Response of Bluebunch Wheatgrass to Drought and Climatic Fluctuations: A Review

Circular of Information 680
October 1979

Agricultural Experiment Station
Oregon State University, Corvallis

AUTHORS: David C. Ganksopp, Extension assistant in Rangeland Resources, and Thomas E. Bedell, associate professor, Rangeland Resources Program, Oregon State University, Corvallis.

RESPONSE OF BLUEBUNCH WHEATGRASS TO DROUGHT AND CLIMATIC FLUCTUATIONS: A REVIEW

David C. Ganskopp and Thomas E. Bedell

INTRODUCTION

No native herbaceous species in the area from the Rockies to the Sierra Nevada and Cascade Mountain ranges has received more scientific attention than bluebunch wheatgrass (Agropyron spicatum Pursh. Scribn. and Smith). This species is a common component of rangeland plant communities in high ecological condition. It makes up a significant part of the forage supply for grazing livestock on both desert and upland ranges. Wide climatic variations including periodic droughts are inherent to its range of ecological amplitude. No single publication or article reviews the reactions and responses of bluebunch wheatgrass to its climatic environment. It is the purpose of this publication to do that, with emphasis on reactions and responses to drought. Hitchcock (1950) described two species with the distinguishing character being the presence or absence of awns. The awned plants were called Agropyron spicatum and the awnless plants were Agropyron inerme (Scribn. and Smith) Rydb. Daubenmire (1960) found that the awned and the caespitose, rhizomatous characteristics of the awnless integrated completely and concluded there were no grounds for separations of the two. This review is based on research conducted on both forms.

Drought Effects on Forage Production, Quality, and Intake

The most noticeable impact of drought on range plants is reduced herbage production. At the Squaw Butte Agricultural Experiment Station in eastern Oregon bluebunch wheatgrass yields were reduced relatively less than other species during drought years (Sneva, 1971). Sneva and Rittenhouse (1970) correlated bluebunch wheatgrass yields with various extended precipitation periods. They found precipitation during the September through April and September through May periods produced the same correlation coefficient, r = .89. In Montana, Heady (1950) observed that growth, when measured in terms of maximum height and number of flower stalks, was favored by greater precipitation and lower temperatures at low elevations, and lower precipitation and higher temperatures at higher elevations. He noted, however, that grams of top growth per plant were poorly correlated with yearly climatic differences. Blaisdell (1958) found a correlation coefficient between July through March precipitation and bluebunch wheatgrass production in Idaho to be r = .46. Plant community or total vegetation data resulted in higher coefficients (r = .94) than data for individual species. This is consistent with the data of Sneva and Rittenhouse (1970) and Craddock and Forsling (1938). In general, the plant community appears more responsive to the general environment than do individual species. If one species suffers from frost or disease, others are often able to capitalize on the unused moisture or nutrients. In some cases, their growth may be sufficient to compensate for the initial setback and total biomass produced by the community may approach normal levels (Blaisdell, 1958).

Interspecific and intraspecific competition also influences growth and production in bluebunch wheatgrass. Generally, yield per plant decreases with increasing plant density (Risser, 1969). Mueggler (1972) demonstrated that by eliminating competition from surrounding vegetation, bluebunch wheatgrass increased its herbage six times and the number of flower stalks 10 times.

Interspecific competition in the seedling stage has been shown to retard root growth and eventually eliminate bluebunch wheatgrass seedlings (Harris and Goebel, 1976). Daubenmire (1942) reported that cheatgrass (*Bromus tectorum*) can successfully invade climax bluebunch wheatgrass stands. However, dominance of cheatgrass is only known to occur as a result of disturbances such as overgrazing, fire, plowing, fertilizer application, or trampling (Harris, 1967).

Current growth of bluebunch wheatgrass is readily grazed by all classes of livestock at some time during the year. Because of its high palatability (Harris, 1954) and abundance, it is recognized as one of the most important native grasses throughout the inland Pacific Northwest (Skovlin, 1967). In some areas, other species are preferred so management must consider this when designing grazing programs.

