

AN ABSTRACT OF THE THESIS OF

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Vegetation

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Native flood meadows are important for hay production and winter feeding areas in many western states. With the introduction of meadow foxtail (*Alopecurus pratensis* L.) and other new species, the botanical composition of the meadows has been steadily changing. With shifting priorities occurring on public lands, these flood meadows, many of which are privately owned, will increase in their importance to the livestock industry. This study was conducted on a 23-hectare representative meadow at the Eastern Oregon Agricultural Research Center, Burns, OR. The objectives were to determine drought and grazing effects on botanical composition, yield, and forage quality of meadow foxtail plus other forage species. Also, corn supplementation effects were examined to determine the ramifications on heifer performance.

Four 50 X 50 meter experimental sites were established in a meadow with half of each area fenced off to prohibit any grazing. The study was conducted over a two-year period during the late spring/early summer of 1992, a drought year, and 1993, an above normal precipitation year. Data were collected in July of both years

and included total yield, percent of total yield, frequency, and basal cover. Forage categories examined included meadow foxtail, sedges, rushes, other grasses, and forbs. Forage quality of meadow foxtail was also measured and included percent organic matter, in vitro OM digestibility, and crude protein content. In 1993, 72 heifers were put on the pasture and fed 0, 0.50, 0.75, and 1.0 kg/d of cracked corn in four treatment groups. The average daily gain of each group was determined by weighing the heifers biweekly. Statistical significance was inferred at $P \leq 0.05$ for all parameters. Total yield of meadow foxtail, sedges/rushes, other grasses, and forbs in 1992 was 257, 29, 36, and 69 kg/ha, respectively. Total yield increased significantly in 1993 to 6184, 967, 614, and 430 kg/ha, respectively. The percentage of total yield for meadow foxtail and sedges/rushes increased (68 vs. 76% and 8 vs. 12%, respectively) while that of forbs declined from 16 to 5%. Even though sedges and rushes appeared to benefit from increased precipitation in 1993, the large increase in the frequency and basal cover of rushes (6 vs. 20% and trace vs. 1%, respectively) revealed that rushes increased in number of plants and not just in increased yields while sedges only increased in terms of yield. Meadow foxtail also increased in basal cover (2 vs. 5%), appearing not to be severely affected by the drought and recovering well. Grazing in 1993 favored meadow foxtail as the frequency (53 vs. 82%) increased with no decrease in basal cover. All other forage classes were unchanged. The drought increased forage quality of meadow foxtail although yield was severely depressed. In vitro OM digestibility (58.8 vs. 83.4%) and crude protein (5.0 vs. 27.1%) were decidedly lower in 1993 than in 1992, but organic matter (89.6 vs. 87.5%) was increased. A dilution effect in the wet year of 1993 may have played

a role in the large decrease in N concentration due to accelerated growth. Grazing also affected meadow foxtail by increasing protein (5.0 vs. 11.9%) and in vitro OM digestibility (58.8 vs. 67.8%) and decreasing organic matter (89.6 vs. 84.8%).

Herbage removal can interrupt development, prevent maturity, and initiate regrowth, thus increasing the amount of higher quality, younger live tissue. Corn

supplementation had no effect on average daily gain in any of the four treatment groups of heifers. Average gain across all groups was 1.1 kg/d. Failure to increase performance was probably due to the inability to utilize any extra energy because the cattle were operating at maximum protein synthesis capacity.

**HEIFER PERFORMANCE AND DROUGHT AND GRAZING
EFFECTS ON FLOOD MEADOW VEGETATION**

by

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HEIFER PERFORMANCE AND DROUGHT AND GRAZING EFFECTS ON FLOOD MEADOW VEGETATION

INTRODUCTION

Native flood meadows, which are located throughout the Intermountain area, rely heavily on snowmelt for the flood stage waters that are responsible for the majority of the moisture that is necessary for summer forage production (Cooper 1956, Rumburg 1963). Many of these meadows are highly productive, and livestock producers are dependent on them to provide winter feed, as hay, and as winter feeding grounds.

During climatic cycles, there are periods of drought that may last a few years, causing a drastic decrease in winter precipitation and a shallow or absent snowpack. A large decrease in the amount and length of the spring runoff may significantly affect the quantity and quality of the meadow vegetation. A few authors have noted that changes in yearly moisture can affect species composition of the vegetation and the maturity dates of the hay (Lewis 1957, Rumburg and Cooper 1961, Rumburg and Sawyer 1965, Gomm 1979). With the introduction of non-native grass species into these regions, the type and time of use of the meadows may be altered even more. This study will look at precipitation effects on the yield, quality, and species composition of native meadows that have undergone a significant change since the introduction of meadow foxtail (*Alopecurus pratensis* L.) and other non-native grass species. It will specifically focus on the effects of drought on the yield and frequency of meadow foxtail as compared to the other plant species.

In addition to less moisture, grazing may be an additional factor that affects species composition and forage quality. With the potential decrease in the availability of public lands for grazing, livestock producers may turn to the meadows as a source of spring and summer forage. Preference for certain forages will increase selective pressure on the more palatable plants, causing them to decrease in abundance. Preference, however, may change during drought years if forage quality and palatability are altered, thus, requiring the need to change management planning. Improper use of the meadows may result if management schemes used during normal years are not compatible with drought years. The research here will look at grazing effects on meadow vegetation which may aid the producer in maintaining sustainable yields over the long term.

Supplementation of roughage diets with high-energy concentrates has long been thought to increase weight gains of growing cattle. The results of some studies concerning this matter have been contradictory (Wagner et al. 1984, Sanson et al. 1990, Hubbell et al 1992). This study will try to determine if corn supplementation will result in an increase in animal performance. In order to justify the added costs in terms of extra feed, time, and labor, separate studies should be done in distinct regions to take into account the type of vegetation, the type of management, breed of cattle, and other factors in order to determine the optimum feeding levels, if any, to ensure an economic gain for the producer.

