates to roughly 35 and 60 percent



reductions, respectively, in amount of herbage removed from the one and three stem

Figure 4

treatments. These reduced levels of utilization initiate build up of even more residual material in bunches, which if not removed, may exacerbate the problem of wolf-plant evolution and even less uniform use of forage in subsequent years.

The mean crude protein content of seed stalks we inserted in the plants was 3.5 percent. When plants were green and growing this lowered the crude protein content of entire plants by 2 to 3 percent. When forage was dormant and brown, crude protein was reduced by only about 1 percent. This being the case, there was some nutritional advantage to be gained by cattle if they avoided contaminated plants or attempted to selectively graze around the cured stems. Extrapolation of these data to the field suggests that most of the forage in wolf-plants will go unused. Out of 100 wolf-plants we find that 60 of the plants will be grazed and 40 will be ungrazed. This gives us 40 units that are not used by the cattle at all. Of the 60 units that the cattle do forage on, they remove only 40 percent as much material as they would from a clean bunchgrass. This amounts to .4 X 60 or 24 units of grass harvested by the animal and 36 units wasted. The loss therefore is approximately 76 percent of the material contained in wolf-plants.

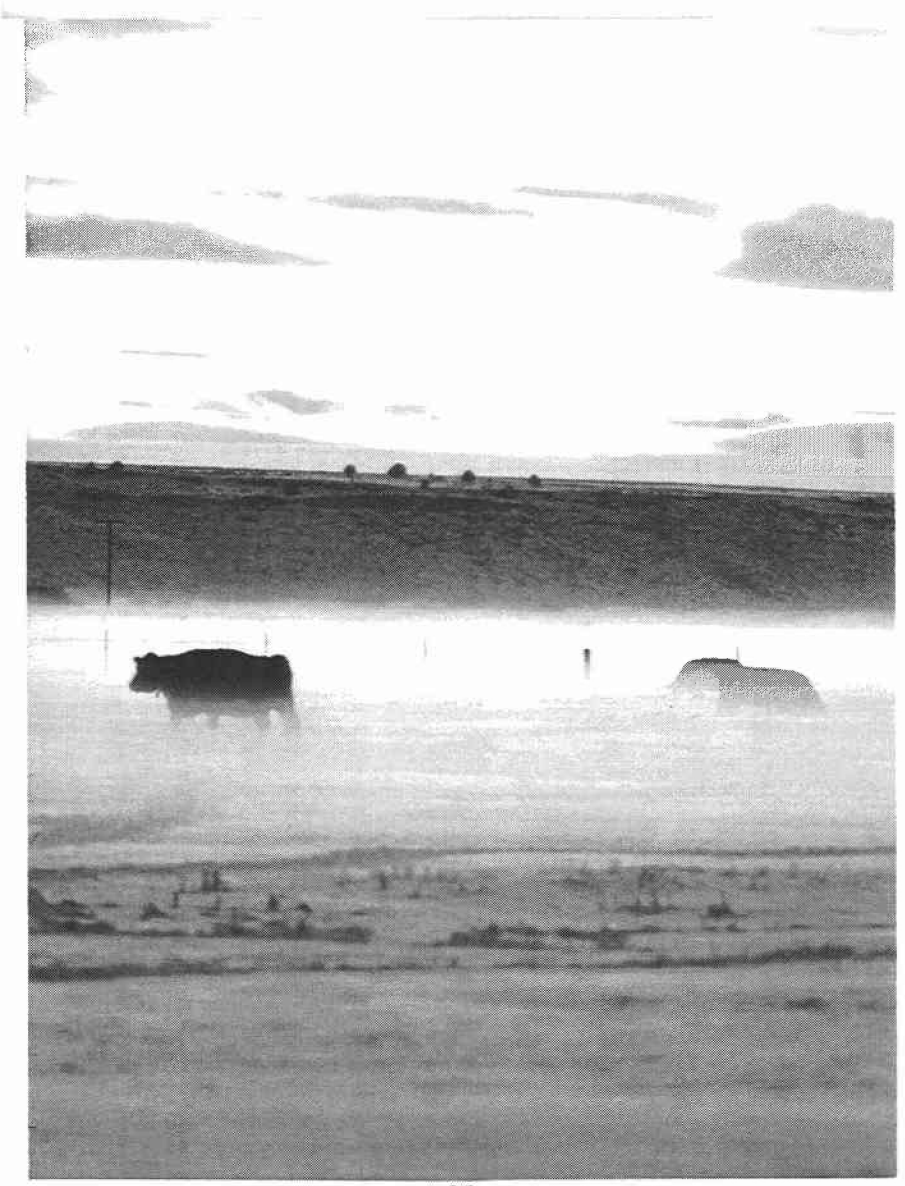
CONCLUSIONS

Cattle were found to be much more sensitive than anticipated to small numbers of cured stems in green and growing bunches of grass. Even one brown seed stalk in a green plant is enough to reduce the probability that a plant will be grazed and the amount of material that the cow will remove from the plant. This emphasizes the importance of obtaining uniform utilization of forages in pastures to avoid development of wolf plants.

Cattle were insensitive to even high numbers of cured stems after plants had gone dormant. This suggest that livestock grazing can be used to clean up pastures supporting wolf plants if grazing is postponed until all forage has cured. Forage quality of grasses is typically deficient this late in the season (4 to 5 percent crude protein) and a nitrogen supplement may be needed if adequate animal performance is desired under such conditions. Other options for clean-up of wolf plants include mowing, if equipment and terrain allow, or possibly burning. Burning, however, may necessitate deferment of a pasture to allow sufficient fuel build up to carry a fire.

Research Projects:

Forage Crops



EFFECTS OF REDUCING DYSTOCIA ON HEIFER PRODUCTIVITY

Harley Turner

SUMMARY: Objectives of these trials were to: 1) measure the effects of reducing or eliminating dystocia through breeding on the productive and reproductive performance of heifers and 2) study the effects of winter nutrition on heifer performance. Longhorn sires reduced dystocia from 36 percent to 1 percent, increased weaning rate from 80 percent to 89 percent, reduced calf mortality from 19 percent to 6 percent, increased production per heifer at weaning from 418 to 486 lb, and tended to shorten calving intervals. Angus sired calves were heavier at birth, 84 vs 73 lb, and born 4 days earlier with no difference in weaning weights.

Breeding heifers to calve at 2 yr of age can increase lifetime beef production. However, heifers at first calving are prone to dystocia. In the absence of dystocia, heifers calving first as 2-yr-olds have a tendency to calve earlier in subsequent years, wean heavier calves, and produce a higher percent calf crop than heifers calving first as 3-yr-olds. However, heifers at first calving are three to four times more likely to suffer dystocia than at second or later calving. Two-yr-old heifers experience prolonged labor and require 1.5 times more assistance during parturition than mature cows. Consequences of dystocia include increased calf mortality, reduced conception at subsequent matings, and increased calving intervals.

In previous research at this station, it was concluded that birth weight of calves and age of heifer were the only factors that significantly impacted dystocia out of a multiple of measures taken. Since most producers like to breed their heifers to calve as 2-yr-olds, and early in the breeding season to help insure they are early calvers during their productive years, this leaves control of birth weight as the only factor involved in dystocia that can be manipulated.

The objectives of this research were to: 1) measure the effects of reducing or eliminating dystocia through breeding on the productive and reproductive performance of heifers and 2) study the effects of winter nutrition on heifer productivity.

MATERIALS AND METHODS

Over a 3 yr period, 203 Hereford x Simmental heifers were stratified by age and weight into four equal groups with the groups then randomly assigned to treatment. Treatments were in a 2 x 2 factorial design with two levels of winter feed and two sire groups. All heifers were wintered on a full feed of an alfalfa-hay mix with one treatment group receiving 2 lb of barley per head per day. Half of the heifers were bred to Angus sires with the others bred to Longhorn sires. Subsequent breedings were to Simmental or Hereford sires.

Heifers were weaned the last week of September or the first week of October each year at a mean weight of 491 lb. Mature weight of this herd at a condition score of 5 is about 1,150 lb. Nutritional treatments were initiated in early December, with breeding commencing in early April. Nutritional regimes were terminated in early May. Prior to breeding, condition scores, utilizing a 1 to 9 system with 1 being emaciated and 9 extremely fat, were estimated by palpating subcutaneous fat over the backbone, ribs, and tailhead. Pelvic area (pelvic height x pelvic width) were also determined at this time. All pelvic measurements were taken by one technician using a Rice Pelvimeter. Height represented the linear distance between the dorsal surface of the cranial end of the symphysis pubis and the ventral surface of the midsacrum, and width represented the

maximum distance between the shafts of the ilia.

Initial and prebreeding weights were taken after an overnight restriction from feed and water. Birth weights were taken within 24 hr of parturition. Conception data were recorded utilizing rectal palpation during the fall. Open heifers were culled. Calves were dropped during late January to late March with a mean calving date of February 1. Subsequent parturitions were about a week later. Severity of dystocia was scored as follows: 1) no difficulty, birth unassisted; 2) slight difficulty, nonmechanical assistance required; 3) considerable difficulty, hard pull by hand or mechanical assistance required; 4) extreme difficulty requiring caesarean section. For statistical analyses all calves were lumped into assisted and unassisted groups.

RESULTS AND DISCUSSION

Productive and reproduction performance of heifers by treatment is presented in Table 1. High energy produced higher winter gains ($P<.05$) and resulted in an increased condition score ($P<.10$). Pelvic areas were similar. Subsequent gains were reversed with heifers from the low level compensating and outgaining those from the high level ($P<.05$). Heifers from the low energy groups were 15 lb heavier at weaning time. Energy level did not have an effect on any of the productive or reproductive measures on the first calf or subsequent calves. Heifers from the low energy level were 65 percent of their eventual mature size at breeding, so additional energy would not be expected to provide positive results and could have possibly created negative effects. Economically, the results from high energy were negative due to the cost of supplemental feeding.

Direct comparisons between the use of Longhorn or Angus sires are presented in Table 2. Dystocia was reduced from 36 percent with Angus breeding to virtually 0 with Longhorn breeding. Only one calf was assisted out of 94 calving with the Longhorn breeding. That calf was assisted at 1 a.m. and likely would not have needed help, but the herdsman wanted to go to bed, so went ahead and provided assistance. Birth weight was reduced by 11 lb with Longhorn breeding and calving date delayed by 4 days. This could be due to a longer gestation period for the Longhorns, or delayed breeding. Weaning weights were 11 lb heavier for the Angus calves, which is the same weight advantage they held at birth. So with the 4 days difference in age, the Longhorn sired calves slightly outgained the Angus sired calves up to weaning. In addition to requiring no assistance at birth, none of the Longhorn calves required assistance in nursing or medication due to calfhood maladies. Nearly 50 percent of the Angus bred heifers or their calves required attention of some kind.

Weaning rates favored the Longhorn bred heifers by 9 percent. Initial conception rates were 5 percent less in the Longhorn group, so calf survival was actually 14 percent higher at weaning than in the Angus sired group. Production per heifer up to weaning favored the Longhorn group by 68 lb. Calving interval was 5 days less in the Longhorn bred group ($P<.10$), with no differences in second calf conception rate or weaning weight. Second calf dystocia was 7 percent higher in the group previously bred to Longhorns with 2 percent of the previously bred Angus groups being repeats. So it appears the Longhorn breeding may have delayed dystocia problems in 5-10 percent of the heifers. Conception rates for the third calf favored those from the Longhorn groups by 8 percent. Weaning rate of the second calf was only 4 percent in favor of the Longhorn group, however heifers losing calves were retained and rebred. This number represents the percentage of heifers that weaned a second calf in relation to the number that started the trial.

A comparison between heifers that experienced dystocia and those that didn't are presented in Table 2. There was no difference in pelvic measurement, condition score, nor size of heifer between the groups, with pelvic measurement being 183 cm^2 for each, and heifer weight 816 and 818 lb respectively, for those requiring assistance and those calving on their own. Birth weight was 29 lb heavier in the dystocia group. This data agrees with previous results. Heifers

experiencing dystocia had 62 percent bull calves as opposed to 47 percent in the other group. This fits the birth weight data in that bull calves are heavier than heifer calves and experience more severe dystocia problems. Heifers calving on their own had 19 percent higher weaning rates, with weaning weights being similar. Production per heifer at weaning favored the unassisted heifers by 103 lb. Calving interval, conception rate, and weaning rate of the second calf was not different (P>.05). However, heifers that lost calves were retained and rebred.

Conception rates for the third calf were 16 percent less in the heifer group that experienced dystocia problems on their first calf. This data agrees with other unpublished data from this research station. The delayed effect on conception rates of initial dystocia has been consistent over 3 yr at two different locations.

In summary, reducing dystocia through breeding improved calf survival, weaning rate, and subsequent conception rates without reducing weaning weights. Production per heifer on the first calf was improved by 68 lb using Longhorn sires on heifers as opposed to Angus sires. Energy level had no effect on reproductive performance of the heifer or calf weights.

CONCLUSIONS

Dystocia can be virtually eliminated in first calf beef heifers through breeding. By utilizing Longhorn sires, the resulting increase in calf survival, calf health, shortened calving intervals, and increase in subsequent conception rates in conjunction with unaffected weaning weights, dramatically improved heifer productivity. Deleterious effects of dystocia were still evident in the form of reduced conception rates and delayed calving dates on the third breeding. Expenses were also reduced dramatically in Longhorn sired heifers and their calves. Labor required for assistance during parturition was virtually eliminated as well as assistance in getting up, nursing, warming up, and handling to provide medication for various calf maladies.

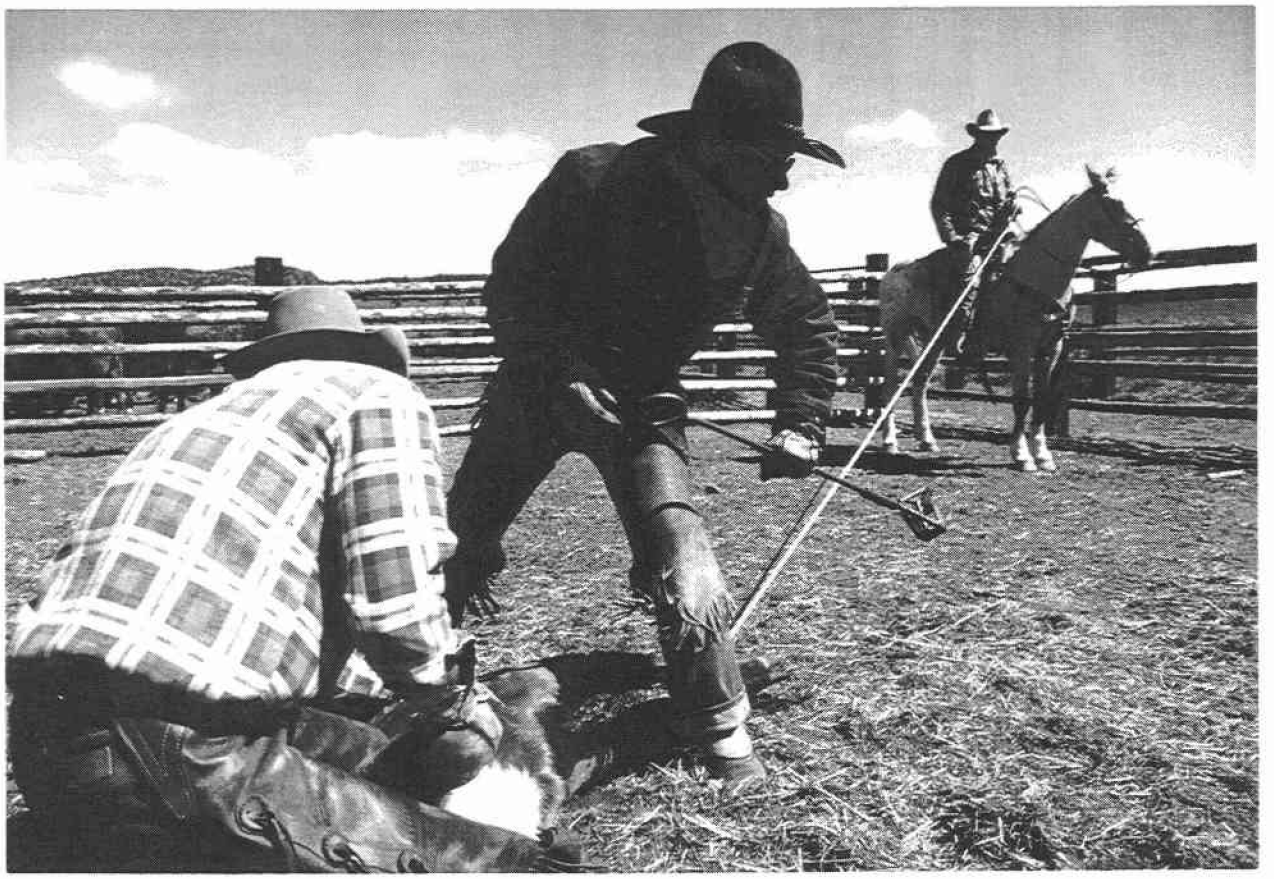


Table 1. Productive and reproductive performance of heifers by treatment.

	Treatment				
	High energy		Low energy		
Item	Longhorn	Angus	Longhorn	Angus	SE[a]
Number	50	51	50	52	
Initial wt lb[b]	541	543	548	539	
Prebreeding gain (lb)[c]	220[h]	222[h]	205[i]	207[i]	4.2
Condition score (1-9)	6.1	6.0	5.9	5.9	.03
Pelvic area (cm^2)	181	185	183	180	
Final wt (lb)[d]	827	825	814	805	
Conception rate (%)	92	100	96	98	
Calving date (Julian)	34[h]	29[i]	32[h]	29[i]	2.1
Birth wt (lb)	73[i]	86[h]	73[i]	81[h]	1.5
Dystocia (%)	0[i]	39[h]	2[i]	33[h]	.04
Weaning wt (lb)[e]	517	543	539	535	9.2
Final wt to weaning gain (lb)	194[h]	191[h]	229[i]	218[i]	8.8
Heifer wt at weaning (lb)	1,021	1,016	1,043	1,023	
Weaning rate (%)	88[h]	80[i]	90[h]	79[i]	.04
Production per heifer (lb)[f]	482	418	491	418	
Calving interval (d)	384	390	387	392	3.1
Conception rate #2 (%)	84	86	80	82	.07
Birth wt #2 (Kg)	81	86	84	84	1.6
Weaning wt #2 (lb)	497	506	499	517	12.1
Weaning rate #2 (%)[g]	70	65	66	63	
Dystocia #2 (%)	8	6	11	0	.04
Conception rate #3 (%)	80	66	86	83	.07

[a]Standard error.
[b]Initiation of energy levels in early December.
[c]Gain from initial wt to breeding in early April.
[d]Weight at termination of energy levels in early May.
[e]Sex adjusted weaning wt.
[f]Based on actual weaning wt and calf survival and assuming equal initial conception rates.
[g]Represents calves weaned in year 2 compared to total number of heifers at the start of the trial.
[hi]Row means without common superscript differ, P<.05.

Table 2. Reproductive and calf performance data comparing sire type and heifers experiencing dystocia vs the others.