Harris (1954) found that fluctuations in utilization of bluebunch wheatgrass were largely caused by varying amounts of seasonal precipitation which provided more forage in some years than in others. He measured forage utilization over a 10-year period at the Starkey Experimental Forest and Range in northeast Oregon. Bluebunch wheatgrass varied from 38 to 60 percent with an average close to 50 percent. Harris (1954) concluded that adjustments in stocking rate on a year-to-year basis would not be justified with such variations in forage production.

Information is quite variable on bluebunch wheatgrass forage quality relative to annual fluctuations in climate. Seasonal forage quality based on crude protein, calcium, phosphorus, and digestibility generally follows that presented in Figure 1 (Hickman, 1966; Blaisdell et al., 1952; Stoddart, 1946). Loss in protein and phosphorus from herbage during the growing season appears to be a result of their transfer to roots. Seed dissemination and shattering are of minor importance. Losses in mature herbage are probably caused by leaching (Blaisdell et al., 1952).

Blaisdell et al. (1952) indicated that annual variation in weather influenced yield and flower stalk production but it apparently had little effect on chemical composition of herbage. Skovlin (1967) noted excellent protein retention associated with high precipitation and extremely low protein levels in conjunction with severe drought conditions on forested summer range.

Reduced gain as the season progresses is not only a result of lower nutrient content of the forage, but also may be a result of decreased daily forage intake. Livestock eat less because of decreased palatability caused by plant maturity (Cook et al., 1956).

Chemical analysis of the entire plant compared to portions representing material consumed showed that both sheep and cattle select the more nutritious portions. This preference became more pronounced as plant maturity increased. In general, levels of protein, phosphorous, cellulose, and gross energy were higher in forage being consumed than in total current growth. These differences were more pronounced for sheep than cattle (Cook et al., 1956).

Drought Effects on Plant Density, Cover, Phenology, and Seed Stalk Production

Pechanec et al. (1937) indicated that bluebunch wheatgrass numbers generally increased during plentiful moisture. With the onset of drought in 1934, a breaking up of individual clumps caused an increase in plant numbers but a decrease in plant cover. Despite above average precipitation the following winter, the mortality of smaller plants and clump remnants caused a significant decrease in plant numbers.

Pechanec et al. (1937) monitored basal area of ungrazed bluebunch wheatgrass for a 3-year period which spanned the 1934 Idaho drought. They found a rapid disintegration of bunches with the larger clumps breaking up to a greater extent than the smaller. Cover decreased greatly during the drought and continued to do so in 1935. Craddock and Forsling (1938) documented similar observations.

Pechanec et al. (1937) indicated that the range superficially appeared to recover with the return of near normal precipitation. They noted, however, that the depleted conditions of the grasses were masked by a great increase in perennial and annual herbs. Annual weeds, nearly absent during the drought, were present in profusion in 1935.

Blaisdell (1958) correlated plant cover to various precipitation periods. No significant correlations were found for grasses (r = .17), however, significant values were obtained for shrubs and total plant cover with correlation coefficients of .52 and .47, respectively. Blaisdell also correlated basal area and herbage weight of grasses and forbs. He found no significant associations and concluded that annual variations in weight were the result of variation in height or density of individual stems within a specified basal area.

Nelson (1934) has indicated that basal area of black grama (Bouteloua eriopoda) was influenced mainly by the vigor of plants at the start of the growing season. Growing conditions in one year influenced the performance of a plant the following year, to some degree (Cable, 1975). Level of plant vigor at the beginning of the growing season influences its ability to capitalize on or tolerate growing conditions. This phenomenom has not been verified in bluebunch wheatgrass although there are hints of its occurrence. Data presented by Clawson (1948) indicated that the previous year's precipitation is poorly correlated to current year's range forage conditions in Oregon. Other researchers studying a variety of vegetation types have documented reductions in cover on both grazed and ungrazed areas following the onset of drought (Jardine and Forsling, 1922; Weaver and Albertson, 1943; Lang, 1945; Young, 1956; Paulsen and Ares, 1961; Herbel et al., 1972).