LITERATURE REVIEW

Native Flood Meadows of Eastern Oregon

Classification and historical vegetation

The native flood meadows of eastern Oregon are classified as seasonally wet due to early spring snowmelt (Cooper 1956, Rumburg 1963). Flooding generally occurs from April through June, depending on the amount of snowmelt in the surrounding mountains (Rumburg and Sawyer 1965). Historically, the forage was composed of native grasses such as Nevada bluegrass (*Poa nevadensis* Vasey ex Scribn.) and beardless wildrye (*Elymus triticoides* Buckl.), rushes, sedges, and a variety of forbs (Rumburg and Cooper 1961). Species composition and productivity for a specific year was determined by depth and duration of flooding with grass and sedge density decreasing, and rush density increasing, as flooding depth and length of flooding period increased (Rumburg and Sawyer 1965). There was some variation between species in tolerance to flooding, but, in general, native grasses, sedges, and rushes required much higher amounts of water and tolerated flooding better than introduced grass species (Lewis 1957, Gomm 1979). It was found that with continuous flood irrigation, botanical composition and yield were also influenced by soil fertility (Rumburg and Cooper 1961) and increased irradiance (Gomm 1978).

With the wild-flood type irrigation, it is difficult to maintain stands of higher-yielding native forage species to maintain maximum production. Early hay harvest is

difficult due to the wet soil conditions that do not allow use of heavy equipment.

Also, native species are not well-adapted to production of multiple crops in the same growing season, resulting in slow recovery after harvest and low production of the second crop (Rumburg 1963). However, Rumburg (1963) did find that earlier hay harvest produced higher quality hay yields, and increased regrowth yields without decreasing total hay yields. The crude protein (CP) content of regrowth was relatively high and increased with increasing levels of nitrogen. He also found that earlier hay harvest helped conserve soil moisture. Another study found that the digestibility of CP, gross energy, and dry matter decreased with each later date of harvest (Raleigh et al. 1964).

Considerable yearly variation in chemical composition and digestibility at different harvest dates in native meadows was attributed to changes in species composition brought about by changes in yearly moisture and other environmental factors that influenced changes in the maturity dates of the hay (Raleigh et al. 1964). Rumburg and Cooper (1961) found that in wetter years, the native meadows consisted of a higher proportion of rushes and sedges than in drier years. Changes in species composition due to environmental variability, plus introduction of non-native grass species which do well in moist or saturated conditions, such as meadow foxtail (*Alopecurus pratensis* L.) and reed canarygrass (*Phalaris arundinacea* L.) (Schoth 1945, Gomm 1978, Walton 1983), have a great impact on type and time of use of native meadows. In the present, meadow foxtail has become a dominant species in

many native meadows of eastern Oregon (Angell 1992) which may necessitate a new outlook on harvest and grazing techniques used on the meadows.

Meadow foxtail

Meadow foxtail (*Alopecurus pratensis* L.) is a native grass of the temperate parts of Europe and Asia. It is grown in wet lands of high fertility to produce hay or silage or for long-term pasture (Schoth 1945, Walton 1983). The grass is a long-lived, early maturing perennial that does best in cool, moist environments, but can tolerate drought (Hannaway 1981). It is one of the first grasses that grows in the spring and can withstand cold weather and frost during the growing season, allowing for early grazing before most other grasses. It has been known to grow throughout the winter in warmer climates. Meadow foxtail can also withstand flooding and has survived in low, alkaline wetlands with a pH up to 8.5 (Schoth 1945, Walton 1983).

Meadow foxtail (MF) hay yields do not average as high as orchardgrass (*Dactylis glomerata* L.), timothy (*Phleum pratense* L.), or smooth brome (*Bromus inermis* Leyss.), but its nutritive value can exceed these grasses (Schoth 1945, Tingle and van Adrichem 1974, Kline and Broersma 1983, Waldie et al. 1983, Walton 1983, Rode and Pringle 1986, Fairey 1991). When nitrogen fertilizer is applied, MF yields can equal or exceed those of the other grasses (Tingle and van Adrichem 1974, Kline and Broersma 1983, Fairey 1991). Tingle and van Adrichem (1974) found that MF had an average dry matter (DM) yield of 2110 kg/ha with a

CP of 9.5 to 22.4%, depending on the stage of maturity. Waldie et al. (1983) determined that the DM and protein digestibility and %CP of MF remained equal to or greater than those of timothy at all stages of maturity. These values, however, decreased as maturity advanced. Rode and Pringle (1986) found that though the carrying capacity of MF as compared to timothy was greater (501 animal days/ha vs. 443), the %CP was greater (17.2 vs. 16.0), and the DM intake was greater (9.1 kg/d vs. 8.6), the average daily gain of steers fed the two grasses separately was significantly higher for timothy than MF (1.13 vs. 0.79 kg/d). Rode (1986) looked at animal performance again in another study comparing MF and timothy and reported similar results. Even after the two groups of steers were put on the same diet, the group fed MF continued to perform poorly. This led to speculation that an antiquality factor may be present in MF.

Drought and Grazing Effects on Vegetation

Botanical composition and yield

Drought can have an effect on the species composition of rangelands and, thereby, also affect nutritive properties of the vegetation. Very little work has been done to look at drought effects on native meadow vegetation in the Great Basin. Rumburg and Cooper (1961) did comment that a higher proportion of rushes and sedges made up native meadow vegetation in wetter years. Also, Raleigh et al.

(1964) found that yearly moisture affected chemical composition and digestibility of vegetation due to changes in species composition. With the increase in the dominance of MF in many native meadows, it is necessary to look at how drought affects the vegetation and, in turn, how management of these areas will be affected.

Drought effects have been studied extensively on rangelands in other parts of the U.S. and the world. In the Great Plains of North Dakota, during the great drought of the 1930's, a reduction in abundance, density, or area occupied by the major species was significant (Whitman et al. 1943). Blue grama (*Bouteloua gracilis* [H.B.K.] Lag.), was the most severely affected of the major species, but rapidly recovered after the drought. Western wheatgrass (*Agropyron smithii* Rydb.), needle-and-thread grass (*Stipa comata* Trin. and Rupr.), and junegrass (*Koeleria cristata* [L.] Pers.) decreased during the drought, but recovered well after the drought. Threadleaf sedge (*Carex filifolia* Nutt.) was not affected by the drought while needleleaf sedge (*Carex eleocharis* Bailey) was, but both improved after the drought. Most of the minor grass species decreased in density except for Sandberg's bluegrass (*Poa sandbergii* Vasey), which increased. Little bluestem (*Schizachyrium scoparium* Nash) was severely affected by the drought and never fully recovered afterwards. A reduction in the height growth, number of fruiting stalks, and fruiting stalk height was noted in all the grasses (Whitman et al. 1943).