Item	Longhorn		Angus	SE[a]	Dystocia		Unassisted
Number	100		103		38		161
Conception rate (%)	94		99		97		96
Calving date (Julian)	33	**	29	1.5	31		31
Birth wt (lb)	73	**	84	1.0	88	**	77
Dystocia (%)	1	**	36	.04	100	**	0
Weaning wt (lb)[b]	528		539	6.4	530		535
Weaning rate (%)	89	**	80	.02	68	**	87
Production per heifer (lb)[c]	486		418		361		464
Calving interval (d)	386	*	391	2.1	390		388
Conception rate #2(%)	82		84	.04	84		83
Weaning wt #2 (lb)	499		513	8.4	486		508
Weaning rate #2(%)[d]	68		64		66		66
Dystocia #2(%)	10		3	.02	2		11
Conception rate #3(%)	83		75	.04	72	*	88

[a]Standard error.
[b]Sex adjusted weaning wt.
[c]Based on actual weaning wt and calf survival and assuming equal initial conception rates.
[d]Represents calves weaned in year 2 compared to total number of heifers at the start of the trial.
*Significant at P<.10.
**Significant at P<.05.

Diet and Performance Of Steers Grazing Eastern Oregon Native Flood Meadows

Ray Angell, Harley Turner, and Dave Blount

SUMMARY: This experiment compared strip (SG) and continuous grazing (CG) effects on livestock diet quality and performance. Biweekly diet samples and fecal collections showed that over the grazing season, crude protein in CG diets tended to be higher than SG (P=0.14), at 13.9 and 10.9 percent, respectively. Crude protein declined significantly between May and September. Digestibility of diets varied between treatments (P=0.07), at 64.6 and 60.7 percent on CG and SG, respectively. Meadows foxtail was the most common grass on the meadows, and was more frequent in SG diet samples (P=0.05). Forage intake was similar (P=0.42) for both treatments, at about 2.1 percent of body weight per day. Steers were weighted biweekly. Steer average daily gain (May to Sept.) was greater under CG (P=.09) (2.5 lbs/day) than SG (1.7 lbs/day). Growing cattle performed very well on native meadows containing meadows foxtail. Grazing is a viable option that may provide increased economic returns to livestock producers.

Native flood meadows (NFM) are used to produce hay and are irrigated by stream flow. In the Harney Basin, control of water is minimal, resulting in an uncontrolled flooding system that often prevents haying until forage has become mature. Traditional management involves haying in summer, with grazing of aftermath and regrowth in the fall, prior to winter hay feeding. Meadows are often fertilized with nitrogen in early spring, with hay yields of about 3,500 lb/ac. Regrowth potential after haying is low because soils are dry, and native species present do not provide adequate regrowth. Recent changes in meadow composition have changed this picture however. Introduced grasses are better able to regrow after clipping in early summer.

Meadows in this area were historically dominated by rushes (*Juncus*) and sedges (*Carex*), but have recently shifted to stands dominated by an introduced species, meadow foxtail (*Alopecurus pratensis*). Meadow foxtail grows early in spring and produces high yields, however it often reaches maturity in mid-to late June. Inability to control timing and duration of surface flooding usually prevents cutting for hay until early to mid-July, resulting in a lower quality hay.

Grazing of meadows containing meadow foxtail appears to be a viable alternative to harvesting for hay only. Objectives of this research were to determine diet quality, diet botanical composition, forage, intake and animal performance of steers grazing meadows with either strip (SG) or continuous (CG) grazing management.

MATERIALS & METHODS

Study Area. The Eastern Oregon Agricultural Research Center is 5 miles south of Burns, Oregon. The dominant grasses are meadow foxtail, saltgrass (*Distichlis stricta*), reed canarygrass (*Phalaris arundinacea*), quackgrass (*Agropyron repens*), and Nevada bluegrass (*Poa nevadensis*). Sedges and rushes are also important components. Common forbs include hesperochiron (*Hesperochiron pumulus*) and common dandelion (*Taraxacum officinale*), with arrowgrass (*Triglochin maritima*) scattered in small quantities throughout the pasture.

Treatments. In April, the meadow was fenced into four equal pastures of about 14 acres. Continuous (CG) and Strip (SG) grazing treatments were applied. Steers on

CG had access to the entire pasture at all times, while animals on SG treatments were restricted to strips by portable electric fencing.

Animals. Eighty yearling steers (556 lb) were stratified by weight into four groups, with each group randomly assigned to treatments. Weight change was determined for each group by weighing 15 steers after overnight restriction from feed and water. At weaning the previous fall, steers had received clostridials, infectious bovine rhinotracheitis, and bovine viral diarrhea vaccinations. Prior to placing animals on treatment all steers received zeranol, and were revaccinated for clostridials.

Sampling. Diet sampling was conducted approximately biweekly, to coincide with the second day of grazing in each strip. Collections were made in each pasture on two consecutive days. Nitrogen percentage of diets was determined by macro-kjeldahl digestion and reported as crude protein (CP=N x 6.25). Digestible dry matter (IVDDM) was determined by 48-hour *in vitro* digestion. Total fecal collections began the day following diet collections. Fecal bags were placed on the animals by 7 a.m. and remained in place for 24 hours. Upon removal fecal bags were weighed and the quantity of feces determined.

RESULTS AND DISCUSSION

Diet Quality. Dietary CP and IVDDM both declined significantly (P<.05) over the summer (Table 1), which is a typical result of advancing plant maturity. Between CG and SG treatments, seasonal means for CP tended to differ (P=0.14), at 13.9 and 10.9 percent, respectively. Likewise, digestible DM was higher (P=.07) in CG steer diets than SG (P=.07), at 64.6 percent vs 60.7 percent, respectively.

Diet quality of steers on SG was significantly lower than for CG steers from June 26 to August 7, because regrowth from strips grazed in May and early June had matured. Soil water was still adequate to allow plant growth, and probably enhanced diet quality for steers on CG pastures. Diet quality did not differ between treatments in late August. At that time SG steers were grazing forage that had been previously grazed in late June. That forage had not reached maturity because decreased soil water had limited growth during July.

Botanical Composition of Steer Diets. Strip grazing increased (P=.06) grass percentage in steer diets (Table 2), which is consistent with other reports of floristic changes in animal diets under intensive grazing management.

The rush and sedge component of steer diets tended to be greater for CG animals (63%) than for SG (49.0%) (P=.14). Forbs represented only minor amounts in steer diets (<1%), and no differences were detected in forb consumption between treatments. Meadow foxtail was significantly greater (P=.05) in SG (43.9%) than in CG (27.1%) diets. Regrowth potential of native sedges and rushes is low but meadow foxtail has been shown to produce regrowth. Therefore, strip grazing may have increased the standing crop of meadow foxtail relative to sedges and rushes, and influenced percentages of grass in steer diets.

Intake and Performance. Daily DM intake was analyzed as lb DM/d on a percentage of body weight (BW) basis. There was no difference between treatment means (Table 3) for daily DM intake (P=.42), at 2.0 and 2.1 percent of BW for SG and CG steers, respectively. Intake (lb DM/d) increased between May and September as a result of increased body mass and rumen capacity. Mean ADG was 2.4 lb for continuous, and 1.8 lb under strip grazing. Increased performance exhibited by CG steers is likely a result of the higher plane of nutrition noted previously. In our study, superior individual steer performance under CG was offset by the smaller pasture area grazed under SG management (14 vs 10 acres, respectively). Gain per acre did not differ between treatments when compared on a total production basis (P=.17), at 25 and 20 lb/ac for CG and SG, respectively.

CONCLUSIONS

Strip-grazing management tended to increase grass consumption and contributed to a 39 percent relative increase of meadow foxtail in steer diets compared to CG management. Individual animal performance tended to be greater for CG steers, which is consistent with the observed plane of nutrition. However, total animal gain per hectare was similar between management systems because pasture area utilized by SG steers during the study was less than for the CG treatment. Increases in diet quality were noted in late August when SG animals were grazing areas that did not have high levels of regrowth, and had remained vegetative. This might indicate that if animal demand had been increased to shorten rotation interval, diet quality might have improved for SG animals in July. This study demonstrated that native flood meadow vegetation containing meadow foxtail can produce excellent animal performance, and that strip grazing will provide similar animal gain/ha while reducing the total land area required. Further research is needed at several stocking rates to determine the effect of increased stock density on performance of steers grazing wet meadows in spring.

Table 1. Crude protein (CP) and in vitro digestible dry matter (IVDDM) of steer diets on continuous or strip grazing systems.

	Continuous		Strip	
Date	CP	IVDDM	CP	IVDDM
May 15	18.7	76	17.2	74
May 29	16.4	70	13.7	69
June 12	15.3	68	12.8	66
June 26	13.9**	66**	9.4	57
July 10	13.7*	65*	9.6	60
July 24	12.8**	62**	8.6	53
Aug 7	12.2**	60**	7.5	52
Aug 21	8.5	54	7.1	55
Sept 4	13.8	59	12.5	60

Asterisks (* or **) indicate grazing treatments differ at P=0.05 or 0.01, respectively.

Table 2. Major components of steer diets while grazing native meadows under either strip (s) or continous (c) grazing management.

	Foxtail		Grasses		Rush/Sedge	
Date	C	S	C	S	C	S
5/15	13	23	3	1	81	75
5/29	29*	46	4	1	32	48*
6/12	32*	56	2	0	34	36
6/26	33	44	3	4	36	47
7/10	23	13	4	6	27	79*
7/24	23	14	9	9	32	74*
8/7	43	51	5	6	48	42
8/21	23*	82	28*	2	51	16*
9/4	23*	68	12	8	35	24

* Means within a forage category and ate differ at $P<0.05$.

TABLE 3. Dry matter (DM) intake (percent of body weight), average daily gain (ADG) and total gain per acre of steers under strip or continuous grazing of native flood meadows May 1 - Sept 4, 1989.

	Treatment		
Item	Continuous	Strip	SEM[c]
DM Intake	2.1%	2.0%	
ADG (lbs)	2.6[a]	1.8[b]	0.4
Total gain[d]	23.3[a]	19.7[a]	0.4

[a,b] Means within rows differ ($P<.10$) when followed by different letters.

[c] Standard error of the mean calculated from treatment by block (error a) and treatment by block period within period (error b: n=16.

[d] Based on total seasonal grazed areas of 13 and 6.5 acres for continuous or strip treatments, respectively.

Nutritional Quality of Grass Seed Residues Harvested for Livestock Feed in Western Oregon

Michele Stamm, Tim DelCurto, Marc Horney, Kelly Brandyberry and Roxane Barton

SUMMARY: A survey of nearly 300 fields of grass seed straw was conducted to address questions regarding the nutritional quality of grass seed residues. Based on this survey, bentgrass, perennial ryegrass and tall fescue had chemical compositions that indicate higher nutritional quality compared to orchardgrass and annual ryegrass. Bentgrass had favorable crude protein and fiber characteristics despite reaching maturity late in the season and higher rainfall. Orchardgrass and annual ryegrass displayed lower crude protein and higher fiber content, which would limit intake and digestibility of these straws when used as a livestock feedstuff.

The potential use of grass seed residues as a alternative winter feedstuff is not a new concept, however, currently only a small fraction of these crop residues are used as a domestic livestock feed. The lack of information and/or industry knowledge regarding the nutritive quality of residues is a primary factor limiting its use as a livestock feed resource. Dramatic changes, however, are occuring in the grass seed and beef cattle industry that may integrate these industries in regard to grass seed residues.

In the grass seed industry, air pollution concerns dictate a search for alternative methods of sanitization of grass fields and disposal of straw residue. Likewise, in the beef cattle industry, large amounts of capital, as well as, meadow acreages are devoted to the production of hays for feeding cattle during the winter months. Additionally, concern over the use of public rangelands may force the beef cattle industry to rely more solely on private rangelands and hay meadows in the near future. Therefore, the increased use of grass seed residues as a livestock feed resource may provide solutions to problems plaguing two of Oregon's most important agricultural industries.

The objectives of the following study were to survey Willamette Valley grass seed residues for 1) nutritional quality, 2) harvesting factors that may influence nutritional quality, and 3) the presence of antiquality factors (ergovaline) in tall fescue and perennial ryegrass residues.

MATERIALS & METHODS

In mid-April of 1991, the Agricultural Fiber Association, an organization composed of baling contractors and grass seed growers, was consulted to obtain a group of baling cooperators who would be willing to participate in the summer sampling of grass seed straws. The twelve baling contractors who agreed to participate were based in both the north and south ends of the Willamette Valley. Each day between 6 a.m. to 7 a.m., during the months of July to mid September, these baling contractors were contacted by telephone to receive daily field baling locations that encompassed a seven county area (Clackamas, Benton, Polk, Linn, Lane, Marion, and Yamhill counties). Grass species sampled included tall fescue (*Festuca arundinacea* Shreb.), orchardgrass (*Dactylis glomerata* L.), perennial ryegrass (*Lolium perenne* L.), annual ryegrass (*Lolium multiforum*), and bentgrass (*Agrostis* L.). Perennial ryegrass composed 46.3 percent of the total samples (136 samples), followed by tall fescue at 41.5 percent (122 samples), bentgrass at 8.8 percent (26 samples) and all other grasses at 3.4 percent (Table 1). Bales were sampled randomly from either stacks or individual bales throughout the field. Enough straw was removed to provide 150 g of sample when ground through a 1 mm Wiley Mill screen (10 to 20 cores per sample). Samples were given identification numbers, identifying the sample by grass species and variety, seed producer, baling contractor, and field location. After the completion of the grass seed harvest, letters and questionnaires were sent to seed producers to obtain background information on the seed field.

RESULTS & DISCUSSION

Background Information. Orchardgrass and

annual ryegrass had the earliest harvest dates for the species sampled, followed by tall fescue, perennial ryegrass, and bentgrass (Table 1) during the 1991 baling season. Annual ryegrass had the shortest time length from swathing to baling, followed by orchardgrass, bentgrass, tall fescue, and perennial ryegrass. In terms of precipitation, bentgrass residues were exposed to the highest levels due to rainfall occurring in late August and early September, during the time this grass species was harvested. Annual ryegrass, was exposed to the lowest amount of precipitation, followed by orchardgrass, perennial ryegrass and tall fescue.

This information was gathered to assist prospective cattle producers who would consider buying straw as a winter livestock feed. These variables can be used as general guidelines in purchasing straw. Knowledge about precipitation is very important, since it can have a large impact on the nutritional quality of straw. In addition, knowledge about when certain grass species reach maturity, and how long until they are baled, can help a producer in planning when to buy a specific species of straw, as well as make transportation and storage arrangements ahead of the time of purchase.

Crude Protein. The range of 6 to 8 percent crude protein (CP) has become a common standard from which to gauge the need for protein supplementation when feeding a particular feedstuff. In this survey, tall fescue, bentgrass, and perennial ryegrass had higher mean CP levels as compared to orchardgrass and annual ryegrass (Table 1). However, these feeds are all deficient in protein and will require some form of protein supplementation.

Traditionally, grass seed straws were put in the same class as cereal grain straws as having low CP levels. In actuality, these levels are higher in comparison to cereal grain straws, which range from 2 to 4 percent CP. Although grass seed straws have higher protein levels, these straws do require some form of protein supplementation, but the amount is relatively small as compared to that required for feeding cereal grain straws. The primary reason most grass seed straws have a higher protein level, as compared to cereal grain straws, is due to a greater leaf content in grass seed straws. Greater leaf to stem ratios are due, in part, to the fact that most grass seed species are perennial crops, whereas cereal grains are annual crops. Stems are often of a lower quality than leaves in mature forage due to increases in lignified structures in stems as compared to leaves.

Acid Detergent Insoluble Nitrogen. Acid detergent insoluble nitrogen (ADIN) gives an indication of the amount of unavailable nitrogen in a particular feedstuff. It yields mainly lignified nitrogen or the amount of nitrogen (CP) that is unavailable for ruminant digestion. Grass seed straws in this survey had low levels of ADIN, even though straw is a highly lignified feedstuff. Tall fescue had the lowest mean ADIN levels, with perennial ryegrass, annual ryegrass, and bentgrass being intermediate, and orchardgrass having the highest levels of ADIN ($P<.05$) (Table 4). Acid detergent insoluble nitrogen levels are expressed as a percentage of the total nitrogen in a sample. A higher percentage of the protein in these straws is available for microbial digestion. In addition, the ADIN levels reported in grass straws are comparable to low quality meadow or grass hays.

Fiber Constituents: Neutral Detergent Fiber and Acid Detergent Fiber. Bentgrass, perennial ryegrass, and tall fescue had similar neutral detergent fiber (NDF) levels as compared to orchardgrass and annual ryegrass ($P<.05$) (Table 5). Neutral detergent fiber measures plant cell wall constituents, such as cellulose, hemicellulose, and lignin, which are partially digestible due to microbial breakdown. Plant cell wall constituents are the primary determinant of intake potential.

Acid detergent fiber (ADF) components mirrored NDF. Bentgrass had a lower percentage ADF as compared to the other four species, with orchardgrass and annual ryegrass having the highest ADF levels ($P<.05$) (Table 1). Acid detergent fiber analysis digests the hemicellulose and cell wall proteins, leaving the cellulose, lignin, and lignified nitrogen as a residue. This analysis indicates the relative digestibility of forages, with higher ADF levels being correlated to lower digestibility.

In vitro dry matter digestibility. In vitro dry matter digestibility measures the availability of feed to rumen bacteria or animal digestive

Table 1. Nutritional Quality and Harvest Conditions for Willamette Valley Grass Seed Residues[a]

Item	Bentgrass	Perennial Ryegrass	Tall Fesue	Annual Ryegrass	Orchardgrass
Fields Sampled	26	136	122	5	5
Harvest Factors:					
Harvest Date	Aug. 4	Jul. 22	Jul. 12	Jul. 8	
Swath to Baling	19.9	23.3	20.7	9.5	11.5
Precipitation	1.2	.6	.7	.5	
Crude Protein:					
Range	3.9-7.0	3.6-9.4	3.7-8.9	4.3-5.2	3.7-5.7
Mean	5.4	5.3	5.6	4.7	4.8
SD	.91	.88	.90	.35	.95
ADIN:					
Range	13.1-25.3	5.1-23.0	7.3-20.7	12.6-22.8	15.6-21.4
Mean	16.6	15.5	12.8	16.4	
SD	2.69	3.03	2.63	4.17	
NDF:					
Range	56.6-76.3	60.5-74.2	62.1-76.6	65.3-80.5	64.3-70.6
Mean	63.7	65.8	67.9	72.8	68.2
SD	3.71	2.79	3.19	6.97	2.75
ADF:					
Range	34.1-40.8	37.9-49.0	39.9-52.9	41.8-52.0	46.2-49.9
Mean	37.9	41.6	43.8	47.8	47.2
SD	1.68	2.05	2.50	4.84	1.52
IVDMD:					
Range	47.7-59.5	43.5-61.5	36.3-62.4	46.5-56.4	46.1-50.7
Mean	55.0	55.5	53.9	51.1	48.7
SD	3.24	3.28	4.14	3.86	1.87

[a].Nutritional quality was based on the following measures; CP = crude protein, ADIN = acid detergent insoluble nitrogen, NDF = neutral detergent fiber, ADF = acid detergent fiber, IVDMD = invitro dry matter digestibility. Precipitation was a measure of exposure of the residues between swathing and baling/storage.

enzymes; it is highly correlated to true digestibility. In this survey, perennial ryegrass and bentgrass had the highest in vitro dry matter digestibilities compared to annual ryegrass and orchardgrass, with tall fescue being intermediate ($P<.05$) (Table 1). Therefore, as expected, straws that have a higher fiber content also displayed a lower digestibility.