During the 1934 drought in Idaho, Pechanec et al. (1937) noted that phenology was advanced approximately one month for bluebunch wheatgrass. Generally, earlier development of grasses and forbs is associated with high temperatures, low precipitation, and relatively clear skies (Blaisdell, 1958; Daubenmire, 1974). Blaisdell (1958) found that bluebunch wheatgrass typically attained 58 percent of its height growth by May 5 in Idaho. During the 1934 drought, however, it had attained 95 percent of its growth by this time.

Drought severely curtails flower and seed production in bluebunch wheatgrass (Harris and Goebel, 1976). Before and after the 1934 drought in Idaho, bluebunch wheatgrass plants averaged 7.6 and 22.3 flower stalks per plant. During the drought, the average was .1 per plant (Pechanec et al., 1937; Blaisdell, 1958). No wheatgrass seedlings occurred in either 1934 or 1935 but as many as 200 per square yard were observed in 1936 (Blaisdell, 1958).

However, fewer than 5 percent survived the 1937 growing season. Blaisdell (1958) found flower stalk production more strongly correlated with March-May weather of the early part of the growing season ($r = .64$) than with that of the preceding July-March period ($r = .26$).

Drought Effects on Carbohydrate Reserves

Plant food reserves have long been emphasized because plants are frequently most valuable as forage at the time their carbohydrate levels are depleted (McIlvanie, 1942). Adequate carbohydrate reserves are important in perennial plants for winter survival, early spring growth initiation, and regrowth initiation after herbage removal when photosynthesis is incapable of meeting plant demands. Most carbohydrate discussions have centered around a plant's ability to accumulate normal reserves either before or after grazing or clipping (Hanson and Stoddart, 1940; McIlvanie, 1942; Julander, 1945). There is no information available on carbohydrate accumulation or mobilization when growth is arrested by drought.

Julander (1945) related carbohydrate accumulations to a plant's ability to tolerate high temperatures. His experiments demonstrated that accumulation of food reserves increased a plant's tolerance of critically high temperatures and thereby enhanced its ability to withstand elevated temperatures commonly associated with drought. Although the tone of Julander's discussion deals with normally occurring seasonal drought, the principles expressed may be applicable when precipitation deficiencies result in growing season drought.

Drought Effects on Roots

Bluebunch wheatgrass seedlings usually germinate in the fall and if they are to become established must become deeply rooted enough to survive the critical dormancy period the following summer (Harris and Goebel, 1976). These researchers found that bluebunch wheatgrass roots grew very little over winter and were less than 7 inches deep on March 9. They noted that soil temperatures averaged about 34° F where wheatgrass root tips were growing and about 37° F at deeper levels where the roots of annual species were actively elongating (Figure 2).

Bluebunch wheatgrass roots began active growth in late April when soil temperatures reached 40 to 43° F. In both the laboratory and the field, increasing competition from annual grasses reduced the rate of elongation of wheatgrass roots. Summer drought under field conditions eventually resulted in the death of wheatgrass seedlings because their roots were only 12 to 16 inches deep in a stratum where soil moisture had been depleted by a rapidly growing stand of cheatgrass. Cline et al. (1977) noted that once a deep rooted perennial penetrated below 20 inches, it would be relatively free from root competition by cheatgrass. An additional survival mechanism for bluebunch wheatgrass is that its roots are heavily suberized in the endodermis area; those of cheatgrass are not. This enables the wheatgrass to rapidly transport water from deep strata through warm, dry surface strata. This is a trait not shared by annual species whose finely divided roots are incapable of translocation through dry soils.