A look at the forbs in the same region found that the perennials increased in abundance, while annuals decreased, but the annuals showed a marked improvement

after the drought. Height growth of forbs was decreased during the drought (Whitman et al.1943).

Other authors noted a similar decrease in the basal cover of vegetation, up to 45%, in both tall and mixed grass prairies of Iowa, Kansas, and Nebraska during the same period. (Weaver and Albertson 1936, Albertson and Weaver 1942). Big bluestem (*Andropogon gerardii* Vitman), little bluestem, some panic grasses, and Kentucky bluegrass (*Poa pratensis* L.) suffered the most damage. After, sometimes even during, the drought, blue grama, side-oats grama (*Bouteloua curtipendula* [Michx.] Torr.), western wheatgrass, and junegrass invaded areas where the other grasses had died.

A close relationship was noted to exist between root depth of tall prairie grass species and resistance to drying (Weaver and Albertson 1936). Forb resistance to drought was also strongly correlated with root extent. Rhizomatous forbs, species with bulbous or fleshy underground parts, and deep-rooted forbs had the smallest losses during the drought (Weaver and Albertson 1936). Shallow-rooted species were killed by the drought, and areas left open were invaded by annuals.

In the short grass prairie, buffalograss (*Buchloe dactyloides* [Nutt.] Engelm.) and the grama grasses increased during the drought, and certain areas of mixed grass prairie converted to short grass prairie (Weaver and Albertson 1936, Albertson and Weaver 1942).

In the desert grasslands of New Mexico, black grama (*Bouteloua eriopoda* [Torr.] Torr.) range can deteriorate severely during drought conditions by as much as

40% (Jardine and Forsling 1922, Nelson 1934, Paulsen and Ares 1962, Hennessy et al. 1983). With improved growing conditions, black grama may recover after a few years, depending on the severity of the drought, but may also die off, allowing invasion by other species such as mesquite or atriplex (Hennessy et al. 1983).

Tobosa grass (*Hilaria mutica* [Buckl.] Benth.), a codominant grass species, appears to be little affected by drought (Jardine and Forsling 1922). Vegetation composition and density seems to be more dependent directly upon available soil moisture than upon current precipitation, while height growth for that season is determined by current summer rains (Jardine and Forsling 1922, Nelson 1934).

In Idaho, Pechanec et al. (1937) found that the drought of 1934 caused a depletion in plant cover and accelerated water and wind erosion. Grasses decreased in basal area and in height by 60% and in density by 38.9%. Perennial herbs decreased in number by 60% and also in height and density. Annual forbs were absent during the drought. After the drought, grasses and forbs recovered well. A good recovery and increased height growth the following year after the drought suggested that the root systems had not been seriously injured in the drought (Pechanec et al. 1937).

Other observations by Beath (1935) in Wyoming and Bell (1935) in Montana noted that the grasses on rangelands were severely damaged by the drought of 1934. Wyoming rangelands recovered well after the spring rains the next year (Beath 1935).

Drought conditions in Kenya, Africa, at least short term, may not significantly affect the botanical composition of rangelands. Research revealed that good condition range did not differ significantly in frequency measurements after drought years and that drought had little effect on perennial grasses (Njoka 1984). In fact, drought may increase basal cover on good to excellent range sites. Poor to fair condition range, which is dominated by ephemeral plants, will decrease in basal cover during drought conditions and may not improve even after 2 years of favorable growing conditions. Any changes in perennial grass cover measured during long-term monitoring of botanical composition will reflect range trend due to grazing (Njoka 1984). Thus, grazing during drought or good years must be considered as a major factor shaping range condition and influencing management of rangelands.

Grazing studies in the mixed prairie found that ungrazed treatments had a higher average % basal cover, but had a greater % change in basal cover loss during the drought in 1935, while moderately grazed areas had lower % basal cover, but little change in the spring to fall period in the same drought year (Weaver and Albertson 1936). On ungrazed plots, drought reduced the number of grass species such as little bluestem, but increased species such as side-oats grama, blue grama, and buffalograss. Grazing of similar sites resulted in preventing the development of a maximal plant cover, which may have been beneficial in that the total water transpired was reduced, allowing greater plant survival throughout the drought (Weaver and Albertson 1936). Grazing of bluestem types left the plants unable to cope with the drought as efficiently as when ungrazed, resulting in an increase in

grazing-tolerant short grasses (Albertson and Weaver 1942). Species such as buffalograss and blue grama appeared to thrive with grazing, showing small losses when protected from grazing. Certain areas of short grass prairie in Kansas suffered less loss of basal cover with moderate grazing, than with no or heavy grazing (Weaver and Albertson 1936, Albertson and Weaver 1942).

In the desert grasslands of New Mexico, moderate to severe grazing deteriorated the range from 45 to 70% in stands of the best forage plants (Jardine and Forsling 1922). Black grama was most severely affected by grazing, as well as by drought, as compared to tobosa grass. As grazing intensity increased, the depreciation of the grama increased, especially in the summer. Light to moderate grazing during the summer and moderate grazing the rest of the year will allow the range condition to be maintained to about the same as ungrazed areas and may allow improvement of poor condition sites (Jardine and Forsling 1922). Areas severely affected by drought can be best recovered under a conservative grazing program, which was found to surpass a total exclusion plan (Nelson 1934, Paulsen and Ares 1962). Tobosa grass, which tends to stagnate when old growth is not removed, can be heavily grazed during the growing season, with or without a drought, with no serious effect (Jardine and Forsling 1922, Paulsen and Ares 1962). Overgrazing of either species can lead to a decrease in the best forage plants which are replaced by less desirable species.

Reports from Idaho and Montana suggest that overgrazing may have played a role in plant damage and increased erosion during drought and that deferred grazing may allow recovery even during a drought (Pechanec et al. 1937, Bell 1935).

Different responses to grazing and drought by plants of the same species may be a result of soil properties and precipitation. In New Mexico, Pieper et al. (1971) reported the relationship between herbage production and precipitation of loamy soil sites in the pinyon-juniper/blue grama zone. Those areas with residual soils had little relationship between herbage production and precipitation, while in areas with alluvial soils, herbage production correlated with annual precipitation. Stocking rates could be nearly constant on the residual sites, except during severe drought, due to the small variation in herbage production, but stocking rates on the alluvial sites needed adjustment due to variable rainfall amounts and plant yield. Earlier, Pieper (1968) found that blue grama production was lower on grazed areas vs. protected areas. The blue grama cover, however, was not reduced by grazing on loamy upland and stony hill sites, but was reduced on loamy bottomland sites.