Ergovaline concentration. Ergovaline is an ergopeptide alkaloid produced by the fungal endophyte, *Acremonium coenophialum*. This endophyte has been introduced into some turf-type tall fescue and perennial ryegrass varieties because of the potential increases in plant hardiness, pest resistance, and drought tolerance imparted by this fungus.

Ergovaline has been implicated in producing deleterious effects when consumed by livestock, particularly ruminant animals and horses. Effects on ruminants include lowered prolactin levels, increased respiration rates, long-dull-rough hair coats, lower feed intakes, lower weight gains, higher rectal temperatures, decreased heart rates, decreased skin surface temperatures of the extremities such as ears, tails, and lower legs, fat necrosis, fescue foot, decreased ruminal fiber digestion, and increased sensitivity to heat. In horses, alkaloid consumption has caused reproductive

Table 2. Ergovaline Content of Tall Fescue and Perennial Ryegrass Varieties[a]

Species	Variety	Number of samples	Range (ppb)	Mean (ppb)	Standard Deviation
Tall Fescue	Arid	8	0-115	35.6	50.1
	Clemfine	3	0-345	201.7	179.8
	Falcon	9	0-130	33.3	48.3
	Mustang	5	85-140	102	22.0
	Rebel II	4	25-210	118.8	75.7
	Titan	6	105-945	551.7	347.7
	Tribute	3	365-680	511.7	158.6
	Trident	5	56-194	123.4	50.9
Perennial Ryegrass	C-21	6	0-90	44.7	37.1
	Charger	4	55-200	128.8	69.7
	Cowboy	4	185-500	362.5	141.8
	Dasher II	3	80-765	386.7	348.1
	Envy	3	60-85	70	13.2
	Fineleaf	5	50-225	109.6	71.5
	Linn	4	75-210	118.8	62.8
	Manhattan II	4	390-790	582.5	199.5
	Palmer	5	105-185	129	32.3
	Pinnacle	3	0-430	181.7	222.6
	Pennant	3	33-425	196	204.2
	Premiere	6	0-440	111.3	165.5
	Riveria	3	400-410	405	5.0
	Seville	3	393-645	502.7	129.1
	SR 4100	5	255-550	378	111.6
	SR 4200	4	240-450	338.8	86.3
	Sunrye	6	0-478	270.5	183.2

[a] Only varieties with three or more samples are reported here.

problems such as agalactia, thick placentas, spontaneous abortions, dead or weak foals at birth, and rebreeding problems. The feedstuffs utilized in these research studies have been seeds, moderate-to-good quality hays, and pastures. No data exists on alkaloid content in grass seed straw.

In this survey, mean ergovaline concentrations for tall fescue and perennial ryegrass were 86 and 214 ppb, respectively. Of the fescue fields sampled, 14 percent had ergovaline levels greater than 200 ppb while 42 percent of the perennial ryegrass contained ergovaline levels greater than 200 ppb. A list of the tall fescue and perennial ryegrass varieties with measurable ergovaline levels is shown in Table 2. All the varieties in the table are turf-type grasses with the exception of Linn perennial ryegrass, which is a forage-type grass. Identification of tall fescue and perennial ryegrass varieties that may contain high alkaloid levels is important when utilizing these straws as a feed. This research suggests high variation within varieties. For example, Titan tall fescue has a alkaloid concentration range from 105 to 945 ppb, with a standard deviation of $\pm$ 347.7. Thus, the identification of species varieties does not tell the whole story. There is a need to identify factors that influence ergovaline concentration beyond variety.

CONCLUSIONS

Not surprisingly, the grass seed residues harvested in the greatest amount for livestock feed are also the residues of the greatest nutritional value (perennial ryegrass, tall fescue and bentgrass). Ergovaline alkaloid is present in tall fescue, perennial ryegrass, and other fescues. However, only a small percentage of tall fescue had levels that indicate a cause for concern. The following report pertains to the feeding of high alkaloid residues on beef cattle nutrition, health, and performance.

Influence of Alkaloid Concentration of Tall Fescue Straw on the Nutrition, Physiology and Subsequent Performance of Beef Steers[1]

Michele Stamm, Tim DelCurto, Marc Horney, Steve Brandyberry and Roxane Barton

Summary: Under the conditions of these studies, the endophyte-produced alkaloids associated with tall fescue straw did not cause health problems or reductions in animal performance. Dry matter intakes and digestive efficiencies were similar across all levels of alkaloids. In addition, no evidence of vasoconstriction or other physiological symptoms associated with fescue toxicosis were observed. Therefore, these studies suggest that properly supplemented low-quality straws up to 475 ppb ergovaline can be fed in winter feeding programs for growing and early to mid-gestating cows without depression in animal health, nutrition, or performance.

Circulating Prolactin levels were decreased, however, with high endophyte/alkaloid straw diets, indicating a possible subclinical effect. This observation suggests that further research is needed to evaluate the effects of high endophyte/alkaloid straw diets when fed to late gestating and lactating beef cattle.

The presence of the fungal endophyte, *Acremonium coenophialum*, in tall fescue (*Festuca arundinacea* Schreb.), has been implicated in reduced animal performance and animal health problems such as fescue foot and fescue toxicosis. These animal performance/health problems are actually caused by alkaloids produced by a fungus that has been intentionally bred into many types of grasses. The fungal endophyte improves plant vigor, as well as resistence to disease and pests. Thus, if the grass species is not intended for livestock consumption, presence of the endophyte actually offers agronomic advantages.

In the Pacific Northwest, a large volume of tall fescue grass seed residue is produced (over 200,000 tons) and has potential use as a winter feedstuff, but concern over the presence of the endophyte, and nutritional quality has curtailed its utilization. In addition, recent research has indicated perennial ryegrass straw also contains substantial amounts of fungal produced ergovaline. To date, most of the endophyte alkaloid research has focused on forages, seeds, and moderate-to-good quality tall fescue hays. No research has been conducted to evaluate the feeding of straw with high alkaloid concentrations and its subsequent effect on animal performance. In addition, very little is known about whether the consumption of a high-endophyte-containing straw by cattle during the winter can induce fescue toxicosis symptoms, specifically vasoconstriction of the extremites. Therefore, this research was conducted to evaluate the effect of alkaloid concentration in feeding high-endophyte-infected tall fescue straw on nutrition, physiology, and subsequent performance of beef cattle.

Materials and Methods

Harvesting and Treatment of Residues. Two varieties of tall fescue straw (Bonanza and Titan turf-type) were selected to assess endophyte effects on beef cattle nutrition and performance. The two varieties were similar genetically and phenotypically, but differed in alkaloid concentrations. The Bonanza straw came from a third year stand and was baled 15 d after seed harvest. The Titan straw came from a second year stand and was baled 27 d after harvest. Both varieties were grown in the Willamette Valley of Oregon and are common varieties grown for seed crop production. Windrows were not raked before baling. Both

[1]Appreciation is expressed to the Agricultural Fiber Association and the Linn-Benton Regional Strategy for partial funding of this study. In addition, appreciation is expressed to Holly Imbach for providing technical assistance during the data collection aspects of these research trials.

Table 1. Chemical Composition[a] of feeds (Exp. 1 and 2)

Item	Titan	Bonanza	Alfalfa pellets
CP, %	6.3	5.3	19.4
ADIN[b], %	9.4	11.6	5.5
NDF, %	67.4	71.1	50.5
ADF, %	44.6	49.2	34.1
IADF[c], %	23.4	28.0	20.5
Ergovaline, ppb	475	0	

[a] Chemical compostion expressed on a DM Basis.
[b] Expressed as a % of total nitrogen.
[c] IADF = indigestible acid detergent fiber.

straw varieties were stored in hay sheds until being trucked to Burns, after which bales were stored in stacks until chopping and feeding occurred. Straw was chopped every three weeks and stored in covered hay sheds. Because the two varieties of tall fescue straw differed in CP concentration (avg CP 7.1% and 4.9% for Titan and Bonanza, respectively), second cutting alfalfa (CP = 18.9%) was chopped and mixed with the Bonanza straw (16% alfalfa to 84% Bonanza tall fescue) to ensure isonitrogenous diets. Chemical analysis of the straws composited across time are listed in Table 1. Samples of each straw were analyzed by high performance liquid chromatography (HPLC) for ergovaline content. The Titan straw contained 475 ppb and 0 ppb for Bonanza.

Experiment 1. Digestion/Physiology Study. In early February 1992, 16 ruminally cannulated steers (avg wt = 370 kg) were used in a randomized complete block design. Steers were blocked by age and weight and, within blocks, randomly assigned to the following treatments: 1) 100 percent Titan; 2) 67 percent Titan-33 percent Bonanza; 3) 33 percent Titan-67 percent Bonanza and 4) 100 percent Bonanza. The basal diets of straw for treatments one through four, in order, contained 475, 317, 158 and 0 ppb ergovaline. Steers were given ad libitum access to the basal straw diets and supplemented with alfalfa pellets at .5 percent of BW of individual steers. This 36 d digestion study involved a 21 d adaptation period, 7 d intake period, 6 d of total fecal collections, 1 d of rumen profiles, and 1 d of rumen evacuations, respectively. Physiological parameters were also measured weekly at 1 p.m. to determine physiological response to ergovaline: rectal temperatures; skin surface temperatures by an infrared thermometer at the tailhead (underside) and the ear (between the second and third rib); heart rates (area behind the left front elbow), and respiration rates were recorded. In addition, weekly blood samples were also collected via jugular venipuncture into vacutainer tubes for prolactin (PRL) analysis. Ambient barn temperatures were also measured during the study; minimum temperatures recorded at 7 a.m. and maximum temperatures at 5 p.m. The average minimum and maximum temperatures were 1.2°C and 11.1°C, respectively and ranged from -3.3°C to 18.9°C.

Experiment 2. Performance Study. Eighty-four Hereford x Angus steers (avg wt = 220 kg) were allotted into one of three weight blocks (light, medium, and heavy), and within weight blocks, randomly assigned to the same above treatments (7 steer/pen) for an 84 d performance trial. All the steers were supplemented with alfalfa pellets at .5 percent BW of the average pen weight. Pens were fed forage daily and feed refused was weighed back and subsampled weekly. Every 28 days steers were weighed after a 16 h shrink to measure weight gains and feed efficiencies. One steer on the 100 percent Titan straw died on d 46 of the performance trial. Necropsy on the steer suggested there was no relationship between the animal's death

Table 2. Dry matter intake and total tract digestion of beef steers consuming graded levels of high endophyte tall fescue

	% Titan tall fescue					Orthogonal contrasts		
Item	0	33	67	100	SE[a]	Linear	Quadratic	Cubic
DM intake, % BW								
Forage	1.7	1.5	1.6	1.7	.09	.84	.14	.85
Total	2.1	2.0	2.0	2.2	.09	.84	.14	.86
Apparent DMD, %	46.0	48.0	47.0	48.8	1.16	.19	.91	.29
NDF digestion, %	44.0	44.0	42.8	44.3	1.35	.94	.94	.52

[a] Standard error, n = 4.

and treatment or alkaloid effects. Weight gain data 1 for this steer was omitted from the final statistical analysis.

RESULTS AND DISCUSSION

Experiment 1. Digestion/Physiology Study. Neither forage nor total intake were affected by treatment; diet intakes averaged 6.0 kg and 7.7 kg, respectively (P>.10). Total intakes on a percent body weight basis averaged 2.1 percent (Table 2). Apparent digestibility was similar for all four diets across treatments, ranging from 46 percent to 48.8 percent. Likewise, neutral detergent fiber (NDF) digestion did not differ among diets (P>.10). These results indicate that alkaloid concentration did not affect the nutrition of the animal. Thus, any detrimental influences on performance or health would have to be mediated through physiological mechanisms.

Physiological Response. In regards to the physiological parameters, no treatment x time interaction occurred (P>.10), so the means were averaged across time (Table 3). Heart rate, respiration rate, rectal, tail, and ear temperatures were similar across treatments (P>.10). Thus, there was no evidence that the steers were stressed due to alkaloid concentration of the diet. If alkaloids were affecting metabolism, steers consuming higher concentrations of alkaloids would have displayed increased heart and respiration rates with, in all likelihood, lower surface body temperatures.

Weekly prolactin (PRL) levels, however, decreased linearly across treatment means (P<.10) as the levels of Titan increased in the diet. This observation does suggest that alkaloids were having a subclinical metabolic affect. The significance of this observation in regard to livestock health/performance is more difficult to determine. Prolactin, is a protein hormone involved in, among other metabolic functions, lactation and growth. Depressions in prolactin due the influence of alkaloids has been shown to reduce calf growth rates, as well as, milk production of the dam. In horses, reproductive problems such as retained and "tough and leathery" placentas have been reported, presumably due to depressions of prolactin and improper late gestational developement. In cattle, this observation has not been substantiated.

Experiment 2. Performance study. Total forage intake illustrated a linear response(P<.10), intakes increased with decreasingalkaloid levels (Table 4). However, steer weight gains and feed/gain ratios did not differ (P>.10), averaging 14.0 kg and 16.2 kg, respectively. Since weight gains and feed efficiencies were fairly similar across treatments, the differences in intake may be attributed to palatability differences due to the presence of alfalfa hay in the Bonanza straw. No adverse health effects were seen during the performance 1 trial, although 100 percent Titan steers were consuming 2 mg/d ergovaline. These levels are

Table 3. Physiological response of beef steers consuming graded levels of endophyte infected tall fescue straw

Item	% Titan tall fescue					Orthogoal contrasts		
	0	33	67	100	SE[a]	Linear	Quadratic	Cubic
Heart rate beats/min	59.4	62.2	62.8	58.9	2.3	.93	.18	.82
Respiration Rate breaths/min	15.4	15.8	16.3	14.3	.87	.47	.22	.51
Temperatures								
Rectal, °C	38.5	38.6	38.4	38.5	.06	.24	.60	.13
Tail head, °C	35.8	35.8	36.1	35.3	.20	.23	.11	.16
Inner ear, °C	25.8	26.2	27.1	27.7	.91	.15	.93	.87
Weekly PRL ng/ml	15.4	18.8	6.7	5.5	5.0	.09	.66	.27

[a] Pooled standard error, n = 3.

Table 4. Performance data for beef steers consuming graded levels of endophyte infected tall fescue

Item	% Titan tall fescue					Orthogoal contrasts		
	0	33	67	100	SE[a]	Linear	Quadratic	Cubic
Forage intake, kg	4.8	4.3	4.3	4.2	.18	.07	.34	.68
Total intake, kg	5.8	5.4	5.3	5.3	.08	.08	.35	.68
Weight gain, kg	14.4	13.1	12.9	14.5	.98	.98	.50	.94
Feed/gain, kg	16.0	16.0	17.8	15.0	.93	.93	.61	.61

[a] Pooled standard error, n = 3.

comparable to other studies in which depressions in beef cattle performance were observed.

Discussion. Absence of negative effects in feeding high endophyte fescue in these studies may be due to lack of environmental stress and/or the physical composition of the straw. Both trials were conducted at average ambient maximum temperatures of 9°C in an arid environment. Thus, a lack of environmental extremes (cold temperatures) may have reduced the risks of observing vasoconstriction, which precludes the onset of fescue foot.

Another possible explanation is that straw, with its more fibrous physical nature, has a longer retention time in the rumen and is not as highly digestible as seeds and/or forages where classical symptoms of fescue syndrome and/or reduced performance are observed. Thus, although straw may have concentrations of alkaloids similar to these feeds, decreased intake, digestion, and subsequent host animal absorption of alkaloids may be lower, reducing the risk of toxicity problems or reduced gains.

Early-Vegetative Meadow Hay Versus Alfalfa Hay as a Supplement for Cattle Consuming Low-Quality Roughages[1]

Marc Horney, Tim DelCurto, Michele Stamm, Roxane Barton, and Steve Brandyberry

SUMMARY: The results obtained by this study suggest that high quality meadow hay is an effective supplement to low-quality forages, particularly in terms of animal performance. However, the addition of supplemental protein failed to improve basal diet intake or digestion. The treatment differences that were observed appeared to be a function of energy provision rather than protein, although the protein probably was necessary to make the supplemented energy available. Improvements in gain and body condition seen in the performance study likely were most related to increases in total intakes and improved dietary digestibilities that came with supplementation. Forage-based protein supplements appears to be a very practical means of improving wintering cow weight and condition maintenance on low-quality forages. Improved maintenance of weight and condition of the cows suggest that it is reasonable to suspect wintering cattle in many areas would require such supplementation in order to maintain acceptable levels of reproductive performance on low-quality diets.

The feeding of low-quality forages, such as crop residues, stockpiled forages, and low-quality hays, to wintering beef cattle is a common practice in the beef cattle industry. Without additional nutritional management, however, these feeds frequently result in low intakes and poor digestion owing to deficiences of host animal, and microbially-available protein and energy. Many studies have documented the benefits of protein supplementation on the intake and digestibility of low-quality forages. Improvements in digestion and intake, in turn, often yield improved cattle weight and condition status throughout the winter feeding period. Ultimately, improved nutritional status through the winter feeding period may provide improved subsequent resproductive efficiency.

Oilseed meals (soybean and cottonseed meal) and alfalfa, the most common forms of supplemental protein in these studies, are often expensive in many parts of the western United States. Cheaper, locally produced forms of supplemental protein would be an advantage to many range cattle operations. Meadow hay is commonly produced for use as a primary winter feed source. Because it is needed in large quantities, production strategies frequently emphasize yield over quality, and most hays are therefore harvested close to phenological maturity. If alternative winter feed resources are utilized, intensive management of hay meadows becomes a viable option to producers. The objective of this study, therefore, was to harvest such an early, high-quality meadow hay and compare its effects to alfalfa hay on the intake, digestion, and subsequent performance of beef cattle fed a low-quality roughage.

Materials and Methods

Hay meadow survey. Two 15 acre tall fescue pastures were grazed by 108 cow/calf pairs from April 19 to May 17, 1991. Cows

[1]Appreciation is expressed to the Agricultural Fiber Association and the Linn-Benton Regional Strategy Commission for partial funding of this study. In addition, appreciation is expressed to Holly Imbach for providing technical assistance during the data collection aspects of these trials.

received 17 lbs meadow hay/head on 18 of 28 days. Both pastures had been fertilized with 50 lbs/acre in mid-March. The early-season grazing was used as a management tool to delay forage maturity so that a higher quality stand could be captured at the normal harvest date. Five clipping plots were established in representative areas within one pasture. Ground-level clippings were taken once every week from five random locations within each plot. The clippings were then weighed, dried, re-weighed, and then ground to pass through a 1 mm screen. Total above-ground dry-matter (DM) production was estimated from average DM yields across plots. Samples were then stored for later analysis of crude protein (CP), soluble nitrogen (N), acid detergent insoluble nitrogen (ADIN), acid detergent fiber (ADF), natural detergent fiber (NDF), and insoluble acid detergent fiber (IVDMD). chemical composition of this forage, alfalfa hay supplement, and the tall fescue basal diet can be found in Table 1. both pastures were harvested between July 10 and July 15.