Weaver (1915) reported an average rooting depth of 50 inches for bluebunch wheatgrass in eastern Washington. Hanson and Stoddart (1940) found roots exceeding 70 inches in Utah. Weaver and Albertson (1943) observed that drought generally causes a decrease in root tissues. There are no specific observations of drought impact on bluebunch wheatgrass rooting depth or root biomass. Many researchers have noted, however, that grazing during the growing season hinders root development, and if continued, eventually results in a decrease in root tissue (Biswell and Weaver, 1933; Hanson and Stoddart, 1940; Heady, 1950; Crider, 1955; Branson, 1956; Hedrick, 1956; Lorenz and Rogler, 1967). Hanson and Stoddart (1940) found that bluebunch wheatgrass roots averaged 26 inches in depth on ungrazed plots and 18 inches on grazed areas. Crider (1955) demonstrated that when a portion of a grass plant was clipped, only the root growth below the disturbed portion was affected. Thus, grazing which may remove only portions of a bunch should not be regarded as synonymous with clipping, which commonly affects the entire plant.

Hanson and Stoddart (1940) indicated that below ground biomass in bluebunch wheatgrass averaged 13 times that of its above ground parts. Branson (1956) reported a more equitable distribution of 53 percent top to 47 percent roots. Despite the latitude of the discrepancy, it is readily apparent that a major portion of a grass plant is below ground. Grazing can significantly impact root biomass. Hanson and Stoddart (1940) found that bluebunch wheatgrass root material averaged 1/4 pounds per cubic foot of soil on heavily grazed areas and 1.5 pounds under protected areas.

Clipping and Grazing Effects

The effects of herbage clipping or grazing on bluebunch wheatgrass are dependent on the season of removal and the portion of the plant removed. In early spring, the date clipping stops is the most important factor influencing plant response, with early cessation being the least harmful (Stoddart, 1946). Blaisdell (1958) stated that herbage removal is apparently most injurious to grasses and forbs during the middle part of their growth period -- after the date when substantial regrowth is prevented by inadequate moisture. Generally this would be about the boot stage in bluebunch wheatgrass (Wilson et al., 1966). Delaying defoliation until after plant maturity resulted in less impact on production the following year than clipping at any other time (Figure 3) (Stoddart, 1946; Blaisdell and Pechanec, 1949; Mueggler, 1950).

Branson (1956), in a clipping experiment with bluebunch wheatgrass, found root production of control plants was more than 100 times as great as that of clipped plants. Yields of tops in this case were separated by only a two-fold difference. Branson concluded that the effects of heavy grazing in bluebunch wheatgrass would be exhibited by plant roots before they are apparent above ground. The fact that roots are less apparent and more difficult to study has in the past and probably will in the future result in their being neglected in most plant studies (Hanson and Stoddart, 1940).

As mentioned previously, drought and warmer than normal temperatures are known to advance plant phenology by as much as one month (Blaisdell, 1958). During drought years, plants may be especially sensitive or in a critical stage of development earlier than expected. This is another argument for basing management on plant phenology rather than specific calendar dates.

CONCLUSION

Bluebunch wheatgrass occurs over a vast area and forms a significant portion of the vegetation in the West. Periodic droughts are normal in the area, occurring on an average of one in five years. Studies over the last 40 years clearly show that bluebunch wheatgrass possesses a remarkable tolerance to drought with an apparent ability to not only maintain production during a drought year but to rapidly return growth to normal after a drought.