Grazing alone, as well as with other factors, can affect species composition and forage parameters of range plants. Costello and Turner (1941), in an overview of grazing effects on different types of rangeland, found that little difference between the number of browse species on grazed or ungrazed areas existed, but that a larger number of grasses and forbs (more diversity) were found in ungrazed areas. Grazing tended to reduce plant cover, while exclusion led to an increase in density and volume of forage production of forbs and most grasses. In the short grass prairie,

native grasses were abundant on both sites, while certain forbs increased on either grazed or ungrazed sites. Other studies in the prairie found that moderate grazing caused a decline in big bluestem and an increase in the cover of forbs and annual grasses, with little effect on little bluestem or other dominant grasses (Collins 1987), while heavy grazing led to a decline in all the dominant tall grasses and an increase in short grasses such as side-oats grama, buffalograss, and blue grama (Herbel and Anderson 1959).

Nelson (1934) reported that conservative grazing of black grama range had little effect on black grama, but heavy grazing caused a decline in black grama and could greatly handicap recovery in later years.

In the sagebrush and juniper-pinyon communities, native grasses such as bluebunch wheatgrass (*Agropyron spicatum* [Pursh.] Scribn. & Smith), western wheatgrass, Indian ricegrass (*Oryzopsis hymenoides* [Roem. & Schult.] Ricker), and blue grama were less abundant on grazed sites, while sagebrush increased (Costello and Turner 1941).

Blydenstein et al (1957) found that no significant change occurred in botanical composition with 50 years protection of a Sonoran desert community. Overall plant density, however, did increase, with perennial grasses and a palatable shrub (*Krameria grayi* Rose & Painter) showing the most significant increases and a dominant species, *Fraseria deltoidea*, decreasing.

In Mediterranean climates, taller native perennial and annual grasses appear to do better under no or slight grazing schemes, while annuals, introduced species, and

low or prostrate species thrive with heavier grazing (Austin et al. 1981, Noy Meir et al. 1989).

A study in the flooding pampa region of Argentina reported little differences in the total green biomass in ungrazed and grazed areas, but biomass concentration was higher in the grazed area (Sala et al. 1986). Grazing exclusion resulted in a 30% increase in cover of grasses and a sedge over four years. Annuals were replaced by perennials and the basal area of major native perennial grasses increased while exotic species decreased. However, the grazed areas supported a larger number of species.

The above studies show how grazing effects on botanical composition and yield significantly vary depending on climate and plant characteristics that are unique to different regions around the world. It clearly emphasizes the need for separate studies of distinct plant communities to determine grazing effects that cannot be extrapolated from data taken from plant communities in other regions.

Forage quality

Little is known about drought or grazing effects on the quality of native flood meadow vegetation. Woodman et al. (1931) and Woodman and Norman (1932) looked at clipping effects in British grass pastures and its influence on forage quality. They found that lengthening the time between successive cuts from a month to 5 weeks led to a decrease in the digestibility and crude protein of the forage. These

effects were most noticeable during the flush period of growth, but were insignificant before or after this period. Cutting at this interval appeared not to be as significant during years of adequate rainfall, but during a drought, premature onset of lignification resulted in a more pronounced decrease in digestibility. A decrease in CP, moisture content, and phosphorus, and an increase in the % of N-free extractives and crude fiber was seen in the forage cut in drought years.

Different grazing intervals were also studied and appeared not to significantly reduce forage nutrient content (Woodman et al. 1931). Early heavy grazing, however, did appear to damage the grasses and adversely affected production later in the season, especially during a drought.

Angell et al. (1990) found that the crude protein of regrowth of crested wheatgrass (*Agropyron desertorum* Schult.) was increased when the plants were clipped at boot stage, but was dependent on available soil moisture.

Motazedian and Sharrow (1990) found that systematic defoliation over a 3-year period increased the yearly average crude protein and dry matter digestibility of perennial ryegrass (*Lolium perrenne* L.)-subclover (*Trifolium subterraneum* L.) forage, but decreased total digestible dry matter yield. As the defoliation interval increased, crude protein and dry matter digestibility declined.

Costello and Turner (1941) looked at grazing effects on the palatability of vegetation in the U.S. and found that it did not differ between protected and grazed ranges. They did discover that high and low palatability plants increased slightly in density, while medium palatability plants decreased in density.

Stoddart (1946) found that as maturity of bluebunch wheatgrass increased, lignin increased, protein decreased, and the cellulose/lignin ratio decreased consistently. The protein levels in the regrowth tended to be lower, but no trend for cellulose or lignin was seen.

Fudge and Fraps (1944) reported that mowing tends to keep forage at a younger stage of growth with protein being twice as high in clipped plots. Jameson (1963) reported similar results in that protein content decreased with maturity and increased with grazing. He also found that with clipping, lignin decreased and forage digestibility increased.

Corn Supplementation Effects on Weight Gain

The use of concentrate supplementation to increase weight gain of yearling calves on green pasture has not been extensively studied. Wagner et al. (1984) found that energy supplementation of growing cattle on wheat pasture increased daily gains. A study in Arkansas that looked at live weight gain of calves grazing cool-season annual grasses and supplemented with corn showed no increase in live weight gain compared to the control group (Hubbell et al. 1992). Other authors have reported decreased or no effect on animal performance and a decrease in forage intake and fiber digestibility in cattle consuming low-quality forage and supplemented with high levels of corn (Chase and Hibberd 1987, Sanson and Clanton 1989, Sanson et al. 1990). Any effects of corn supplementation on yearling calves grazing flood

meadows must be assessed to determine if any increased weight gains will bring in sufficient returns to justify additional feed and labor costs.

MATERIALS AND METHODS

Study area

The study was conducted at the Eastern Oregon Agricultural Research Center (EOARC) located approximately 6 km south of Burns, OR. Meadow number "six east," a 23-ha pasture, was chosen for the study. Botanical composition was similar to that described by Blount (1991), with meadow foxtail (*Alopecurus pratensis* L.) being the most dominant species in the meadow.