Table 1. Chemical composition of feeds

	Tall Fescue straw	Meadow hay	Alfalfa hay
CP, %	4.05	11.92	18.97
% Sol Prot	37.65	23.87	28.38
ADIN[a], %	12.93	6.76	9.32
ADF, %	50.38	34.95	35.26
NDF, %	73.63	57.01	51.71
IADF[b], %	32.89	7.75	18.16

[a]Expressed as a percentage of total N
[b]Indigestible ADF

Cattle Trials. Endophyte-free tall fescue straw was utilized as the low-quality basal diet for both trials. This straw was ad-libitum. The alfalfa hay supplement was fed at .4 percent body weight (BW), a value suggested by previous low-quality forage at a level that supplied the same amount of protein as the alfalfa hay supplement in order to equalize protein effects on digestion. Both supplement hays and the straw were chopped (2-4) inch length) prior to feeding in the digestion trial. This facilitated handling, weighing, and a reduction in waste resulting from feed pulled out of the bunks. In the cow performance study, the supplement hays and the straw were fed directly from standard rectangular bales.

Experiment 1: Digestion Study. Fifteen ruminally cannulated steers (average wt = 860 lbs) were blocked by weight and randomly assigned to one of three treatments: 1) tall fescue straw without supplement (negative control; 2) tall fescue straw plus a meadow hay supplement; 3) tall fescue straw plus an alfalfa hay supplement. The 28 d digestion study was divided into a 14 d adaption period, a 6 d intake period, and a 6 d fecal collection period, with a rumen profile on d 27 and rumen evacuations on d 28.

Experiment 2: Cow performance trial. Ninety gestating Hereford X Angus cows (average wt = 1,056 lbs) were stratified by age and body condition and, within stratum, randomly assigned among three replications of the dietary treatments. All cows shared one common pasture, with the supplemented cows gathered and sorted at 11 a.m. each day to be fed their supplements. Supplemented cows were fed in pens of 10 according to supplement type. Straw was fed from bales scattered across the pasture each day between 7 a.m. and 9 a.m. Supplements were fed for 84 d, from November 19, 1991, to February 11, 1992. Cows were weighed and condition scored (C-scored) on d 0, 28, 56, 84. At 4 p.m. the day before each weigh/scored date, the cows were gathered and placed in a corral away from feed and water overnight. Cow body condition was judged independently by two observers using a 9-point scale (1=extremely thin, 9=extremely fat). Calf weights were estimated according to a formula based upon heart-girth measurements. Cows were weighed and C-scored again on d 204 (June 11) to find any post-calving differences in weight and

Table 2. The influence of sampling date on production and chemical composition of tall fescue meadow forage

	SAMPLING DATE						
	5/23	5/30	6/06	6/12	6/20	6/27	7/04
DM prod.kg/Ha	46.66	86.44	146.86	252.77	392.95	494.61	587.85
CP, %	24.43	21.87	18.90	16.06	11.67	10.98	9.42
% Sol Protein[a]	44.07	46.81	37.39	37.62	42.07	39.53	37.23
ADIN[b], %	3.10	3.10	2.79	3.38	5.14	4.51	5.69
ADF, %	24.02	23.93	24.94	26.95	33.59	31.44	34.10
NDF, %	43.94	45.6	42.25	46.14	52.89	51.99	56.93
IVDMD, %	77.43	77.93	80.52	78.55	72.15	73.55	69.80

[a]Expressed as a percentage of total protein
[b]Expressed as a percentage of total N.

Results and Discussion

Hay meadow survey. Average CP levels across plots ranged from a high of 24 percent to a low of 9 percent (Table 2). The decline in CP is probably due to a progressive accumulation of structural components and leaf losses. The percent soluble N values (Table 2) declined by approximately 7 percent from May 23, through July 4, although these results were quite variable across dates. While the primary forage species in these pastures was tall fescue (*Festuca arundinacea*), a number of other grasses were also present, principally orchardgrass (*Dactylis glomerata*), cheatgrass (*Bromus tectorum*), and Kentucky bluegrass (*Poa pratensis*). Two plots included regions with a substantial cheatgrass component, and as this grass matures much earlier than the other species, quality decline was not completely uniform across plots. It should be noted that the production estimations were made upon the basis of ground level clippings, and do not represent harvestable forage. Likewise, quality determinations on the clipped forage included the lower, leaf-poor and more lignified portions of the the grass plants that would be left behind by harvesting equipment. Therefore the quality estimations of the clipped forage may be somewhat poorer than what the actual harvested forage would have achieved.

Experiment 1: Steer Digestion Study. Intake and digestibility. Total DMI ranged from 13 to 26 percent greater ($P<.01$) for the supplemented treatments than for the negative control group (Table 3). Likewise, total DMI was 12 percent greater ($P<.10$) for the meadow hay supplemented treatment than it was for the alfalfa hay supplemented treatment. In contrast, straw DMI tended to be lower for the supplemented treatments compared to the nonsupplemented control group ($P=.18$). Dry matter digestibility was 8 to 19 percent greater for supplemented treatments than for the control ($P<.05$), and, within supplement treatments, was greater for meadow hay supplemented steers than for alfalfa hay supplemented steers ($P<.10$). Likewise, digestible DMI was more than 22 percent greater ($P<.001$) for steers on the supplement treatments that for animals on the control diet, and 24 percent greater for steers on the meadow hay supplement treatments than for steers supplemented with alfalfa hay ($P<.01$). In situ extent of digestion was slightly greater (2%) in steers supplemented with alfalfa hay relative to the

meadow hay fed steers (P<.05). However, this difference does not appear large enough to have biological significance. In addition, in situ rate of digestion did not differ with supplementation or between the supplement sources (P>.10). These results seem to indicate that the additional protein provided by the supplements did not aid digestion of the basal diet. Therefore, the improvement in total diet digestion appears to be largely a function of each supplement's own relative digestibility and quantity of supplement fed.

Experiment 2: Cow performance trial. The results of this study described pronounced effects, both of supplementation and type of supplement on cow weight gains and body condition changes over the winter. Supplemented cows in this study gained more weight (P<.001) than nonsupplemented cows over the 84 d supplement feeding period, and the meadow hay supplemented cows gained more weight (P<.10) than the alfalfa hay treatment. In the same way, cows on supplements lost 50 percent less body condition than their control counterparts. (P<.01), and the meadow hay cows tended to lose less condition than the alfalfa hay fed cows (P=.23).

The potential production advantage conferred by supplementation, especially through periods of physiological stress, is clear. Without supplementation, cattle on such low-quality diets are unable to meet their nutritional needs and consequently may manifest symptoms of poor nutrition in terms of impaired reproductive performance.

Table 3. Effects of early-vegetative meadow hay and alfalfa hay supplementation on the intake and digestion of low-quality roughages

Item	Treatments			SE[a]	Contrasts	
	Control	Meadow hay	Alfalfa hay		Supplement vs non-supplement	Meadow hay vs Alfalfa hay
Total DMI	1.71	2.12	1.97	.08	.0099	.2107
Straw DMI	1.71	1.53	1.59	.08	.1511	.6227
Supp DMI	-	.59	.38	-	-	-
DDMI[b] (kg/day)	2.89	4.36	3.53	.14	.0003	.0036
DMD[c] , %	44.00	52.2	47.4	1.68	.0225	.0781
NDF dig, %	41.05	49.38	42.71	1.76	.0494	.0281
Basal diet in situ digestion kinetics:						
Lag, h	3.84	3.84	3.86	.04	.8691	.8519
Rate (% /h)	1.08	1.08	1.09	.05	.9752	.9141
Extent, %	57.67	57.26	58.57	.35	.5875	.0315

[a]SE = Standard error of the means (n = 5)
[b]Digestible DMI
[c]Apparent DM digestibility

Table 4. Influence of early-vegetative meadow hay versus alfalfa hay supplementation on cow weight, condition score changes and calf birth weight

	Treatments				Contrasts	
	Control	Meadow hay	Alfalfa hay	SE[a]	Supplement vs non-supplement	Meadow hay vs Alfalfa hay
Initial						
Body weight, lbs	1054.7	1056.4	1064.4	-	-	-
Condition score	5.47	5.42	5.33	-	-	-
d 0-84						
Weight change, lbs	+16.6	+69.2	+52.1	5.84	.0009	.0844
C-score change	-1.43	-.40	-.71	.16	.0054	.2311
d 84-204						
Weight change, lbs	-7.3	-37.7	-28.1	7.52	.0325	.4097
C-score change	+.67	+.02	+.44	.14	.0377	.0763
d 0-204						
Weight change, lbs	+10.3	+34.6	+25.7	10.7	.1749	.5741
C-score change	-.74	-.30	-.31	.11	.0151	.9791
Calf Birth Wt, lbs	80.7	80.8	79.9	1.19	.8394	.6400
Calf ADG, lbs	1.78	1.80	1.79	.04	.8505	.8898

[a]SE = Standard error of the means (n = 3)

Vegetation Change in Response to 56 Years of Livestock Exclusion

Jeffrey Rose, Rick Miller, and Tony Svejcar

Summary: Response of big sagebrush plant communities to long-term livestock exclusion was evaluated by resampling grazing exclosures established in 1936 on the Northern Great Basin Experimental Range. Plant cover and density were determined for plots inside (ungrazed since 1936) and outside (grazed) of the permanent exclosures. In general total plant cover was slightly greater inside of the exclosure. Big sagebrush cover was also greater inside the exclosure, but density was greater outside where grazing had occurred. Cover of large perennial grasses was also greater inside of the exclosure, but density of the grasses did not show consistent trends. Sandbergs bluegrass, a small, low growing bunchgrass, was the only grass to have greater cover and density outside of the exclosures. Most forb species had greater densities outside of the exclosures. Livestock grazing has appeared to have a slight effect on plant cover and density at the Northern Great Basin Experimental Range. Results were variable across exclosures, but in general there was slightly greater grass cover in the exclosures, but greater grass density in the grazed areas.

It is often difficult to isolate the effects of domestic livestock on plant community dynamics from other factors. Exclusion of grazing animals has often been one technique to evaluate the effects of herbivores on plant community composition and structure. However, few studies have observed changes for more than 20 years. Many years of study are usually required before changes become apparent. Other studies have compared adjacent pastures with different grazing histories. Results from these previous studies have been variable, but most agree that some change in plant communities can be attributed to livestock grazing. A more important question may be how these changes permanently affect ecosystem integrity. The Northern Great Basin Experimental Range can help clarify some of these questions. In 1936, a study was initiated to observe long-term changes in big sagebrush plant communities protected from grazing by livestock.

STUDY SITE AND HISTORY

The Northern Great Basin Experimental Range was established 1936 in response to local livestock producers requests. A 25 mi^2 block of land was initially divided into 14 major pastures. Within 13 of these major pastures a 5 ac permanent livestock enclosure was established. Only livestock grazing was excluded. Early in this century the range was part of a larger wild horse range. From 1920 to 1936, the area was used by sheep, March through May. Almost ten years of drought and heavy use by livestock had degraded the range. Vegetation was in a very low successional stage when the exclosures were constructed. Grazing since 1936 has been by cattle and sheep until 1939, and by cattle alone from 1939 to 1989. Since the 1960's range use on the experimental range has been around 2000 AUM, and time of use has varied from mid-April to early November.

Vegetation on the experimental range is dominated by western juniper (*Juniperus occidentalis* Hook.), and the three subspecies of big sagebrush (*Artemisia tridentata* ssp. *tridentata* Nutt. Gray, *A. tridentata* ssp. *wyomingensis* Bettle, and *A. tridentata vaseyana* (Rydb.)Bettle). The major perennial grasses are, Bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. & Smith), Idaho fescue (*Festuca idahoensis* Elmer), Thurbers needlegrass (*Stipa thurberiana* Piper), and

Sandbergs bluegrass (*Poa secunda*). Large numbers of perennial and annual forbs are present, with species composition varying across sites.

In the spring and summer of 1990 the exclosures were resampled to evaluate the effects of long-term livestock exclusion. Our initial hypothesis was that livestock grazing had no effect on the big sagebrush plant communities.

MATERIALS AND METHODS

Response of plant community composition was evaluated by comparing plant cover and density. Plant cover was estimated by establishing 10, 100 ft transects in each pasture where an exclosure existed. Five sampling transects were located inside the long-term exclosures, and five transects were located outside the exclosures. Transects outside were at least 200 ft from the enclosure fence. Canopy length of each species intercepting the transect was measured and percent canopy cover determined. Density of each plant species was determined by counting total number of individuals rooted within each of 10, 2 ft^2 rectangular frames placed at 10 ft intervals along each cover transect. Twelve of the thirteen original exclosures were resampled. Pasture 5 was not resampled because past management and research activity had drastically altered the vegetation outside of the exclosure.

Analysis of cover and density data were by analysis of variance (ANOVA) with pastures as blocks. Mean separation was done using LSD at the $p \leq 0.05$ level. Cover and density values reported are means across the blocks to illustrate the general trends in response to removal of livestock grazing.

RESULTS & DISCUSSION

Total plant cover inside of the exclosures was not statistically different from the cover outside of the enclosure. However, total plant cover appeared to be slightly greater inside where no grazing by livestock had occurred (Table 1). Shrubs comprised the largest percentage of the total cover inside and outside of the exclosures(15 to 14% of the total 25 to 20% cover respectively). Total shrub and big sagebrush cover values were slightly greater inside of the exclosures for these two groups (Table 1). Green rabbitbrush, often found to increase under grazing had very similar cover values between inside and outside. Granite gilia (*Leptodactylon pungens* (Torr.) Nutt.), a small, low growing shrub, was the only shrub to have significantly greater cover inside of the exclosures. Studies in Utah have found that this shrub will generally decrease in density and cover in response to grazing. Total grass and total perennial grass cover was greater inside the exclosures where no grazing had occurred since 1936. (Table 1). Perennial grasses comprised over 99 percent of the total grass cover. Cover of all perennial grasses were greater inside the exclosures with the exception of Sandbergs bluegrass. Cover of Sandbergs bluegrass was significantly greater outside of the enclosure.

Shrub density was greater outside of the enclosure than inside (Table 1). Granite gilia showed the opposite trend, greater densities inside the exclosures. As mentioned above granite gilia has been found to decrease under grazing pressure. The greater cover and density values found here supports these findings from other locations. Total grass, total perennial grass, Sandbergs bluegrass, bottlebrush squirreltail, and Thurbers needlegrass had significantly greater densities outside of the exclosures. Idaho fescue was the only grass found to have greater densities inside of the exclosures. Bluebunch wheatgrass, another large perennial bunchgrass, did not show a significant difference in density, but the density appeared to be slightly greater inside compared to outside of the exclosures. Sandbergs blue grass is a small bunchgrass often increasing with low successional conditions. This grass was very common both inside and outside of the exclosures, making up 49 percent and 67 percent of the total grass density. The difference between the perennial grasses inside and outside the exclosures becomes nonsignificant by removing Sandbergs bluegrass. In 1936, when the station was constructed, Sandbergs

bluegrass was the dominant grass in most pastures, and until 1974, increased inside and outside of the exclosures. However, Sandbergs bluegrass has been declining since 1974, possibly indicating change in successional stage.

Total, perennial forb, and annual forb density were greater inside than outside of the exclosures. Only three forbs showed any significant difference between inside and outside. *Colinsia sparsiflora* Fisch. & Mey. (an annual forb), and low pussytoes (*Antennaria dimorpha* (Nutt.) T. & G.), had greater plant densities outside the exclosures. Low pussytoes is a low growing perennial forb and it is often found in greater densities in areas with moderate to heavy grazing. Tapertip hawksbeard (*Crepis acuminata* Nutt.), a medium to large forb from the composite family, was the only forb to have greater densities inside the exclosures.

The data indicates there is a difference between plant communities inside the long-term exclosures. Shrub densities are greater and cover lower outside the exclosures, indicating that there may be more smaller shrubs. Greater recruitment and turnover of older shrubs may have occurred outside the exclosures. The age structure of shrubs outside the exclosures may be younger, indicating greater turnover of shrubs. Density and cover of lower successional grasses was also greater outside the exclosures. Removal of livestock grazing from these plant communities has appeared to favor Idaho fescue, and to a lesser extent bluebunch wheatgrass and prairie junegrass (*Koleria cristata* Pers.), all of which are considered high successional grasses.

Table 1. Plant cover and density of major shrubs, grasses, and orbs from the Northern Great Basin Experimental Range.

	Cover (%)		Density (# 10 ft^{-2})	
Species or Group	Inside Exclosure	Outside Exclosure	Inside Exclosure	Outside Exclosure
Total	25.0	19.6		
Total Shrub	15.2	13.6	0.82	0.97
Big Sagebrush	12.4	11.2	0.46*	0.60
Green Rabbitbrush	1.6	2.0	0.18*	0.30
Granite Gilia	0.6*	0.1	0.15*	0.04
Total Grass	8.5*	5.0	31.21*	38.75
Perennial Grass	8.5*	5.0	30.33*	38.83
Perennial Grass w/o Sandbergs Bluegrass	7.4	3.4	15.57	12.78
Idaho Fescue	2.4*	0.9	4.64*	2.69
Bluebunch Wheatgrass	2.8*	1.1	5.04	4.08
Sandbergs Bluegrass	1.0*	1.6	14.76*	26.05
Bottlebrush Squirreltail	0.6	0.5	1.73*	2.56
Thurbers Needlegrass	0.7*	1.3	2.85*	4.84
Prairie Junegrass	0.2	0.1	1.21	0.88
Cheatgrass			0.88	0.91
Total Forbs	1.2	1.0	12.77*	15.92
Perennial Forbs			7.23*	9.38
Annual Forbs			5.43*	6.55
Colensia			1.60*	2.68
Low Pussytoes			0.06*	0.27
Tapertip Hawksbeard			1.00*	0.23

* Indicates significant difference ($P \leq 0.05$) between location (inside exclosure or outside exclosure).

Perennial Grass w/o Sandbergs bluegrass indicates that Sandbergs bluegrass cover and density were subtracted from the Perennial Grass group.

PHYSICAL MODIFICATION AND(OR) SUPPLEMENTATION STRATEGIES TO IMPROVE THE FEEDING VALUE OF TALL FESCUE STRAW FOR BEEF CATTLE.

Roxane Barton, Tim DelCurto, Steve Brandyberry, Michele Stamm and Marc Horney.

SUMMARY: A digestion study was conducted to determine the effects of physical form (pelleting) and supplementation on the intake and digestion of tall fescue straw fed to beef cattle. Pelleting increased intake of tall fescue straw over long stem straw. Supplemented pelleted straw and pelleted straw/alfalfa mixture increased intake by 50 percent over long stem treatments. Additionally, intake of pelleted straw/alfalfa mixture was increased an additional 7 percent above supplemented pelleted straw. Apparently DMD (dry matter digestibility) was decreased with pelleting, however, digested DM (dry matter) of supplemented pelleted straw and pelleted mixture was increased 50 percent over long stem diets.

In Oregon, ongoing environmental concerns are forcing livestock producers from the east side of the state, as well as grass seed producers from the west side, to find alternative methods to traditional management and production systems. Grass seed producers traditionally burn grass seed fields after harvest as a means of sanitizing fields and removing straw residue. Yet, concerns over air pollution are forcing grass seed producers to utilize alternative methods for removing straw residues. Additionally, controversy over the use of public rangelands may force the beef cattle industry to rely on more winter hay feeding and private rangelands.