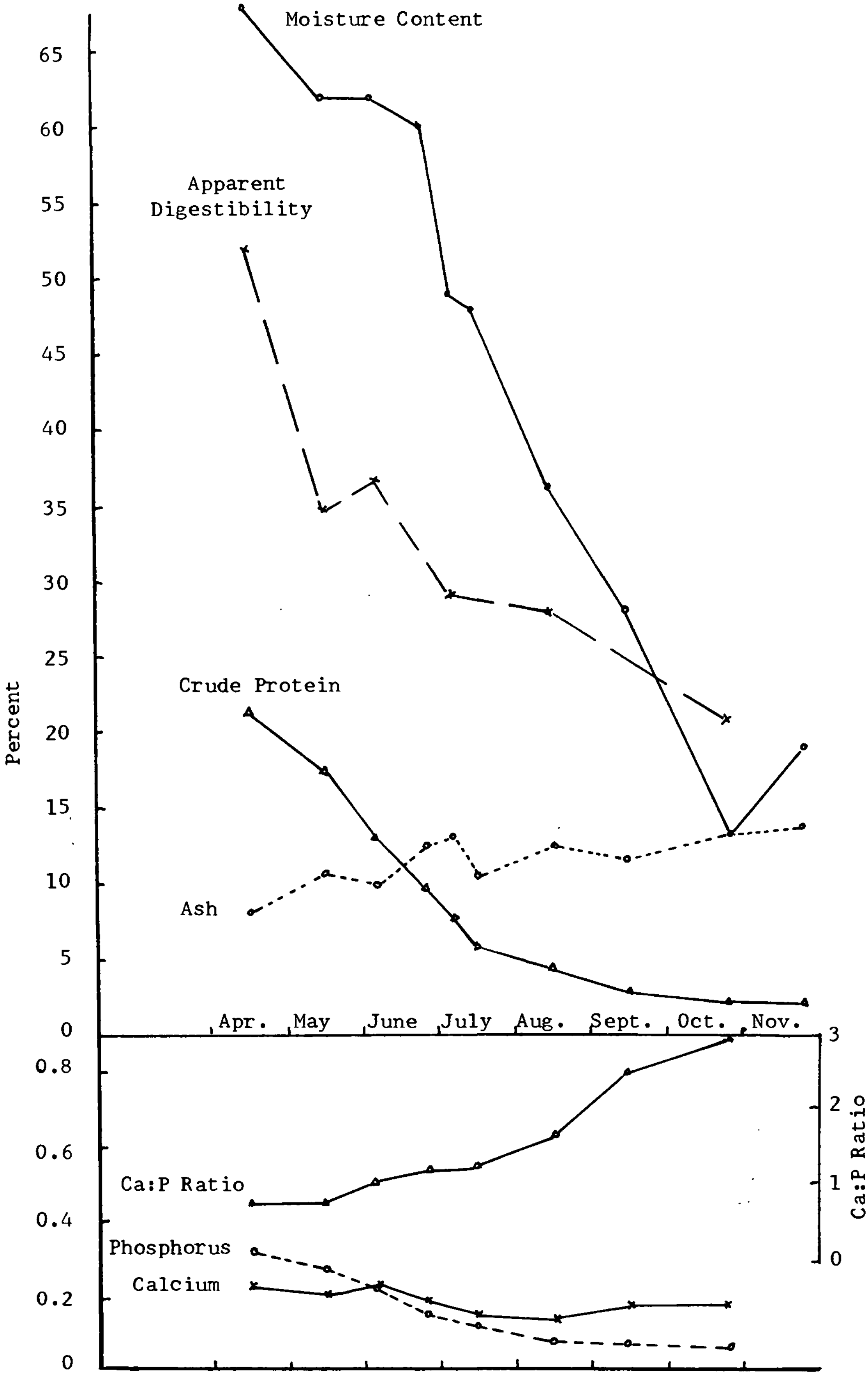

Figure 1. Seasonal trends of constituents in bluebunch wheatgrass. From Hickman, 1966.