Precipitation data were obtained from a local weather station administered by the National Oceanic and Atmospheric Administration (NOAA).

Four 50 X 50 m experimental sites were established in the northern end of the pasture. Sites were selected based on uniformity of vegetation, with a predominance of meadow foxtail. Half of each area (25 X 50 m) was fenced off using high-tensile steel electric fencing to prevent grazing by cattle that were released to graze the remainder of the pasture.

Sampling

Vegetation

Forage yield, botanical composition, and meadow foxtail quality were studied during the late spring/ early summers of 1992 and 1993 to determine the effects of drought and grazing on these parameters. Yield was measured by clipping ten

0.25m² plots systematically placed at 5m intervals on a diagonal line-transect from one corner of a treatment site to the other corner. In 1993, 0.19m² plots were used. A total of 80 plots were clipped per year. The forage was separated into four categories: meadow foxtail, sedge/rush, other grasses, and forbs. The clippings were dried in a forced air oven at 60° C for 48 hours and weighed. In 1992, clippings were taken from July 13 through July 16, while in 1993, they were taken from July 12 through July 15. Total forage yield and percent of total forage yield for each category was calculated from these data.

Frequency and basal cover were measured using a modified step-point technique (Owensby 1973). Two hundred points were taken for each treatment in each block, totaling 1600 points. Data were arranged into five categories: meadow foxtail, sedges, rushes, other grasses, and forbs. In 1992 and 1993, data sampling occurred from July 7 through July 9.

Forage quality was only measured in the meadow foxtail due to low forage yield of the other species in 1992. The clippings were ground through a 1 mm screen using a Udy cyclone sample mill in 1992, but were ground through a Thomas-Wiley Laboratory Mill in 1993 due to the large amount of forage clipped that year. In vitro digestibility was analyzed using the technique of Tilley and Terry (1963). Crude protein was determined by the Kjeldahl method (AOAC 1980) using a Kjeltac Auto 1030 Analyzer. Organic matter and ash were determined by combustion of samples in a muffle furnace at 500° C for 8 hrs.

Livestock

In 1992, eight fistulated steers were released on the pasture in May, then removed after a week of grazing because the standing crop was very low and locusts consumed a large portion of the green material. Essentially, there was no grazing treatment that year because of the drought.

In 1993, 84 head of cattle were initially put on the pasture beginning on May 3. Because of the large amount of snowfall the previous winter, flood water levels were much higher than in 1992 when no flooding occurred at all. Cattle were allowed to graze the pasture throughout the study. On June 10, 12 head of cattle were removed to prevent over utilization of the forage and their performance data were not included in the study. The rest of the cattle remained on pasture through July 19.

Animal performance

Energy supplementation with corn was studied to determine its effect on weight gain. Seventy-two yearling heifers were chosen from the EOARC herd and were blocked into 3 groups by weight in May 1993. Animals were then randomly assigned to one of 4 treatment groups. There was one control group and three corn-fed treatment groups in which the heifers were fed either 0.50, 0.75, or 1.0 kg/d of cracked corn.

The heifers were initially weighed on May 3 and implanted with Synchronate B (CEVA Laboratories). Each heifer received a numbered, color-coded ear tag for easy identification and was released to graze on the pasture. The implants were removed on May 12 and the heifers were bred by artificial insemination on May 14, then, put back out on pasture with 4 clean-up bulls. On June 9, the bulls were removed from the pasture.

The heifers were gathered each day around 0700 and separated into different pens by treatment group. The corn was group-fed in a large trough, and heifers were allowed to eat for a period of one to two hours. After the corn was consumed, the heifers were released back out on the pasture. A one-week acclimation period was provided at the beginning of the study to allow the heifers to become accustomed to the corn supplement. After this period, orts were weighed to more accurately determine corn consumption, but after 3 days, the heifers were completely consuming all the corn provided.

Weight gain was monitored over a 72-day trial period by weighing the heifers every 2 weeks in random order. Weighing dates were May 3 and 24, June 7 and 21, and July 6 and 19. The study ended July 19, 1993.

Statistical analysis

The study was designed as a randomized complete block with flooding depth as the blocking factor. Grazing effects on all parameters were analyzed as a split-

plot design. Precipitation effects in 1992 and 1993 were analyzed as a whole block design. The model contained the effects of treatment and block in the whole plot, with block by treatment as the whole plot error.

Analysis of variance was carried out using ANOVA of the Statistical Analysis System (SAS 1987). Protected LSD tests were used to determine any significant differences between means. Statistical significance was inferred at $P \leq 0.05$.

RESULTS

Precipitation

Precipitation can vary significantly from year to year in eastern Oregon native flood meadows, but occurs primarily in the winter and spring months. In the Burns area, total precipitation in 1990, 1991, and 1992 was 464 mm, 201 mm, and 260 mm, respectively. From January 1993 to September 1993, total precipitation was 243 mm. Winter precipitation is the most important factor determining summer forage production. Snowmelt from the surrounding mountains is critical for the flooding required for high production of forage. In the Burns area, snow accumulation from October through March in the years 1991/1992 and 1992/1993 were 282 mm and 1786 mm, respectively. Snow levels in the higher elevations were even greater. The large increase in snow levels in 1993 was largely responsible for the increased flood irrigation that summer compared to the previous year. There was no flooding at all on the pasture in 1992, but considerable flooding occurred in 1993 from the end of April to the beginning of July. Whereas, the majority of the forage growth in 1993 was attributable to the flood irrigation, much of the measured growth in 1992 was a result of over 77 mm of precipitation in June 1992.

Forage yield

The total forage dry matter yield in the ungrazed treatment exclosures was significantly higher in 1993 than in 1992 for all categories of plants (Table 1). Effects of drought on forage parameters were only examined in the ungrazed exclosures since grazing treatments between the two years were not the same.

The percentage of total yield of meadow foxtail(MF) and sedges/rushes increased by 12% and 58%, respectively and forbs decreased by 67% from 92 to 93. Other grasses showed no significant change. These results agree with observations by Rumburg and Cooper (1961) who reported that sedges and rushes made up a higher proportion of native meadow composition in wetter years.