Although the concept of utilizing grass straw as a forage base for wintering beef cattle is not a new one, the concept is not widely practiced in Oregon. Grass straws tend to be high in fiber, low in protein, and therefore coincide with low intakes. Thus, when used independently, grass straws are not adequately digested and will not provide the proper amounts of nutrients needed to maintain an acceptable level of beef cattle performance. However, when grass straws are used in conjunction with the proper amounts of supplement, grass straws can and are used very efficiently. Likewise, physical alteration of a low quality forage, such as chopping or pelleting, has also increased intakes. Thus the objective of the following study was to evaluate the effects of pelleting and/or supplementation of grass straw on intake and digestibility.

MATERIAL & METHODS

Twenty Hereford x Angus steers fitted with rumen cannula's were randomly assigned to one of the following treatments (5 steers/treatment): 1) long stem tall fescue straw; 2) long stem tall fescue straw plus supplement; 3) pelleted tall fescue straw; 4) pelleted tall fescue straw plus supplement; 5) pelleted tall fescue straw/alfalfa mixture (75% straw/25% alfalfa mixture). Steers receiving supplements were supplemented at a level of 25 percent of their previous 5 day intake with alfalfa pellets. Following a 14 day adaptation period was a 6 day intake period in which daily feed and ort (or refusals) subsamples were taken. During the intake period, feed and orts are weighed daily. Following the 6 day intake period, steers were fitted with total fecal collection bags. Total fecal collection is necessary for determination of digestibility (measured feed intake divided by measured fecal output gives an estimation of digestibility). All subsamples of feed (basal forage and supplement), orts and feces were analyzed for dry matter.

RESULTS & DISCUSSION

Nutritional quality of the diet (Table 1) indicates that pelleting of long stem tall fescue straw depressed neutral detergent and acid detergent fiber fractions of the diet. Neutral detergent fiber is a measure of the portion of plant material (in this case straw) that is mostly digestible (or a measure of the digestible portion of the plant cell wall). Neutral detergent fiber is also the primary determinant of intake. However, in general, acid detergent fiber is a measure of the portion of plant cell wall that is not digestible. Acid detergent fiber is inversely related to digestibility (higher ADF values relate to lower digestibility). In general, forage crude protein values of 6 to 8 percent have been an indication of when to supplement protein. The protein values of the long stem and pelleted straw (Table 1) fall within the range in which protein supplementation would be beneficial.

Pelleting tall fescue straw increased forage intake significantly ($P<.01$) over long stem straw by approximately 30 percent (Table 2.). Steers receiving pelleted straw consumed more than the steers on the long stem treatments. However, steers receiving supplemented diets consumed less forage ($P<.10$) than nonsupplemented steers. This may suggest that steers were only marginally protein deficient. Total DM intake (TDMI; forage intake plus supplement) also was increased by pelleting. Steers consuming pelleted straw consumed more ($P<.01$) than steers consuming long stem straw. Likewise, TDMI of steers consuming pelleted straw plus supplement and pelleted straw/alfalfa mix (MIX) were increased 50 percent over TDMI of steers consuming long stem treatments. Additionally, steers receiving MIX consumed an additional 7 percent over steers receiving pelleted straw plus supplement. A consumption of 2 percent of body weight for a low quality forage is often a target intake. In general, steers consumed approximately 2 percent of BW for both long stem and pelleted diets. However, steers receiving pelleted straw plus supplement and MIX consumed more than 3 percent of BW.

Apparent dry matter digestibility (ADMD; or the % of diet digested) was decreased with pelleting. An increase in intake of a low quality is often accompanied by depression in digestibility. However, digested DM (or the actual lbs of forage digested) for pelleted straw was increased ($P<.05$) 50 percent over long stem diets. Thus, any depression exhibited in ADMD was greatly offset by the magnitude of increases in intake.

CONCLUSIONS

From the results of this study, pelleting of tall fescue straw had a significant impact on both intake and digestion. Furthermore, these data may suggest that pelleting tall fescue straw produces greater nutritional benefits than does supplementation; and pelleting, plus supplementation, produced more than additive benefits. Intakes of supplemented pelleted straw and MIX were increased 50 percent over long stem diets, and intakes of MIX were increased an additional 7 percent over supplemented pelleted straw. Therefore, these results may suggest that tall fescue straw may not be limited to mature nonlactating cows. But, may have potential of being a main component in diets of growing steers and heifers, as well as other species of livestock.

(See Tables 1 and 2 on following page).

Table 1. Nutritional Quality of Basal Diet and Alfalfa Supplement.

Item[a]	Long Stem Tall Fescue Straw	Pelleted Tall Fescue Straw	Pelleted Straw & Alfalfa Mixture	Alfalfa Pellets
CP, %	6.13	7.00	10.39	21.14
ADIN %	10.18	13.57	10.18	10.59
NDF, %	74.16	71.09	66.99	58.25
ADF, %	49.80	44.89	43.38	39.37

[a]Nutritional quality expressed on a dry matter basis for the following measures: CD = crude protein, ADIN = acid detergent insoluble nitrogen, NDF = neutral detergent fiber, ADF = acid detergent fiber.

Table 2. The Influence of Physical Form and (or) Supplementation on Dry Matter Intake and digestibility Estimates of Tall Fescue Straw for Beef Cattle.

	TREATMENTS				
	Long Stem Straw		Pelleted Straw		
Item[a]	No Suppl	Suppl	No Suppl	Suppl	Pelleted Mix
Dry Matter Intake, lb					
Forage [b,c]	17.40	12.69	21.01	19.84	20.90
Total [b,d]	17.40	16.52	21.01	26.44	28.23
Dry Matter Intake, % BW					
Forage[b,c]	2.05	1.51	2.39	2.27	2.41
Total [b,d,e]	2.05	1.96	2.39	3.03	3.25
Apparent DMD, %[b]	50.0	51.5	45.1	46.2	48.0
Digested DM, lb[c,d]	8.01	8.10	8.95	11.66	12.72

[a]Dry matter intake expressed in terms of actual lbs consumed and as a % of body weight, Apparent DMD = apparent dry matter digestibility, Digest DM = digested dry matter.
[b]Pelleting increased intake, and lowered digestibility (P<.01).
[c]Supplementation decreased forage intake and increased digested dry matter (P<.10).
[d]Pelleted Mix increased intake and digested DM above all other treatments (P<.01).
[e]Pelleted mix increased intake, in terms of $ BW, above all other treatments (P<.10).

PHYSICAL FORM AND FREQUENCY OF ALFALFA SUPPLEMENTATION FOR BEEF CATTLE WINTER GRAZING NORTHERN GREAT BASIN RANGELANDS[1]

Steve Brandyberry, Tim DelCurto and Ray Angell

SUMMARY: A performance/digestion study was conducted to determine the effects of physical form and frequency of alfalfa supplementation to beef cattle on a winter grazing program. Results from this study indicate that feeding alfalfa hay or pellets either daily or every other day does not affect performance, intake, digestion, or grazing behavior of winter grazing beef cows. However, weather conditions and the supply of available forage did have an impact in this study, and should be considered in the planning and implementing of any winter grazing program. Results to date indicate that winter grazing is a viable management plan in the northern Great Basin; however, year to year variations in climate and available forage are areas that require additional research.

Traditional grazing management programs in the northern Great Basin involve hay feeding on meadows during the fall and winter, with animals grazing native range during the spring and summer. Winter grazing is an alternative management plan, whereby animals graze native range from spring to late summer, graze meadows in fall, and then move back to native ranges during the winter. This program may be economical and beneficial to range condition and productivity, since the range is being used during a time of minimal plant growth and development. Grazing after fall dormancy is usually considered to have a minimal impact on subsequent growth and development of common cool-season perennial bunchgrasses, such as bluebunch wheatgrass; thus, winter grazing should minimally impact the forage resource. Protein supplementation is beneficial when animals are consuming low-quality roughages, such as dormant winter forage. Alfalfa is commonly fed as a supplement in the northern Great Basin because it is more available and economical than traditional concentrate supplements, such as soybean or cottonseed meals. Alfalfa has been found to be as effective as protein meal supplements in improving the performance of grazing animals. Pelleting alfalfa, while somewhat expensive, has been shown to increase the intake of dormant forage, increase weight gain, and reduce condition loss when compared to long-stem hay. Alternate-day feeding of protein supplements has been shown to be as effective as daily feeding and may offer economical advantages, such as reduced labor and travel associated with feeding. However, work done in this area has usually involved feeding protein meals or concentrates, not alfalfa. Therefore, the objectives of this study were to compare: 1) physical forms of supplemental alfalfa (pelleted vs. long-stem hay); and 2) frequency of alfalfa supplementation (daily vs. every-other-day) on beef cattle winter grazing northern Great Basin rangelands.

MATERIALS & METHODS

The study was conducted on the Squaw Butte Experimental Range, 42 miles west of Burns, at an elevation of 4,600 ft. Average

[1]Appreciation is expressed to Shane Bennett and Hugh Smith for assistance in collecting data, and Kelly Brandyberry for laboratory analysis.

annual precipitation is 11 in.; approximately 60 percent of this occurs as snow during the fall and winter, with only 25 percent as rain during the growing season. Approximately 9.7 in were received in the crop year (September-August) immediately preceding the study. Second cutting alfalfa was obtained in late July of 1991 from a field at the station headquarters. Alternate windrows were put up either as long-stem hay or sun-cured and made into pellets. In late October of that year, 60 mature, pregnant Hereford X Angus cows (avg. initial wt = 1,030 lb) were grouped by age, condition score (CS) and fetal age were 5.58 and 127 days, respectively) and randomly assigned within group to one of four treatments: 1) 4.4 lb/d of alfalfa pellets; 2) 4.4 lb/d of alfalfa hay; 3) 8.8 lb alfalfa pellets every other day (4.4 lb/d) and 4) 8.8 lb alfalfa hay every other day (4.4 lb/d). The 70 d study was initiated in early November and continued through mid-January. The trial was initially intended to cover 84 days. However, due to excessive snow cover and limited forage availability in January, the study was terminated at day 70. Two 1,000 acre native range pastures were used in the study; animals were moved to the second pasture at d 28. Species composition of the pastures included Wyoming big sagebrush, bluebunch wheatgrass, sandberg bluegrass, squirreltail, and needle-and-thread. All animals were gathered at 8 a.m. daily, sorted into individual pens, and fed their supplement. On days when only two groups received alfalfa supplement, the remaining two groups were returned to graze. Cow weights and condition scores (1-9 point scale) were obtained following overnight removal from feed and water on d 0, 28, 56, and 70. Two sampling periods (early December and mid-January) were conducted to obtain estimates of forage intake, digestibility, grazing behavior, and quality of diet selected. Ten days prior to the first sampling period, six groups of randomly selected cows were dosed with continuous-release chromic oxide capsules in order to obtain estimates of fecal output. The same cows were used for the second period. Fecal grab samples were taken once daily for eight days in period 1 and seven days in period 2. Six different groups of randomly selected cows were fitted with vibracorders and digital pedometers in order to monitor time spent grazing and distance travelled. Diet quality samples were obtained for four consecutive days during each sampling period by using five esophageally fistulated steers (avg. wt. 1,048 lb). During period 2, five ruminally fistulated steers (avg. wt. 696 lb) were fitted with total fecal collection bags in order to validate chromic oxide release rate. Fecal output estimates were 96 percent of actual fecal output as determined by total collection; therefore, fecal output estimates were not adjusted. All steers received 4.4 lb/d of alfalfa pellets.

Weather data were recorded daily at a station approximately .9 miles from the study pastures. All samples were dried at 55°C in a forced-air oven for 48 h, ground to pass a .04-in screen in a Wiley mill, then analyzed in duplicate for dry matter (DM), ash, and neutral detergent fiber (NDF). Indigestible acid detergent fiber (IADF) content of all samples was determined by a 144 h in vitro fermentation followed by ADF extraction. Supplement and esophageal samples were analyzed for ADF, acid detergent lignin (ADL) and acid detergent insoluble N (ADIN) as determined by Kjeldahl N analysis of ADF residue. These samples were also analyzed for in vitro digestibility. Fecal samples were analyzed for chromium (Cr) content. Estimates of forage and total organic matter (OM) intake and digestibility were calculated from in vitro digestibility values for esophageal samples and supplements, and fecal output estimates obtained via Cr analysis.

RESULTS

Estimates of diet quality obtained from esophageal collections are shown in Table 1. Nutritive value declined from period 1 to period 2 ($P<.01$), with the exception of crude protein (CP), which tended ($P=.08$) to be higher in period 2. Increasing concentrations of ADIN, with lesser changes in CP, illustrates a reduction in the amount of digestible protein available to the animal, due to changes in the plant. Forage quality typically decreases as the seasons advance,

due to increased concentrations of fiber and lignin and decreased leaf:stem ratios. However, forage was already dormant when this study was initiated; therefore, forage quality may not have been greatly changed. The decline in diet quality in period 2 may be due more to reduced forage availability. Forage was readily available during sampling in period 1, while in period 2, snow cover and limited availability may have forced animals to select a lower-quality diet.

Performance data are presented in Table 2. Since no treatment X period interaction was observed (P>.10), all results will be presented across periods. Changes in weight and body condition were similar among treatments (P>.10), averaging 3.1 lb weight gained and 1.34 units body condition lost across the 70-d trial. While treatments did not affect animal performance, the climate did. A significant (P<.01) difference was observed in pattern of weight loss. Cows lost weight during the first 28 days of the study, then gained during the next 28 and 14 days. Animals were moved to a new pasture with more available forage after day 28; this may have accounted for the observed pattern of weight changes. Condition losses were greater (P<.01) during the last 14 days of the trial than the two previous 28 d periods; losses were similar (P>.10) at day 28 and 56. Reduced forage availability and rapidly increasing fetal growth could be contributing factors, as cows began to mobilize their body reserves to meet the increased demands of the fetus.

Grazing behavior, intake and digestibility results are reported in Table 3. Distance travelled (6.2 miles/d) and time spent grazing (5.93 hr/d) were similar (P>.10) across treatments; however, cows grazed significantly longer in period 1 (6.68 vs. 5.18 hr/d; P<.01). Adverse winter weather conditions have been reported to reduce grazing activity, as animals try to reduce energy expenditures to conserve energy for heat production; colder temperatures and snow cover in period 2 may have contributed to a reduction in the time spent grazing. Cows grazed less on days in which all animals received supplement (5.66 vs. 6.30 hr/d; P<.01), due presumably to the increased time required for feeding. Approximately 3.5 hours were needed to gather and feed on days when all cows were fed; however, when only two groups were fed, only 2 hours were needed. Total forage and NDF intakes and digestibilities were similar (P>.10) across treatments. When providing a supplemental feed to grazing animals, the added feed should not substitute for the range forage; maximizing utilization of the range forage is the primary goal. Similar intakes in the current study indicate that if substitution of alfalfa for native forage was occurring, it was minimal. Both intakes and digestibilities of the total diet, forage, and NDF were lower in period 2 (P<.01). Reduced forage availability may have forced animals to consume a diet of lower quality, since cows were observed grazing bare sagebrush twigs during period 2. Consuming a lower quality diet could cause reductions in intake and digestibility; reduced grazing time could also decrease intakes. Calf birth weight and ADG was not affected by treatment (P>.10; data not shown). Subsequent cow performance (weight, condition, and reproductive) was also not influenced by treatment (P>.10; data not shown).

CONCLUSIONS

Results of this study indicate that feeding alfalfa pellets or hay on a daily or an alternate-day basis did not affect performance, intake, digestion, or grazing behavior of beef cattle winter grazing northern Great Basin rangelands. Weather conditions and supply of available forage did influence these parameters and should be considered in winter grazing of low-quality forages. This study indicates that alternate-day feeding of alfalfa hay does not negatively impact animal performance, and may offer the benefits of reducing labor and feed processing costs.

Table 1. Chemical composition of alfalfa supplements and forage selected by esophageal steers winter grazing northern Great Basin rangelands[a].

ITEM	ALFALFA		FORAGE		SE
	PELLETS	HAY	EARLY DECEMBER	EARLY JANUARY	
OM	88.50	90.06	72.48[b]	87.29[c]	1.43
ADF	36.41	35.08	77.32[b]	66.70[c]	1.68
NDF	43.85	49.46	83.90[b]	72.61[c]	1.40
IADF	20.06	27.60	24.43[b]	46.92[c]	1.10
CP[d]	18.08	19.86	5.09[b]	5.86[c]	.26
ADIN[e]	20.37	20.53	23.88[b]	50.62[c]	.97
In vitro OMD	67.25	63.62	58.44[b]	34.36[c]	1.13
ADL	8.32	9.10	9.79[b]	20.67[c]	.36

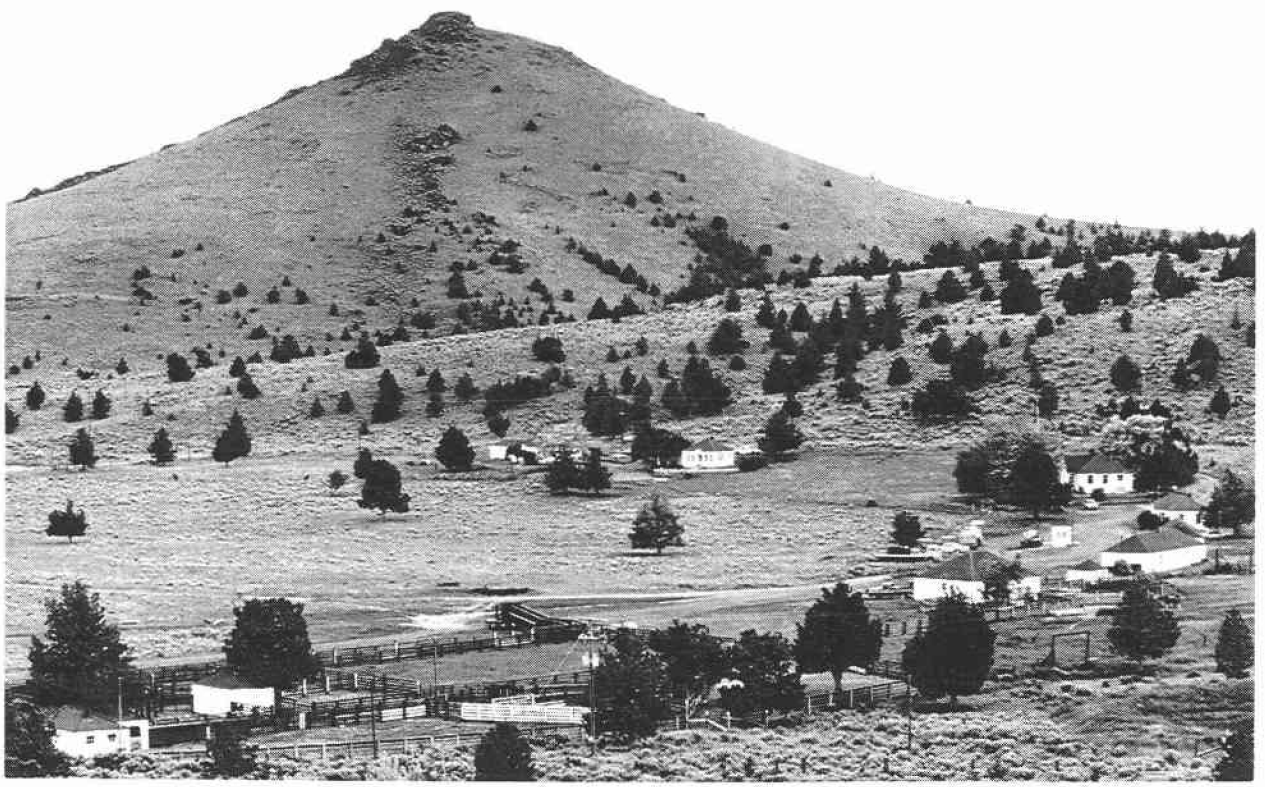


Table 2. Influence of physical form and frequency of alfalfa supplementation on weight gain and condition score of beef cattle winter grazing northern Great Basin rangeland.