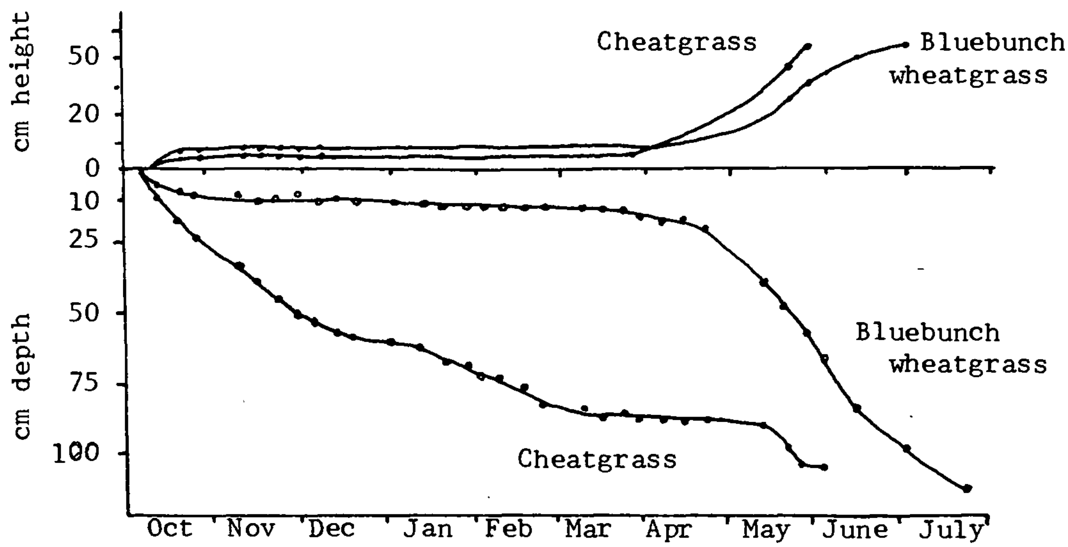

Figure 2. Seasonal leaf and root growth of bluebunch wheatgrass and cheatgrass in glass tubes in the field 1963-1964. From Harris and Goebel, 1976.