When comparing ungrazed plots to grazed plots in 1992, the percentage of total yield of sedges/rushes and other grasses in 1992 decreased by 78% and 49%, respectively. Meadow foxtail and forbs were unchanged. There were no significant changes in the percentage of total yield in any of the four categories between ungrazed and grazed plots in 1993 (Table 2).

Frequency and basal cover

The frequency of MF decreased in 93 as compared to 92, but increased significantly for rushes. The basal cover of the above two categories increased significantly in the wetter year of 93. The frequency and basal cover of sedges, other grasses, and forbs were unchanged (Tables 3 & 4).

Table 1. Mean total forage dry matter yield (kg/ha) and standard error of meadow foxtail, sedges/rushes, other grasses, and forbs in grazed and ungrazed plots for 1992 and 1993.

Year	Meadow foxtail		Sedges/Rushes		Other grasses		Forbs	
	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed
1992	257*±141	274±141	29*±35	5±9	36*±69	12±31	69*±95	35±64
1993	6184*±2007	1014±674	967*±699	89±128	614*±876	9±31	430*±657	57±90

*Means between years and within forage classes with asterisk differ significantly ($P \leq 0.05$).

Table 2. Mean percent of total forage yield (%) and standard error of meadow foxtail, sedges/rushes, other grasses, and forbs in grazed and ungrazed plots for 1992 and 1993.

Year	Meadow foxtail		Sedges/Rushes		Other grasses		Forbs	
	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed
1992	68* ^a ±8	85*±20	8* ^a ±8	2 ^b ±2	9*±15	4 ^b ±12	16* ^a ±19	9*±16
1993	76* ^a ±18	83*±20	12* ^a ±8	9*±12	6*±9	2*±7	5* ^a ±7	7*±12

*Means between years and within forage classes with asterisk differ significantly ($P \leq 0.05$).

^{ab}Means within years and forage classes not followed by the same letter differ significantly ($P \leq 0.05$).

Table 3. Mean frequency (%) and standard error of meadow foxtail, sedges, rushes, other grasses, and forbs in grazed and ungrazed plots for 1992 and 1993.

Year	Meadow foxtail		Sedges		Rushes		Other grasses		Forbs	
	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed
1992	71 ^a ±15	91 ^a ±6	14 ^a ±13	4 ^a ±4	6 ^a ±6	2 ^a ±2	4 ^a ±2	2 ^b ±2	5 ^a ±3	2 ^a ±1
1993	53 ^a ±13	82 ^b ±7	10 ^a ±12	2 ^a ±2	20 ^a ±9	12 ^a ±7	13 ^a ±7	3 ^a ±2	5 ^a ±4	1 ^a ±0.5

^aMeans between years and within forage classes with asterisk differ significantly ($P \leq 0.05$).

^{ab}Means within years and forage classes not followed by the same letter differ significantly ($P \leq 0.05$).

Table 4. Mean basal cover (%) and standard error of meadow foxtail, sedges, rushes, other grasses, and forbs in grazed and ungrazed plots for 1992 and 1993.

Year	Meadow foxtail		Sedges		Rushes		Other grasses		Forbs	
	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed
1992	2 ^a ±0.3	2 ^a ±1	T ^a	0 ^a	T ^a	0 ^a	T ^a	0 ^a	T ^a	T ^a
1993	5 ^a ±1	4 ^a ±1	1 ^a ±1	0 ^a	1 ^a ±0.4	1 ^a ±1	1 ^a ±1	T ^a	T ^a	T ^a

^aMeans between years and within forage classes with asterisk differ significantly ($P \leq 0.05$).

^{ab}Means within years and forage classes not followed by the same letter differ significantly ($P \leq 0.05$).

Grazing appeared to have little effect on frequency and basal cover of the five categories MF, sedges, rushes, other grasses, and forbs, but for two exceptions. In 1992, the frequency of other grasses was cut in half in the grazed plots, and in 1993, the frequency of MF increased by 56% in the grazed plots.

These results differ from those of Sala et al. (1986) and Costello and Turner (1941) who found that grazing generally resulted in a decrease in plant cover, especially of the major grasses and forbs.

Forage quality of meadow foxtail

Forage quality was found to be significantly different between the two years. Organic matter(OM) increased in 1993, as compared to 1992, but IVOMD, and CP decreased. These results contradict those of Woodman et al. (1931) which claimed that drought brought about a decrease in crude protein and digestibility.

Grazing had no effect on forage quality in 1992, but in 1993, the grazed plots had lower OM and increased IVOMD, and CP (Table 5). These results are similar to those of Fudge and Fraps (1944) and Jameson (1963).

Table 5. Mean organic matter (%), in vitro OM dig. (%), and crude protein (%) and standard error of meadow foxtail in grazed and ungrazed plots for 1992 and 1993.

Year	% Organic matter		In vitro OM digestibility		Crude protein	
	ungrazed	grazed	ungrazed	grazed	ungrazed	grazed
1992	87.5 ^a ±0.2	87.2 ^a ±0.6	83.4 ^a ±1.7	81.0 ^a ±3.6	27.1 ^a ±0.8	27.7 ^a ±2.1
1993	89.6 ^a ±1.1	84.8 ^b ±2.4	58.8 ^a ±2.5	67.8 ^b ±5.0	5.0 ^a ±0.6	11.9 ^b ±3.2

^aMeans between years and within forage classes with asterisk differ significantly ($P \leq 0.05$).

^{ab}Means within years and forage classes not followed by the same letter differ significantly ($P \leq 0.05$).

Weight gain with corn supplementation

Seasonal gain and final body weight values were not significantly different between any of the treatment groups (Table 6). Average daily gain between each weighing date remained equal among all treatment groups (Table 7). Heifers gained 1.1 kg/day in 1993 as compared to steers that gained 1.2 kg/day in 1989 (Blount et al. 1991). The results were similar to an Arkansas study that found no difference between control and corn supplemented calves feeding on cool-season annual grasses (Hubbell et al. 1992), but contradicted the results of Wagner et al. (1984) who supplemented cattle on small grains pastures.

Table 6. Average final weight (kg) and average daily gain (kg/d) of each treatment group of corn-fed heifers grazing native flood meadows.

	Corn Supplement (kg/d)			
	0	0.5	0.75	1.0
Avg. final wt.	352±34	352±30	359±31	357±29
Avg. daily gain	1.0±0.1	1.0±0.1	1.1±0.1	1.1±0.1

Table 7. Average daily gain (kg/d) of each treatment group of corn-fed heifers grazing native flood meadows from May 4 to July 19, 1993.