Item	TREATMENT[a]					PERIOD[b]			
	1	2	3	4	SE	1	2	3	4
Weight gain, lb	3.10	-5.11	5.68	7.00	10.76	-81.85	80.77	10.66	3.20
Condition change, units	-1.20	-1.49	-1.30	-1.40	.10	- .40[c]	- .32[c]	- .63[d]	.60

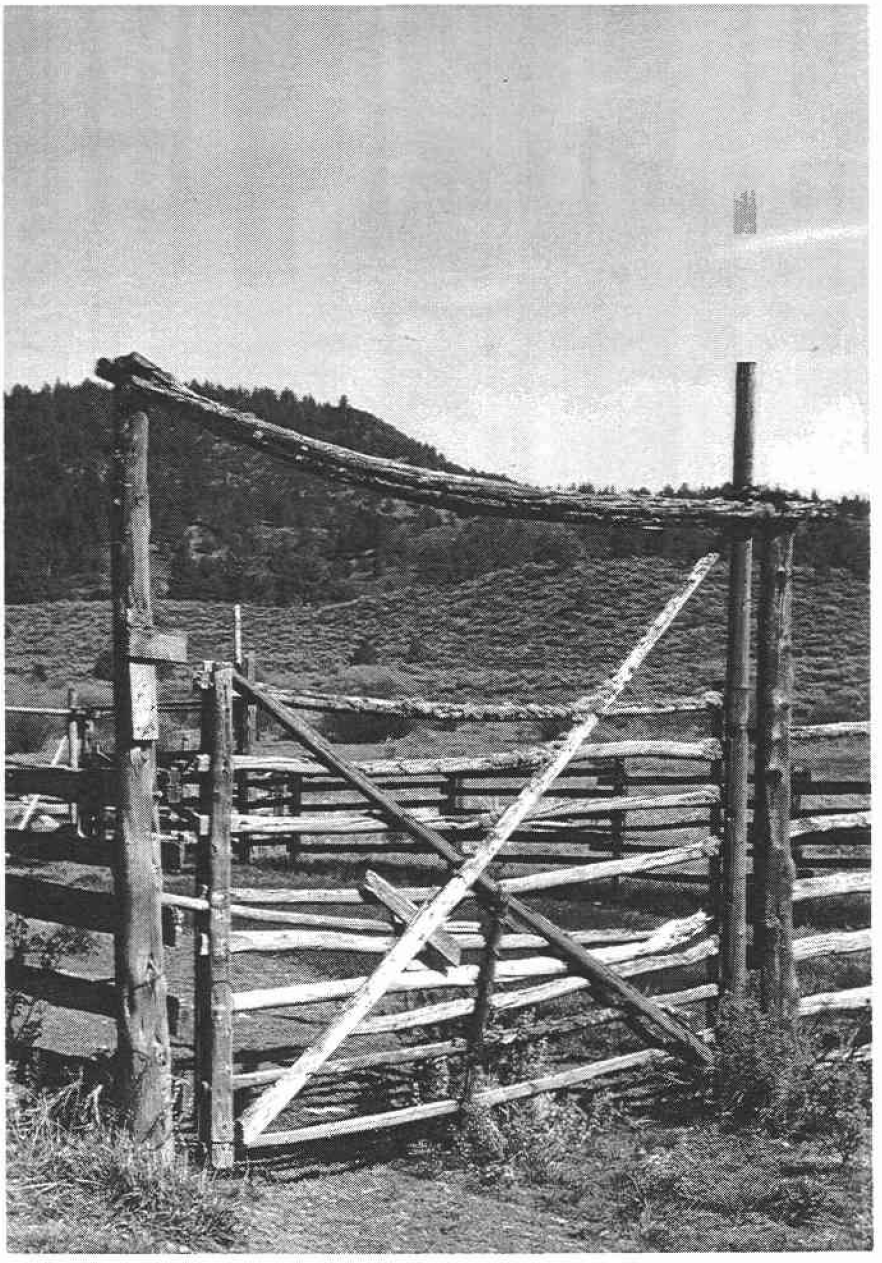
[a] Treatments: 1 = 4.4 lbs pellets; 2 = 4.4 lbs hay; 3 = 8.8 lbs/every other day pellets; 4 = 8.8 lbs/every other day hay.
[b] Periods: 1 = day 0 to day 28; 2 = day 29 to day 56; 3 = day 57 to day 70.
[c,d,e] Period means with different superscripts differ (P<.01).

Table 3. Influence of physical form and frequency of alfalfa supplementation on intake, digestibility and grazing behavior of beef cattle winter grazing northern Great Basin rangelands.

ITEM	TREATMENT[a]					PERIOD[b]		
	1	2	3	4	SE	1	2	3
OM intake, lb.								
NDF	16.36	16.52	16.76	16.78	.52	20.13	13.10	.30
Forage	18.17	18.22	18.63	18.41	.64	21.52	15.20	.36
Total	22.58	22.62	23.04	22.82	.64	25.92	19.60	.36
OM intake, % BW								
NDF	1.59	1.60	1.71	1.68	.18	2.00[a]	1.29[d]	.07
Forage	1.77	1.76	1.90	1.84	.21	2.14[c]	1.50[d]	.08
Total	2.20	2.19	2.34	2.28	.23	2.57[c]	1.93[d]	.08
OM digestibility, %								
NDF	44.74	44.56	44.20	44.14	.60	56.46[c]	32.36[d]	.38
Forage	46.40	46.40	46.43	46.39	.05	58.46[c]	34.34[d]	.02
Total	51.03	50.01	51.04	50.22	.21	59.68[c]	41.47[d]	.14
Grazing time, hr/d	5.96	6.17	5.63	6.00	.30	6.69[c]	5.19[d]	.18
Distance travelled, miles	3.80	3.86	3.89	3.68	.36	3.71	3.91	.22

[a] Treatments: 1 = 4.4 lbs/d pellets; 2 = 4.4 lbs/d hay; 3 = 8.8 lbs/every other day; 4 = 8.8 lbs/every other day hay.
[b] Periods: 1 = early December; 2 = early January.
[c,d] Means between periods with different superscripts differ (P<.01).

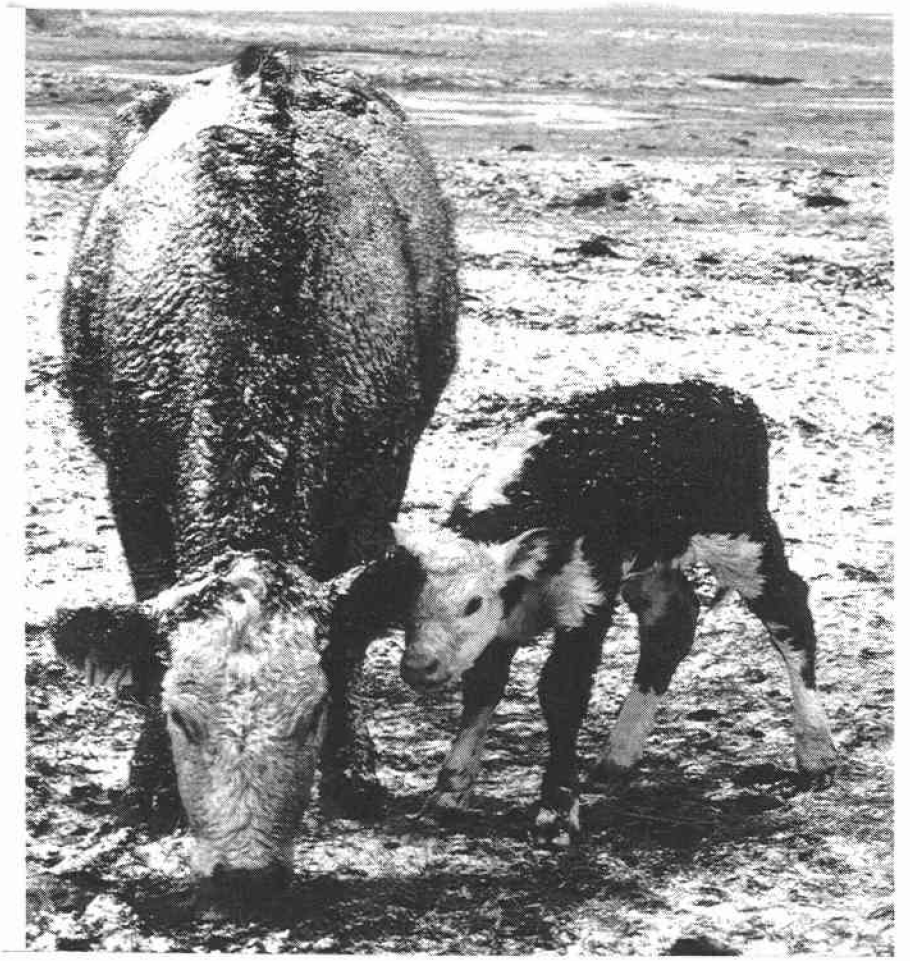
Research Projects Update



THE INFLUENCE OF SUPPLEMENTATION STRATEGIES ON DIGESTION AND PERFORMANCE OF BEEF CATTLE BEING FED TALL FESCUE STRAW

Tim DelCurto, Roxane Barton, Kelly Brandyberry and Steve Brandyberry

This research will be further evaluating the value of grass straw as a winter feed resource. More specifically, it will be evaluating several supplementation strategies for feeding pelleted grass straw. Two studies will be conducted. The first will be a digestion study to evaluate the effects on the rumen. It will utilize 20 ruminally cannulated steers and they will be assigned to one of five treatments; 1) pelleted grass straw, 2) pelleted grass straw plus once daily supplement, 3) pelleted grass straw plus twice daily supplement, 4) pelleted grass straw plus alternate day supplement, 5) pelleted grass straw/alfalfa mixture (75% straw/25% alfalfa mix). The second study will be a performance study evaluating the effects of the treatments on heifer performance.
The first study will be completed by May 1, 1993, and the second study will be conducted in the winter of 1993-1994.



ONGOING STUDIES AT THE STARKEY EXPERIMENTAL FOREST

Martin Vavra, Larry Bryant, Chuck Ballard and Wade Titus

Ongoing studies in the Starkey Experimental Forest are focused on grazing strategies for riparian zones and improved beef production, and participation in the long term livestock/wildlife/timber management study. Research is in partnership with the USDA-Forest Service PNW Experiment Station Range and Forestry Laboratory in La Grande.

The grazing strategies studies are long-term projects in the Meadow Creek drainage that are designed to provide some deferment of the riparian zone and uplands during the grazing season while providing for improved beef production. Increased livestock production can be accomplished with pasture systems that use predominately south facing slope pastures during the first half of the grazing season and north facing slope pastures during the latter half of the grazing season.

At the present time, cattle from the station are being used in distributional studies as part of the cattle/wildlife/timber management research. Animals are fit with radio tracking devices and monitored as to their pasture movements. Future studies hope to focus on dietary overlap and forage utilization among cattle, mule deer, and elk.

POTENTIAL OF GOATS AS BRUSH CONTROL AGENTS

Babajide Fajemisin, Martin Vavra, Tim DelCurto and Dave Ganskopp.

Commonly used approaches to brushwood management are prescribed burning, mechanical methods, and herbicide applications. However, due to rising costs of fuel, equipment, legal restriction against the use of herbicides, environmental hazards from uncontrolled burning, and health concerns, a low-input biological control by goat appears to be a viable alternative to reduce these woody plants.

Goats are generally efficient at suppressing brush. However, many of these woody species produce anti-herbivory compounds in their leaves and stems that can reduce nutrient digestibility and retention. Information on the utilization of these components would help to plan grazing for goats on brush ranges, and shift the advantage towards use of the animals for production purposes and as biological control agents. The following study was therefore designed to evaluate the utilization of two brush species, western juniper (*Juniperus occidentalis*), and big sagebrush (*Artemisia tridentata*) by goats and also to investigate the possibilities that exist for manipulating vegetation through managed goat browsing.

Terminal twig portions with associated leaves and buds of big sagebrush and western juniper were separately hand-harvested. Plant materials were coarsely chopped and mixed manually into graded portions with chopped alfalfa hay. Experimental diets were formulated to provide four each of alfalfa to sagebrush/juniper diets in ratios of 100:0; 90:10; 80:20 and 70:30 on dry matter basis, and fed to eight growing female Spanish goats weighing between 25 to 30 kg, fitted with ruminal cannulas, in a dual 4 X 4 Latin square design to examine the voluntary intake and rumen kinetics.

Goats were weighed before and after each trial, which consisted of 14 days adaptation and 7 days of total fecal collection. Goats were kept in elevated digestion crates and were fed enough feed once daily. Water and mineral licks were provided for free choice throughout each trial. Feed, orts, feces, and urine samples were obtained daily during each fecal collection period for chemical analyses. Total fecal output and urine volume were recorded daily, and samples composited. Volatilization of ammonia from urine samples was prevented by adding 100 ml of 1.2 N HCl to the collection vessel.

On day one of the collection period, each goat was dosed intraruminally with about 30 g of Yb-labeled forage to determine the rate of passage. Rectal grab samples were collected before dosing (0 hr) and at 12, 18, 24, 30, 33, 36, 48, 60, 72, 96, 120, and 144 hours after dosing. Ruminal samples were taken at 0, 3, 9, 12, 18, and 24 hours on the last day of collection. The pH of digested samples was measured, and strained ruminal fluid was acidified with metaphosphoric and hydrochloric acids and stored frozen for VFA and NH_3 analyses.

Duplicate 5 cm x 10 cm nylon bags (pore size 50 + 10um) filled with about 2 g ground basal diet sample were suspended in the rumen on day 3 of the collection period to estimate the in-situ digestion. Bags devoid of forage served as blanks. All goats received 3 bags per incubation time (duplicate sample of basal diet plus 1 blank). Bags were retrieved after 0, 12, 24, 36, 48, 72, and 96 hours, then rinsed with tap water until rinse water was clear. Samples were dried at 60°C for 48 hours, weighed, and later assayed for residual neutral detergent fiber (NDF). These trials are presently in progress.

As follow-up to the digestion trials, field research would be carried out to quantify the grazing impact and utilization pattern of the vegetation by goats. To determine these, observations would be made on the types of forages available for consumption, botanical composition, and the nutrient content of the diet selected. The influence of grazing on individual plants and parts of plants would be monitored to define the frequency, extent, and pattern of defoliation. Detailed assessment of goats movement, amount of time spent ruminating, watering, resting, and other related behavior would be noted. These data, combined with forage use and plant vigor, would provide guidelines to plan grazing for goats as management tools.

BIG GAME AND CATTLE INTERRELATIONSHIPS AND THEIR INFLUENCE ON BIOLOGICAL RESOURCES, SEASONAL RANGELAND AND AGRICULTURAL LAND IN NORTHEASTERN OREGON

Dennis Sheehy, Martin Vavra, Teena Tibbs and Ron Slater

Livestock/wildlife conflicts continue to be an area of concern to livestock producers, public, and private land managers, and wildlife management agencies even though studies in some areas have shown the conflict to be more perceived rather than actual. Winter ranges are of particular concern since they are usually a mixture of public and private ownership. Elk winter range in Oregon is approximately 50 percent private ownership while deer winter range is approximately 30 percent private ownership.

Factors contributing to compatible use by livestock and wildlife need to be identified. Once these factors have been identified, compatible use areas and conflict use areas should be compared and evaluated to determine causes of conflict and the management changes that can be implemented to alleviate current or anticipated conflict on seasonal rangeland, especially on winter ranges considered to be problem areas.

Although results of previous studies and on-going management practices will be used to design the model for conflict resolution, the study will have a research component to identify previously unstudied conflict mechanisms and approaches to resolution. Research will be used to determine management modifications and/or inputs that can be used in applying the conflict resolution mode. Livestock and wildlife use and vegetation parameters will be monitored before and after management modifications have been implemented to validate the applicability of management practices in the conflict resolution model.

The benefits of a study of this nature conducted at the present time would be substantial. Grazing on public and private land by livestock is coming under increased scrutiny by the general public as environmental conservation groups become increasingly involved in policy making for future use of public and private grazing land. As a consequence, private and public land managers are being placed in a defensive position relative to many grazing issues. A cooperative study designed to identify management practices that have been successful in resolving conflict over allocation of forage and habitat on seasonal winter ranges presents an opportunity for private and public land managers to take a pro-active position relative to these issues. A study of this nature also presents the opportunity for cooperators to demonstrate their concern for proper use of the land resources and their ability to resolve issues voluntarily rather than in response to imposed mandates.

The projects being developed will be cooperative in nature and involve private landowners, Oregon Department of Fish and Wildlife, U.S. Forest Service, and O.S.U. Extension Service.

EFFECTS OF EARLY SPRING GRAZING OF RANGELANDS USED IN WINTER GRAZING PROGRAMS IN THE NORTHERN GREAT BASIN

Steve Brandyberry, Tim DelCurto, Roxane Barton, Kara Paintner and Kelly Brandyberry

Winter grazing is a grazing management plan currently receiving a great deal of interest at the Eastern Oregon Agricultural Research Center. This alternative management plan may be economical and beneficial to range condition, as well as reducing conflicts over multiple use of public rangelands. With the possible exception of the winter environment, nutrition is the most critical factor in winter grazing. Previous research efforts have focused on supplementation strategies to improve animal performance on winter range. The potential may exist to improve the quality of winter forage available. Early spring grazing, or "preconditioning", involves grazing pastures utilized for winter grazing in the spring, rather than deferring grazing throughout the growing season. Preconditioning the forage may allow it to remain in a more vegetative state, thereby improving the quality of the diet. However, this may also reduce the amount of forage available to the animals, especially during dry years. Therefore, the objectives of this study were: 1) determine the effects of preconditioning on the quality of winter forage, and 2) determine the effects of preconditioning on the amount of forage available for winter grazing.