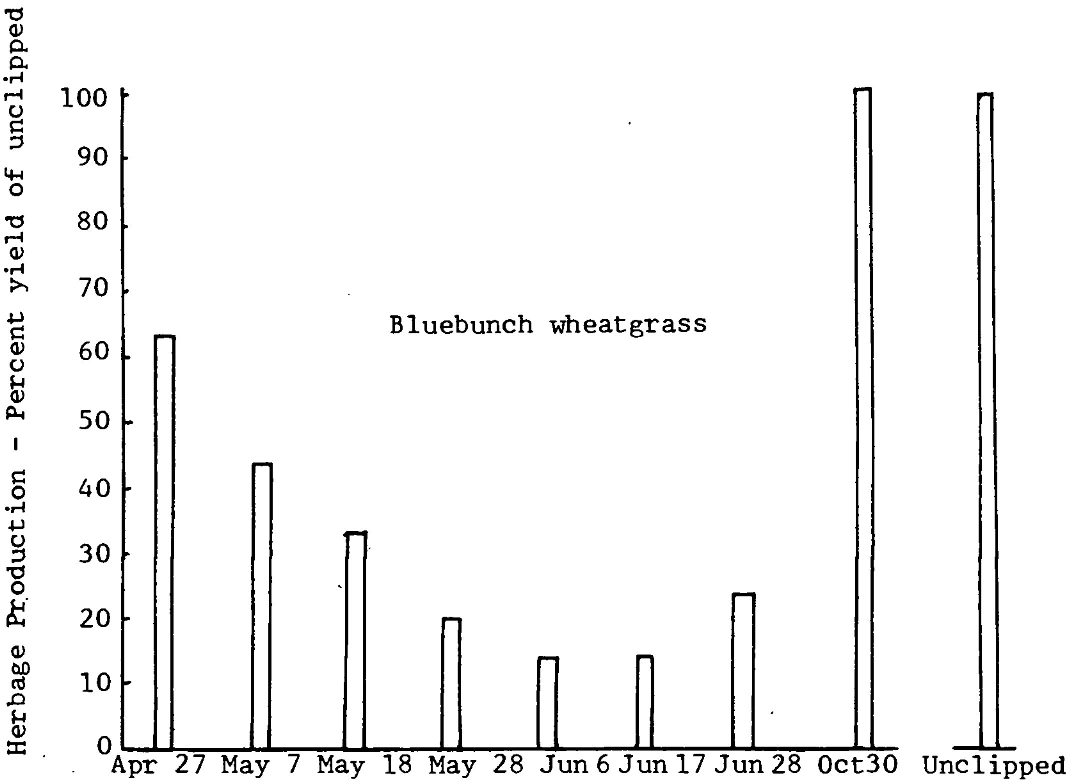

Figure 3. Average herbage production the year following ground level clipping at eight dates. From Blaisdell and Pechanec, 1949.

LITERATURE CITED

Biswell, H. H. and J. E. Weaver. 1933. Effect of frequent clipping on the development of roots and tops of grasses in prairie sod. Ecol. 4:368-389.

Blaisdell, J. P. 1958. Seasonal development and yield of native plants on the upper Snake River plains and their relation to certain climatic factors. USDA Tech. Bull. 1190. 68p.

Blaisdell, J. P. and J. E. Pechanec. 1949. Effects of herbage removal at various dates on vigor of bluebunch wheatgrass and arrowleaf balsamroot. Ecol. 30:298-305.

Blaisdell, J. P., A. C. Wiese, and C. W. Hodgson. 1952. Variations in chemical composition of bluebunch wheatgrass, arrowleaf balsamroot, and associated range plants. J. Range Manage. 5:346-353.

Branson, F. A. 1956. Quantitative effects of clipping treatments on five range grasses. J. Range Manage. 9:86-88.

Cable, D. R. 1975. Influence of precipitation on perennial grass production in the semidesert southwest. Ecol. 56:981-986.

Clawson, M. 1948. Range forage conditions in relation to annual precipitation. Land Econ. 24:264-280.

Cline, J. F., D. W. Uresk, and W. H. Rickard. 1977. Comparison of soil water used by a sagebrush-bunchgrass and a cheatgrass community. J. Range Manage. 30:199-201.

Cook, C. W., L. A. Stoddart, and L. E. Harris. 1956. Comparative nutritive value and palatability of some introduced and native forage plants for spring and summer grazing. Utah Agr. Exp. Sta. Bull. 385. 39p.

Craddock, G. W. and C. L. Forsling. 1938. The influence of climate and grazing on spring-fall sheep range in southern Idaho. USDA Tech. Bull. 600. 43p.

Crider, F. J. 1955. Root growth stoppage resulting from defoliation of grass. USDA Tech. Bull. 1102. 23p.

Daubenmire, R. F. 1942. An ecological study of the vegetation of southeastern Washington and adjacent Idaho. Ecol. Monog. 12:53-79.

Daubenmire, R. F. 1960. An experimental study of variation in the Agropyron spicatum - A. inerme complex. Bot. Gaz. 122:104-108.

Daubenmire, R. F. 1974. Plants and Environment: a textbook of autecology. 3rd ed., John Wiley & Sons, Inc., New York. 422p.

Garrison, G. A. 1966. A preliminary study of response of plant reserves to systems and intensities of grazing on mountain rangeland in northwest USA. Proc. 10th International Grassland Congress, pg. 937-940.

Hanson, W. R. and L. A. Stoddart. 1940. Effects of grazing upon wheatgrass. J. Amer. Soc. Agron. 32:278-289.

Harris, R. W. 1954. Fluctuations in forage utilization on ponderosa pine ranges in eastern Oregon. J. Range Manage. 7:250-254.

Harris, G. A. 1967. Some competitive relationships between Agropyron spicatum and Bromus tectorum. Ecol. Monogr. 37:89-111.

Harris, C. A. and C. J. Goebel. 1976. Factors of plant competition in seeding Pacific Northwest bunchgrass ranges. College of Agr. Res. Center, Washington State University, Pullman. Bull. 820. 21p.