Corn fed	May 24 ¹	June 7	June 21	July 6	July 19
0 kg/d	1.2±0.3	1.3±0.5	1.0±0.5	-0.4±2.0	2.1±2.5
0.5 kg/d	1.0±0.3	1.3±0.3	1.2±0.3	0.2±0.4	1.5±0.4
0.75 kg/d	1.2±0.4	1.4±0.5	1.2±0.4	0.2±0.3	1.6±0.6
1.0 kg/d	1.1±0.4	1.5±0.4	1.1±0.2	0.3±0.4	1.5±0.5

¹Weighing dates

DISCUSSION

The increased forage DM yield in 1993 was not surprising because of the significant amount of snowfall from October '92 through March '93 as compared to the same period the previous year. With adequate amounts of moisture for a longer period of time, the stomates were able to remain open, allowing continued photosynthesis, which provided energy for synthesis of plant tissues and increased yield (Salisbury and Ross 1969). Moreover, when grazing occurs, the increased flooding period allows for regrowth of most species until soil moisture becomes depleted or the onset of dormancy.

The type of soil may be important in determining the amount of herbage production. The soil in the native flood meadows around Burns, OR consists of lacustrine sediments and alluvium deposits (Gomm 1979). Pieper et al. (1971) found that in alluvial soils, herbage production correlated with annual precipitation, while on other residual soils, annual precipitation had little influence on herbage production.

The increase in the percentage of total forage yield of MF and sedges/rushes is a result of the large response in growth to the increased moisture in 1993. The dramatic rise in the percentage for sedges/rushes may be a result of the precipitation pattern in 1992. Late rainfall in June '92 allowed a spurt of regrowth in the MF, while sedges/rushes did not appear to respond as well. However, the next year, due to adequate moisture, sedges/rushes made an impressive response in growth. Even

though sedges and rushes are capable of tillering like grasses or reproduce from rhizomes, they do not appear to be as responsive to added moisture during drought conditions as meadow foxtail.

Frequency was also affected by water levels. Rushes, sedges, and other grasses responded well to the increased moisture in 1993, thus, resulting in a decrease in the frequency of MF. Basal cover of MF, however, increased significantly, along with rushes. These results suggest that MF plants may have increased in number during the drought, while other species suffered, and then responded well to increased moisture in 1993. Meadow foxtail appears to adapt well to environmental changes and can use whatever nutrients are available to survive during tough times. It can enter dormancy early to decrease photosynthesis and water use during times of drought, yet it also can survive in anaerobic conditions during long periods of flooding. With a frequency of 71% in 1992 and 53% in 1993 as compared to a reported frequency of 35% in 1989 (Angell 1992), one can see that the plasticity of MF has permitted it to increase throughout the region.

The notable increase in the frequency of rushes and the lack of any change in sedges may lead to speculation that the rushes may have been the major contributor to the increase in yield of sedges/rushes and that the drought had a larger negative effect on sedges. In 1989, rushes and sedges had a frequency of 17% and 26%, respectively (Angell 1992), as compared to 20% and 10% in 93. Rushes may have a larger capacity or a better mechanism to store reserves than sedges for long dry periods and then are better able to respond when soil moisture eventually rises.

The other grasses and forbs seemed to have also been affected by the drought. Frequency and basal cover were unchanged and the percentage of the total yield decreased, suggesting that these plants did not respond to increased water levels as favorably as the MF and rushes. Forb species seen during the dry year of 1992, such as *Thlaspi arvense* L., *Descurainia richardsonii* (Sweet) Schultz., and *Aster occidentalis* (Nutt.) T. & G., were replaced by wetland species, such as *Hesperochiron pumilus* (Griseb.) Porter, *Triglochin maritima* L., and *Cryptantha* sp. Lehm., plus increased numbers of other species that were present in both years, including *Haplopappus lanceolatus* (Hook.) T. & G., *Potentilla gracilis* Dougl. ex Hook., *Madia glomerata* Hook., and *Taraxacum officinale* Weber (Nixon 1994, unpublished data). When compared to frequency data in 1989 reported by Angell (1992), the frequency of other grasses and forbs in 1993 appears to have changed little. Basal cover data may have shed more light on the effects of drought on these species; but because the frequency of these groups was low, I was not able to discern if basal cover was actually affected from the data I had gathered.

The effects of grazing on the percentage of total forage yield in 1992 were minimal. Since the total forage available for grazing was very low, only a few cattle were permitted to graze the pasture for a short time. After the cattle were removed in late May, the area received over 77 mm of rain in June which allowed new growth to appear. Thus, essentially there was no grazing treatment. To compound the problem, a locust swarm consumed a substantial amount of the green material in all treatment sites so that samples gathered were primarily regrowth after the June rain

and locust grazing or whatever was left over. Cattle were never put back on the pasture that year. This situation may explain why the yield of sedges and rushes as a percentage of the total yield was significantly decreased while the other species were not affected. Since sedges and rushes do not recover well after clipping compared to grass (Rumburg 1963), the added moisture in June did not result in as great a response in regrowth as seen in the other species. Along with the lack of change in the frequency and basal cover of rushes and sedges, the data suggest that grazing, at least short term, may affect the yield, but not the number of plants.

Frequency and basal cover was unchanged for all the other plant groups. These results may support the idea that minimal stocking densities and length of grazing time on native meadows during drought periods may not severely affect desired forage species and will maintain some species diversity on the meadows.

In 1993, the percentage of total yield was not different between grazed and ungrazed plots for any plant category. In theory, one would expect this percentage for sedges and rushes to decrease after grazing since these plant groups do not recover well after clipping like grasses do. Many grasses can regrow from the same meristem after being clipped, while rushes and sedges may not; therefore, grasses will produce a larger proportion of the yield after a regrowth period. The decrease in the availability of sedges and rushes plus an increase in the palatability of grass regrowth may have led to an increase in the grazing of MF or other plants, thus, keeping the percentage of the total forage yield for sedges and rushes from falling.