When completed, this study will cover two years (1992 and 1993); results from 1992 will be reported here. In early to mid-March of 1992, five 100 x 165 ft sites were selected in a 1,000 acre, native range pasture on the Northern Great Basin Experimental Range, and fenced off using electric fencing. Cow-calf pairs were turned onto the range and remained until mid-April, removing approximately 75 AUM's of forage. Following animal removal, no further grazing occurred in this pasture until the sites were sampled in early November. This pasture was utilized in a winter grazing study this past winter, and will be again in 1993-94. Prior to the introduction of the 31 head involved in the winter grazing study, fences were lowered at each site to allow animals access to the inside of the sites. Growing season precipitation totalled 9.1 in which is approximately 90 percent of the long-term average. This precipitation pattern has held for the past seven years, with below-average precipitation occurring each of those years. Temperatures in late winter and early spring were mild, which caused forage to begin spring growth earlier than normal. However, low levels of precipitation at this time caused plants to cease growth and become dormant by mid-May. In early November (following the first hard freeze, which terminated any plant growth activity), total forage production was estimated by clipping 20 randomly selected 3.3 $ft.^2$ plots on both the inside (ungrazed) and the outside (grazed) of each site. Immediately following clipping, five esophageally fistulated steers were used to obtain diet quality samples. Steers grazed first inside, then outside of each site. Total forage production was lower in grazed sites, compared to sites where grazing was excluded. However, diet quality was not enhanced by preconditioning. We concluded from this year's data that preconditioning winter range forage reduces the amount of forage available for winter grazing, with no improvement in diet quality.

The second year's (1993) study is just getting started. Cow-calf pairs have recently been taken to the pasture, and the preconditioning has begun. All techniques and procedures will remain the same for this year, the only possible difference being the sampling time next fall. If a hard freeze occurs in mid-to late October, sampling will be done then. This year should provide an interesting contrast to last year, since precipitation levels will be higher. We should have the final results from this study by December of 1993.

ENVIRONMENTAL INFLUENCES ON NUTRITIONAL PHYSIOLOGY AND PERFORMANCE OF BEEF CATTLE WINTER GRAZING NORTHERN GREAT BASIN RANGELANDS

Steve Brandyberry, Tim DelCurto, Roxane Barton, Kelly Brandyberry and Kara Paintner

Winter grazing studies conducted in recent years have provided general information in regard to environmental influences on nutrition. The winter environment is one of the most important variables to be considered in a winter grazing program, and if severe, can have a significant (and potentially serious) impact on animal performance. Grazing animals have been shown to reduce their grazing activity and decrease intake of range forage during severe environmental stresses. Animal response to various environmental variables (temperature, precipitation, wind speed) on a short and long-term basis is still not clear. We have recently completed a study that should describe the mechanisms by which animals respond to the environment on a day-to-day basis. We also hope to be able to show the type and magnitude of environmental change, which is needed to cause nutritional, physiological and behavioral changes in the animal.

During the winter of 1992-93, 24 mature, pregnant Hereford X Angus cows were individually fed, beginning at 8 a.m. each day, 4.4 lb./hd/d of a corn-cottonseed meal supplement (20% CP), which also contained 2.0 gms of chromic oxide, and an indigestible marker used to determine fecal output. Feeding began on November 11, 1992. Seven ruminally and esophageally fistulated steers were kept with the cows and fed the same amount of supplement. The sampling period began on November 23. Fecal grab samples were obtained daily from each cow. Also at this time, all cows were fitted with vibracorders and pedometers in order to measure grazing behavior. Cow weights and condition scores were obtained on each Monday of the study. At this time, blood samples were also obtained to determine blood urea N and cortisol levels. Every other week, three of the steers were fitted with total collection bags in order to validate the recovery of the marker. On weeks when the bags were not used, the remaining four steers were originally intended to be used on four consecutive days to obtain diet quality samples. However, due to excessive snow cover, this only happened one time, in early December. These four steers were ruminally evacuated on the fifth day of these weeks, in order to determine digesta kinetics (ruminal fill and passage rates). Intake estimates will be made on a daily basis, based on daily fecal output values and weekly diet quality values. Digesta kinetics will be used to adjust fecal output estimates to the time of environmental events. Daily intake estimation is an untested approach in a grazing situation; therefore, we hope this procedure provides encouraging results.

Due to excessive snow cover, we began feeding grass straw to the cows on December 7. The straw was provided in sufficient amounts to ensure ad libitum intakes. Following the onset of straw feeding, cows greatly curtailed their grazing activity; in fact, they spent all their time in the feeding ground. Beginning in early January, on two consecutive days of every other week, cows were visually observed to determine when they were eating straw and when they were eating snow. The animals had not been to water since mid-December, and had been using snow as their water source. The observation was done in order to separate straw and snow eating events on the grazing charts. The study was terminated on February 22; extreme snow drifting had closed the roads into the pasture and feeding facility, causing us to end the study one week ahead of time.

A weather station in the study pasture recorded environmental effects such as wind speed and direction, temperature, solar radiation, and precipitation. While the amount and the persistence of the snow cover forced us to change the study from its original design, we still hope to get some new and valuable information regarding nutritional response to environmental stress. This study should be completely analyzed and published by January of 1994.

YEAR AND SEASON EFFECTS ON DIET QUALITY OF BEEF CATTLE GRAZING NORTHERN GREAT BASIN RANGELANDS

Steve Brandyberry, Tim DelCurto, Roxane Barton and Jeff Rose

Performance of beef cattle on native range is affected by many factors. One of the most important factors is the quality of the diet selected. While many things can influence diet quality (plant species available, stocking density), climate is probably the most important. Climatic changes can be either short-term, such as changes during the growing season, or more long-term, such as year-to-year changes. Forage quality decreases as the season advances, due to increases in plant fiber constituents and decreased amounts of digestible protein. While these season-long changes have been well documented, the effects of longer-term climatic change on forage quality have not been studied. The objectives of this study have been to determine changes in diet quality both across the growing season and between growing seasons.

This study, when completed, will encompass four consecutive growing seasons (1990, 1991, 1992, 1993). Diet quality samples were obtained from five to six esophageally fistulated steers on two consecutive days of each month from April to September of each year; 1993's collection period has not yet begun. So far, only samples from 1990 and 1991 have been analyzed. Collections were made in mid-morning from the same 160 acre native range pasture. This pasture is grazed in late fall or winter to remove the previous growing season's vegetative material (20 AUM's/year). Precipitation received from September through the following August is reported as growing season precipitation. All samples were (or will be) analyzed for dry matter, ash, crude protein (CP), acid detergent insoluble nitrogen (ADIN, a measure of the unavailable protein), neutral and acid detergent fiber (NDF and ADF), acid detergent lignin (ADL), and in vitro organic matter digestibility (OMD).

Growing season precipitation for 1990, 1991, and 1992 measured 5.5 in, 8.8 in, and 9.1 in, respectively; these are 55 percent, 87 percent and 90 percent of the long-term average. Precipitation for 1993 should be much higher, however. Results from 1990 and 1991 indicate that diet quality improved early in the growing season, then began to decline as the summer wore on. Fiber constituents (ADF, ADL, NDF) were high early in the season, declined as forage growth began, then rose again in late summer as the forage became dormant. Crude protein and OMD followed opposite trends, being low early, then increasing during plant growth, only to decrease again late in the season. Reductions in diet quality associated with the advancing season are likely caused by increasing amounts of fiber and a reduction in the amount of digestible protein. In addition, increased lignification and a decreased leaf:stem ratio also contribute to declines in nutritive value.

Diet quality was generally higher in 1991. Precipitation received that year was nearly 60 percent greater than in 1990. This increased level of precipitation may have stimulated increased plant growth, as well as promoting active plant growth and maintaining diet quality longer into the season. Water stress tends to retard plant growth and maturity, causing plants to remain in a vegetative state, which increases digestibility at the cost of dry matter yield. Thus, we would expect higher diet quality in dry years. However, adapted perennial desert plants may resort to dormancy in a dry year, pulling reserves into their roots and leaving an aboveground part of lower nutritive value. These plants may respond to increased moisture by continuing growth, and retain higher quality by not reverting to dormancy. Increased forage production during these times would provide more plants, giving animals more grazing opportunities and increasing their chances of selecting a higher quality diet.

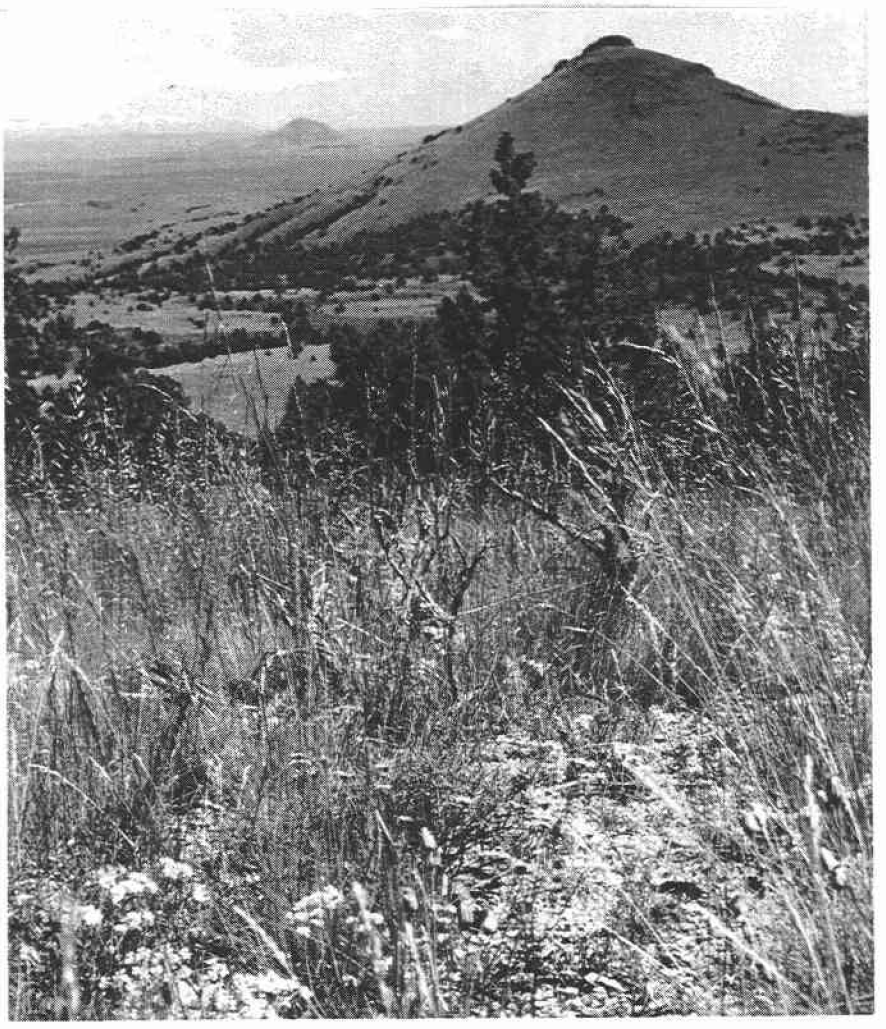
Both 1992 and 1993 should provide more insight into the effects of year on diet quality. Higher precipitation levels in 1993 will allow comparisons to the drier years of 1990-92. In addition, estimates of total forage production will be available for 1992 and 1993, to investigate the potential role of forage availability on diet quality. While seasonal effects on diet quality do exist, yearly effects also occur and may, in some instances, have a greater influence on the quality of the diet selected. We anticipate having results from this study by January of 1994.

WEATHER AND PHYSICAL DATA

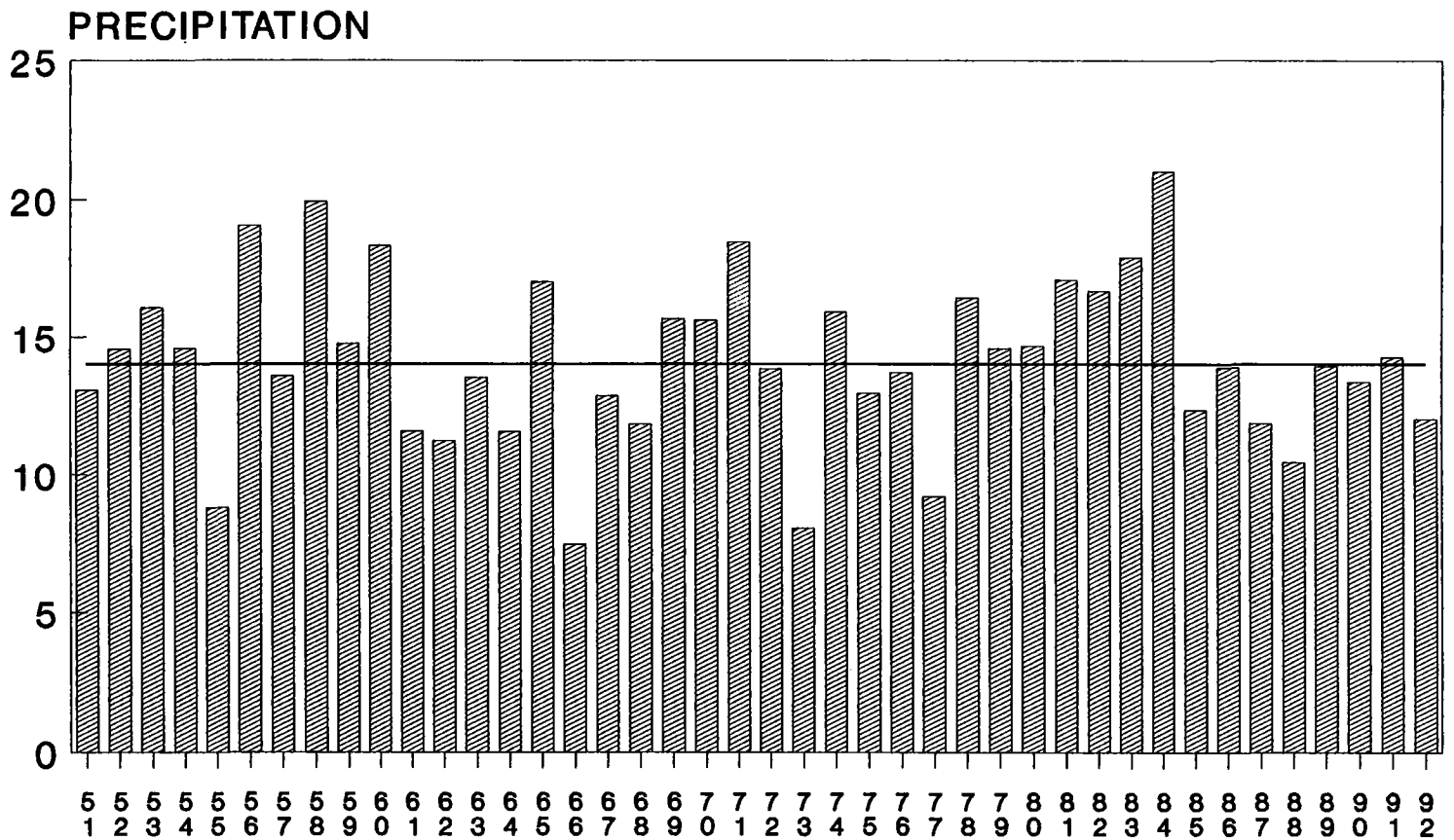
- **Union Station**
- **Hall Ranch**
- **Northern Great Basin Experimental Range (formerly Squaw Butte)**