Heady, H. F. 1950. Studies on bluebunch wheatgrass in Montana and height-weight relationships of certain range grasses. Ecol. Monogr. 20:55-81.

Hedrick, D. W. 1956. Safe degree of use on key forage plants. Paper presented to the Pacific Northwest Section, American Society of Range Management, Nov. 26, 1956, at Penticton, British Columbia. 6p.

Hedrick, D. W. 1964. Overstory-understory grass seeding on sagebrush bunchgrass range. Oregon Agr. Exp. Sta. Tech. Bull. 80. 31p.

Herbel, C. H., F. N. Ares, and R. A. Wright. 1972. Drought effects on semi-desert grassland range. Ecol. 53:1084-1093.

Hickman, O. E. 1966. Seasonal trends in the nutritive content of important range forage species near Silver Lake, Oregon. Tech. Rep. submitted to the Range Management Program, Oregon State University. Corvallis. 95p.

Hitchcock, A. S. 1950. Manual of grasses of the United States. 2nd ed. Revised by Agnes Chase. USDA Misc. Pub. 200. 1051p.

Jardine, J. T. and C. L. Forsling. 1922. Range and cattle management during drought. USDA Bull. 1031. 84p.

Julander, O. 1945. Drought resistance in range and pasture grasses. Plant Physiol. 20:573-599.

Lorenz, R. J. and G. A. Rogler. 1967. Grazing and fertilization affect root development of range grasses. J. Range Manage. 20:129-132.

Lang, R. 1945. Density changes of native vegetation in relation to precipitation. Wyoming Agr. Exp. Sta. Bull. 272. 31p.

McIlvanie, S. K. 1942. Carbohydrate and nitrogen trends in bluebunch wheatgrass, Agropyron spicatum, with special reference to grazing influences. Plant Physiol. 17:540-547.

Mueggler, W. F. 1950. Effects of spring and fall grazing by sheep on vegetation of the Upper Snake River Plains. J. Range Manage. 3:308-315.

Mueggler, W. F. 1972. Influence of competition on the response of bluebunch wheatgrass to clipping. J. Range Manage. 25:89-92.

Nelson, E. W. 1934. The influence of precipitation and grazing upon black grama grass range. USDA Tech. Bull. 409. 32p.

Paulsen, H. A., Jr. and F. N. Ares. 1961. Trends in carrying capacity and vegetation on an arid southwestern range. J. Range Manage. 14:78-83.

Pechanec, J. E., G. D. Pickford, and G. Stewart. 1937. Effect of the 1934 drought on native vegetation of the upper Snake River Plains of northern Idaho. Ecol. 18:490-505.

Risser, P. G. 1969. Competitive relationships among herbaceous grassland plants. Bot. Rev. 35:251-284.

Skovlin, J. M. 1967. Fluctuations in forage quality on summer range in the Blue Mountains. U.S. Forest Serv. Res. Pap. PNW-44. 20p.

Sneva, F. A. 1971. Progress Report. Squaw Butte Exp. Sta. Burns, Oregon. 109p.

Sneva, F. A. and L. R. Rittenhouse. 1970. Annual report of range research. Squaw Butte Exp. Sta., Burns, Oregon. 62p.

Stoddart, L. A. 1946. Some physical and chemical responses of Agropyron spicatum to herbage removal at various seasons. Utah Agr. Exp. Sta. Bull. 324. 24p.

Weaver, J. E. 1915. A study of the root systems of prairie plants of southeastern Washington. Plant World 18:227-282.

Weaver, J. E. and F. W. Albertson. 1943. Resurvey of grasses, forbs, and underground plant parts at the end of the great drought. Ecol. Monogr. 13:64-117.

Wilson, A. M., G. A. Harris, and D. H. Gates. 1966. Cumulative effect of clipping on yield of bluebunch wheatgrass. J. Range Manage. 19:90-91.

Young, V. A. 1956. The effect of the 1949-1954 drought on the ranges of Texas. J. Range Manage. 9:139-142.