Frequency and basal cover of the forage species were generally unaffected by grazing. The increase in frequency of MF with no decrease in the other categories may be due to the high variability in the data. If changes in other categories occurred, they could not be detected statistically. The number of plants or tillers did not appear to be affected by grazing, even with the heavy stocking rate in 1993. Several years of study need to be done to determine the long-term effects grazing may have on the native meadows. Even though no significant changes may occur in one year's time, small changes may accumulate over time to dramatically change the community structure of the meadows.

Forage quality of grasses has been shown to decrease as maturity advances (Waldie et al. 1983, Cherney et al. 1993). Restricted soil moisture during the vegetative growth stage can create slow growth and delay maturation to maintain forage quality at a higher level than in more mature stages (Huston and Pinchak 1991). This may help explain why the CP and digestibility were higher in MF in 1992 than in 1993.

Mislevy and Everett (1981) proposed that the nutrient content of forages in well-watered regions may decline rapidly due to developmental changes or dilution produced when growth exceeds uptake. Coleman et al. (1993) found that increased levels of CO₂ in the environment may also reduce tissue nitrogen concentrations as a product of accelerated growth. Translocation of leaf nutrients, associated with leaf senescence, is increased by drought. An accumulation of nutrients during drought may help the plant grow when the water supply is restored (Bittman et al. 1988). As

plants mature, the leaf total nitrogen concentration decreases rapidly as cell walls thicken and cellulose dilutes plant nitrogen (Beevers 1976). Drought has been shown to lower concentrations of lignin, hemicellulose, and cellulose in tropical grasses (Wilson et al. 1980).

Grazing can affect the chemical composition of individual plants by altering the form of growth or the progress of development of existing plants (Laycock and Price 1970). Grazing plots in 1993 had higher protein and digestibility and less OM than ungrazed plots. Herbage removal by grazing or clipping interrupts development of plants, prevents maturity, and prolongs growth or initiates regrowth (Laycock and Price 1970). Younger live tissue by virtue of its greater metabolic activity is of higher quality than older live tissue (Huston and Pinchak 1991). As plants mature, CP and the more digestible carbohydrates decrease while crude fiber, lignin and cellulose increase (Stoddart et al. 1955). The higher OM in MF from ungrazed plots was probably due to a large increase in the lignin, cellulose, and hemicellulose content as the plants matured. Stoddart (1946) reported that as bluebunch wheatgrass matured, the cellulose/lignin ratio decreased. The lower digestibility of the ungrazed MF was apparently caused by an increase in the amount of lignin compared to cellulose as the plant maturity increased.

Corn supplementation had no effect on the performance of heifers grazing native flood meadows. Cattle fed grain did not differ significantly in average daily gain (ADG) from the cattle that never received any grain. The negative ADG of the control group from June 21 to July 6 may have been caused by poor performance of

one heifer who had been limping during this time or by a faulty reading of the scale, but the group appeared to make up for the loss by the next weighing date.

During the same period above, all of the treatment groups had a depressed ADG. The reason for this is unknown. It may be due to increased shrinkage because the cattle were held longer than usual before weighing or to decrease in feed availability on the pasture due to slow regrowth.

The lack of response to all levels of corn supplementation may be attributed to either the heifers' inability to consume enough crude protein to take advantage of the increased energy intake for protein synthesis or their inability to utilize the extra energy intake because they were operating at maximum protein synthesis capacity and not protein-limited. The latter hypothesis is probably true since the crude protein of the MF in grazed areas averaged at 12%. Cattle tend to select from the highest quality components of the available forage pool first (Huston and Pinchak 1991). Thus, they may select plants high in protein and low in fiber under range conditions, including many forbs and less mature grass tissue (Hart et al. 1983, Huston and Pinchak 1991). When higher quality and more digestible feeds are consumed, cattle will increase their organic matter intake (Corbett et al. 1963, Hodgson and Wilkinson 1968); therefore, it is highly unlikely that either protein or energy were limiting.

Horn and McCollum (1987) suggested that small amounts of energy supplements fed to growing cattle may improve performance by decreasing the N/DOM ratio of the total diet and increasing microbial protein synthesis in the rumen. However, if cattle are consuming a high protein diet, an increase in energy

intake will not bring about an increase in nitrogen retention or the efficiency of nitrogen utilization (Lofgreen et al. 1951). The ability to utilize absorbed nitrogen for tissue building is limited by the rate at which the body is able to synthesize protein tissues. One may conclude that the protein and energy levels in the diet were adequate to maintain the maximum rate of protein synthesis in the study herd.

Since meadow foxtail begins growth so early in the season, it may be necessary to repeat this experiment at least one month earlier to determine if energy supplementation may have any effect on animal performance earlier in the year.

CONCLUSIONS

Increasing amounts of water on the flood meadows shifted the percentage of the total yield toward flood-tolerant species in the wetter year of 1993 and resulted in greater overall yields of meadow foxtail, sedges/rushes, other grasses, and forbs. The drought, which occurred in 1992 and the years before, appeared not to have severely affected meadow foxtail and did not have an impact on yield as flood irrigation resumed in 1993. Rushes also recovered well after snowmelt waters returned, while sedges appeared to be more negatively impacted by the drought.

Frequency and basal cover data suggest that the drought may have caused some changes in diversity, shifting populations toward increasing numbers of grasses and rushes and less forbs and sedges, with meadow foxtail by far the most dominant species.

Grazing appeared to favor meadow foxtail, in percentage of total yield, over other species during the dry year of 1992, as compared to ungrazed areas, but had no effect on any of the vegetation in the wetter year of 1993. Grazing did not affect the frequency of meadow foxtail during the drought, but did increase the frequency of meadow foxtail in 1993. Apparently, grazing tends to favor meadow foxtail and allows it to spread, thus decreasing the diversity of species and leading to a more monoculture type of pasture. Grazing in conjunction with drought conditions may continue to contribute to the increased dominance of meadow foxtail in eastern

Oregon flood meadows. Monitoring of the meadows should be continued to determine long-term trends in meadow forage composition.

Decreased precipitation had an effect on the quality of meadow foxtail. Percent organic matter was lower, but digestibility and crude protein content were higher in the drought year of 1992 as compared to 1993. Grazing did not affect forage quality in 1992, but did lower the percent organic matter and increase digestibility and crude protein content in 1993.

Different levels of corn supplementation had no effect on animal weight gain either between treatment levels or compared to the control group. Further studies should be conducted earlier in the growing season to determine any energy supplementation effects on animal performance.

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