SOIL MOISTURES

- **Northern Great Basin Experimental Range**

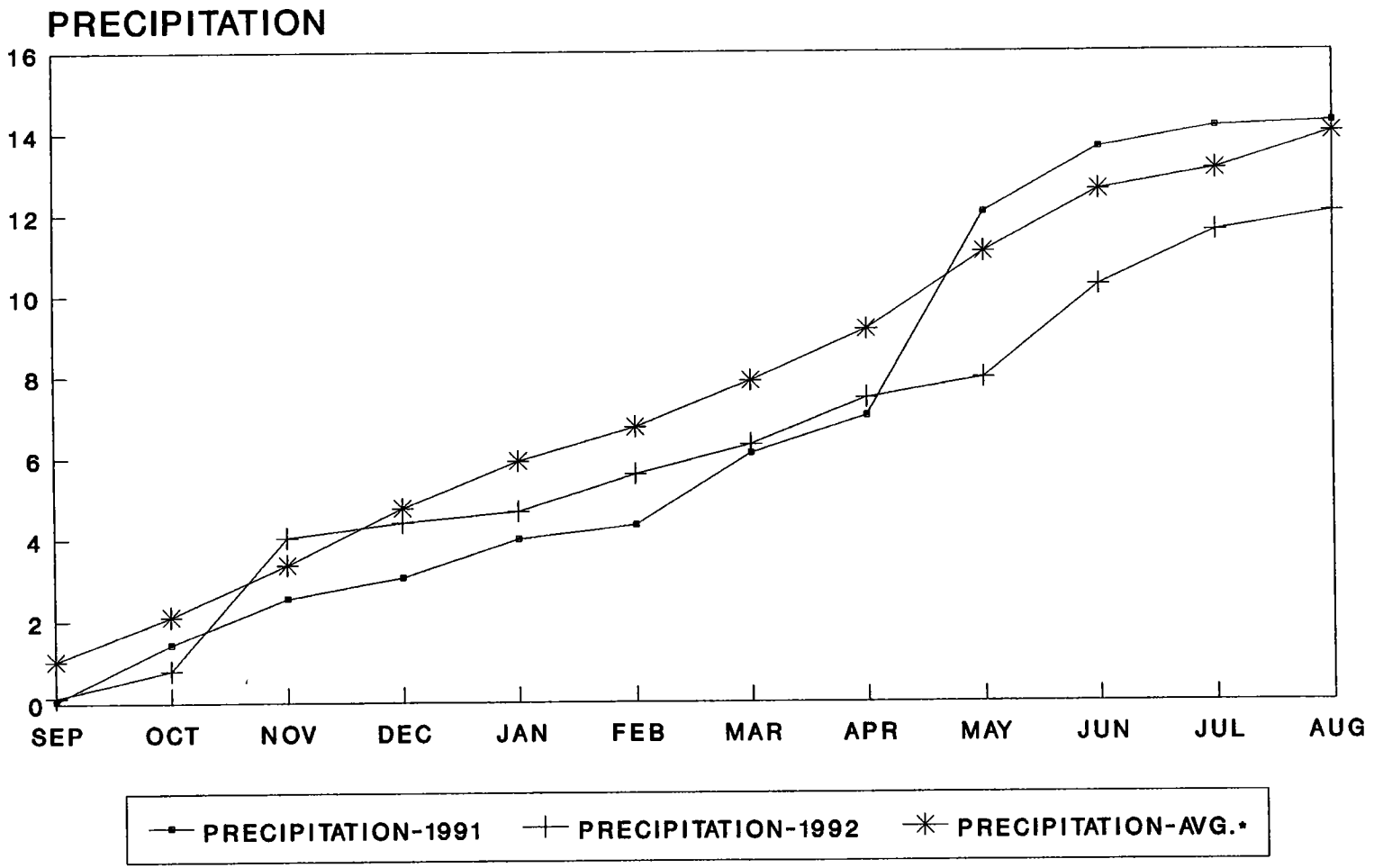


UNION PRECIPITATION - CROP YEAR - 1951-1992



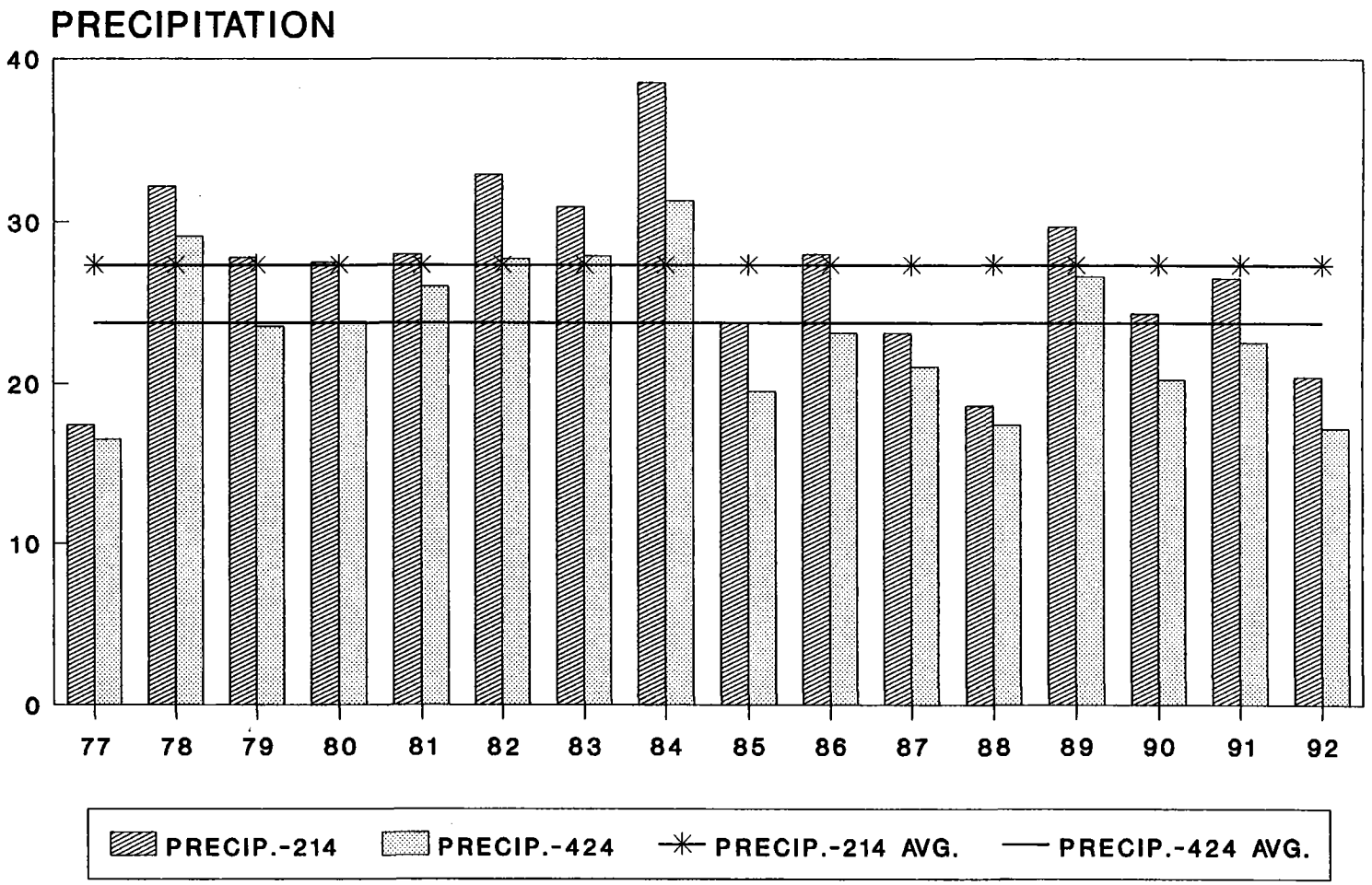
1) SOLID HORIZONAL LINE DENOTES THE AVERAGE PRECIPITATION.
2) AVERAGE TAKEN FROM 1951-80 DATA.

UNION PRECIPITATION - CROP YEAR - 1991 AND 1992



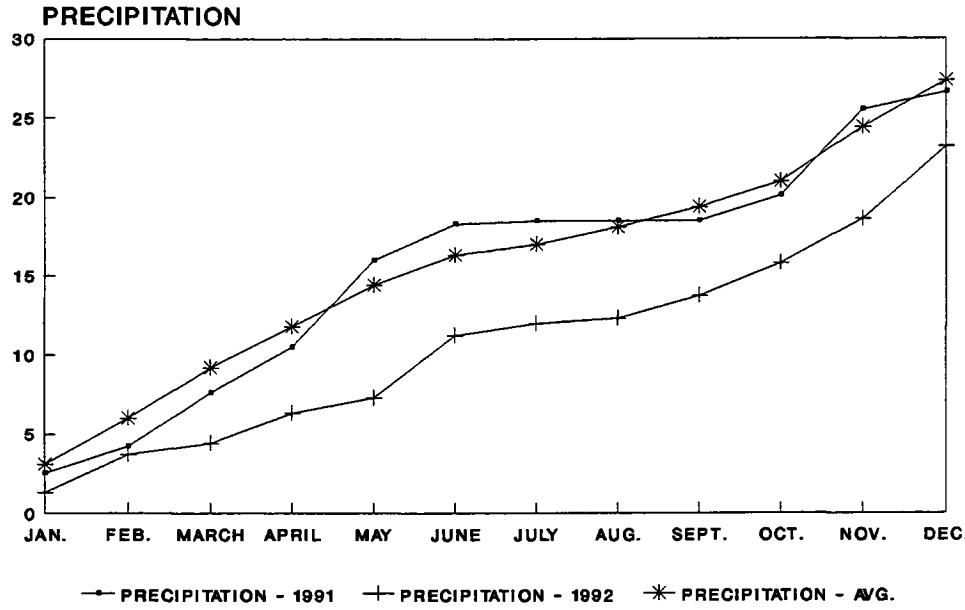
* AVERAGE WAS TAKEN FROM 1951-1980.

HALL RANCH PRECIPITATION - CROP YEARS 1977-1992 - STATIONS 214 AND 424

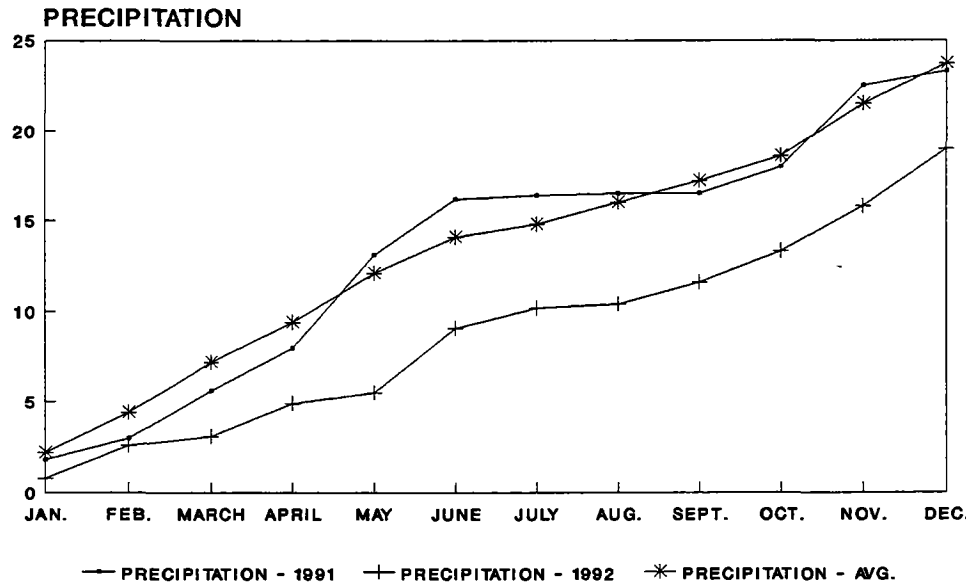


1) STATION #214 - ELEVATION 3900 FEET.
2) STATION #424 - ELEVATION 3480 FEET.

HALL RANCH PRECIPITATION - 1991 & 1992- STATION #214



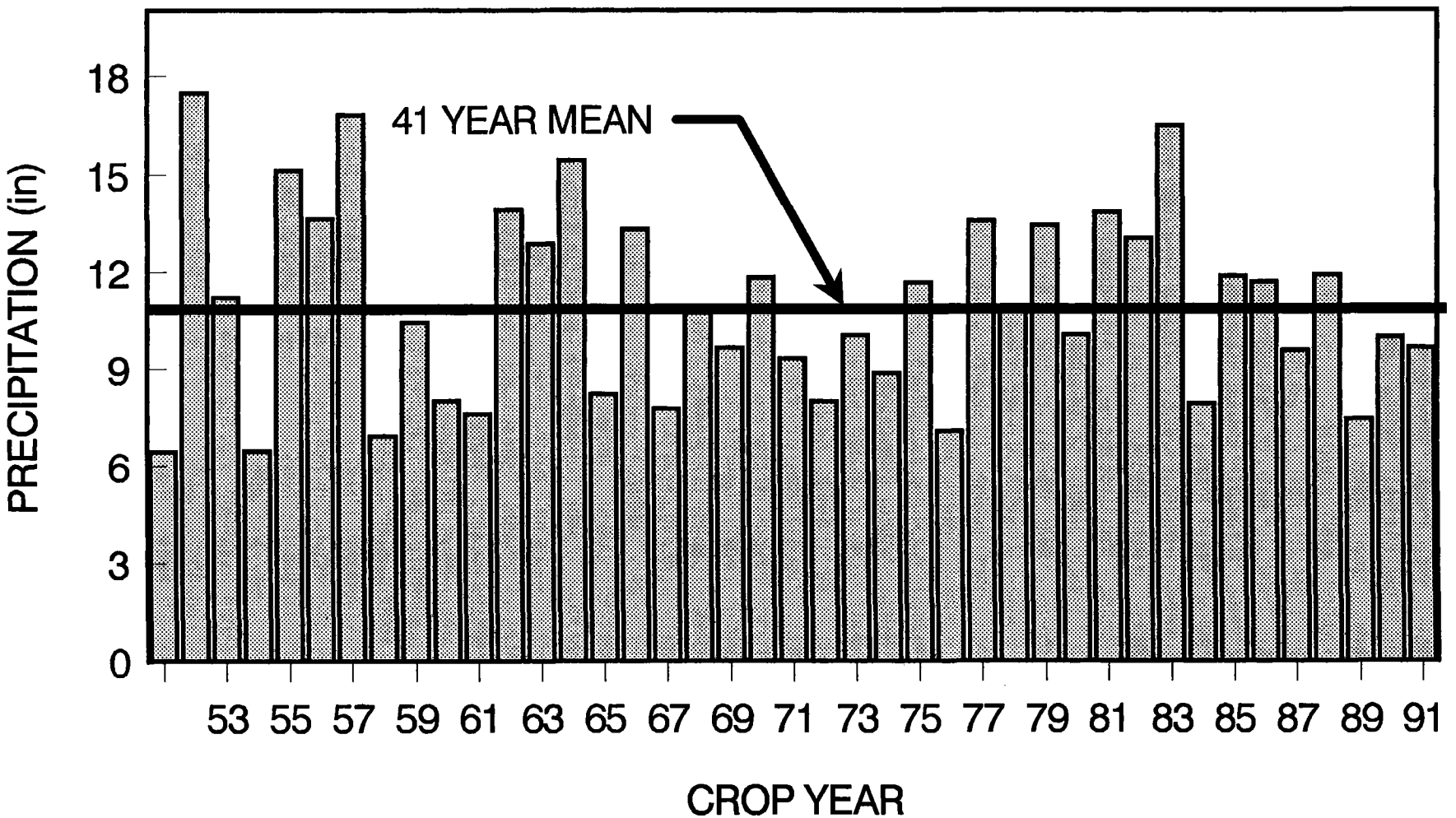
HALL RANCH WEATHER - 1991 & 1992 - STATION #424



1) AVERAGE TAKEN FROM THE YEARS 1977-1992.

CROP YEAR PRECIPITATION (SEPT to AUG)

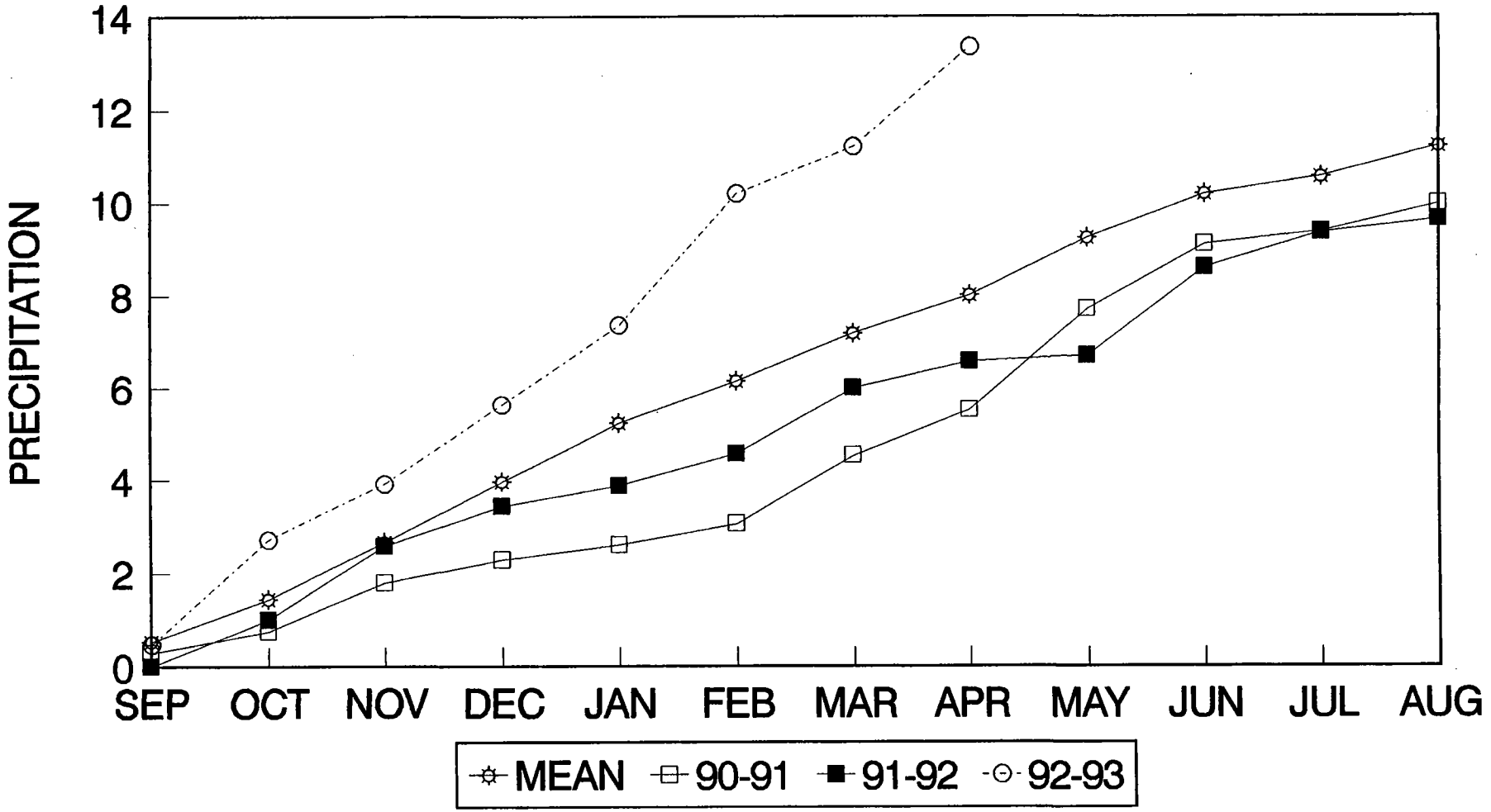
NORTHERN GREAT BASIN EXPERIMENTAL RANGE



CROP YEARS 1951-1952 to 1991-1992

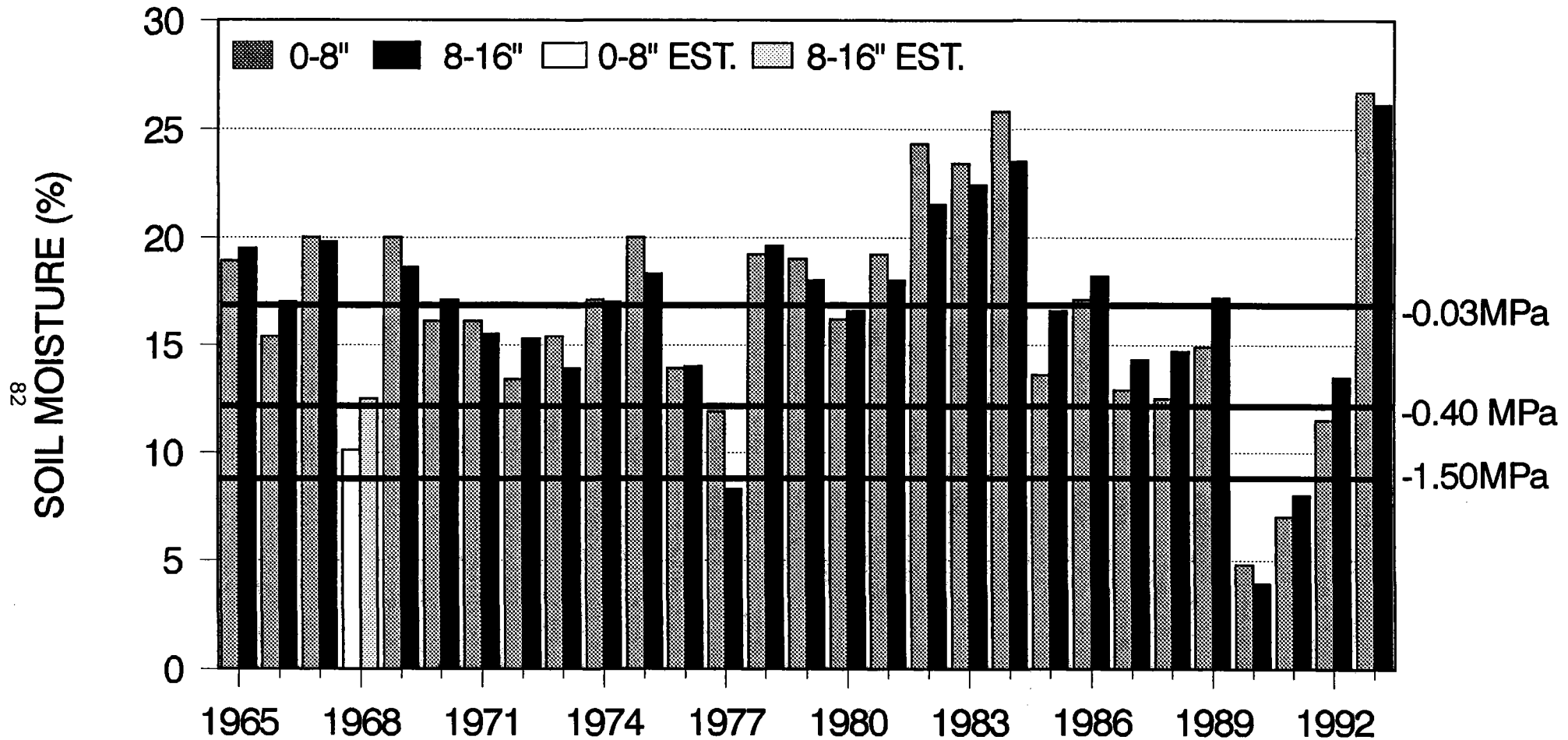
CROP YEAR PRECIPITATION (SEP to AUG)

NORTHERN GREAT BASIN EXPERIMENTAL RANGE



SOIL MOISTURE

NORTHERN GREAT BASIN EXPERIMENTAL RANGE



Taken April 15th