Ecological aspects of the life history of Agropyron smithii Rydb. in central Montana with related effects of selective herbicide treatments of rangeland
by Henry Edward Jorgensen

A thesis submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of DOCTOR OF PHILOSOPHY in BOTANY
Montana State University

Abstract:
The three problems considered include studying ecological aspects of the life history of Agropyron smithii central Montana; relating growth of A. Smithii- to environmental factors; and determining effects of rangeland treatments related to Artemisia tridentata control.

Procedures used to obtain information on the life history were; weekly measurements of height growth; weekly leaf number counts; density measurements; caryopsis counts; seed germination studies, rhizome and root growth experiments; a study of cluster pattern; and determination of dry matter production= The relation of A. smithii growth to environmental factors was studied by correlating results from the life history experiments with information from weather data, soil moisture determinations, soil texture analyses, plant nutrient analyses and growing of A. smithii in different soils under controlled conditions.

The effects of herbicide treatment of the rangeland on A. smithii were observed by comparing growth and life history patterns between control and treated sites.

These studies produced the following results: Maximum height growth occurs during May and June. Crude and specific densities are very similar, implying an even distribution. The density of living culms drops to zero in winter and increases rapidly during early spring. The plant ordinarily is found with culms in small groups which are interconnected with rhizomes. Reproduction is mainly by rhizomes with sexual reproduction apparently unimportant. The presence of ecotypes resulting from site differences was not indicated by experiment. Differences in soil characteristics (possibly due to parent material differences) resulted in differences in growth and density of A. smithii throughout the region. Clay soils generally, although not always, tended to reduce growth of leaves and roots. Highest dry matter productivities were on cracking clay soils, and lowest productivities were on noncracking clay soils. Coarser-textured soils had intermediate productivities. Effects of salinity were not determined. Annual dry matter production is more strongly influenced by moisture conditions in May and June than at any other time of the year.

Herbicide treatment conducted to control Artemisia .tridentata resulted in an increase in height growth and dry matter production of A. smithii as compared with practically identical non-treated sites for at least 2 years following treatment, The effects were less noticeable after 2 years than after I year following treatment, The reason for increased grass growth following herbicide treatment was not ascertained, but could have been due to increased available nitrogen and moisture. The increase in grass growth following contour furrowing is at least partially due to an increase in available nitrogen. in the soil.

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ABSTRACT

The three problems considered include studying ecological aspects of the life history of *Agropyron smithii* in central Montana; relating growth of *A. smithii* to environmental factors; and determining effects of rangeland treatments related to *Artemisia tridentata* control.

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INTRODUCTION

This study was stimulated by a desire to study some ecological aspects of the life history of *Agropyron smithii* (western wheatgrass) in central Montana, and its relation to the communities in which it occurs.

Statement of Problem

This paper considers three problems. The first of these is studying autecological features of *Agropyron smithii* in the region around Winnett, Montana. Items determined are; the growth curve during a single growing season, the distribution and areal extent of clonal plants, the heights of culms, the numbers of leaves produced, density and distributions of culms and rhizomes, sexual reproductive capacity, possible genetic variability and the patterns and amounts of root growth.

The second problem is the relation of *A. smithii* to the environments occurring in the region. This problem area includes the effects of soil differences on above and below-ground plant parts, effects of differences in weather between years on the growth and reproduction of *A. smithii*, the responses of *A. smithii* to normal and unusual weather changes taking place through a single growing season, the effects of different soil moistures on growth and the effects of yearly soil moisture distribution on reproduction. An attempt is made to define the effects of macronutrient status of the soil on growth and reproduction of *A. smithii*.

A third problem is to determine the effects of rangeland treatments related to *Artemisia tridentata* (big sagebrush) control on factors of the environment such as soil moisture and nutrient status; and especially the possible relations between these changes in environmental factors and changes in growth and reproduction of *A. smithii*.

Literature Review

Studies of the life history and ecological requirements of *A. smithii* have been comparatively few. Most information on this taxon has been catalogued from studies of a general nature, for example, those including several species of plants.

The most extensive research concerning root growth characteristics has been carried out by J. E. Weaver. Near Lincoln, Nebraska, Weaver (1942) determined a root growth rate for young plants of up to 0.76 meters in 3 months. In moist soil, most of the roots grew vertically downward, whereas in drier soil there was a greater concentration of roots near the surface. From studies near Burlington, Colorado, Weaver (1958) noted that most horizontal root growth was in the upper 30 to 45 cm of soil. Distribution of root weights according to depth was as follows: 0 to 15 cm = 55 percent; 15 to 30 cm = 15 percent; and 30 to 60 cm = 16 percent. This agrees favorably with some other results from Nebraska (Weaver and Darland 1949) in which the upper soil had an average of 60 percent of the roots, with a sharp decrease in root weight as depth increased. Coupland and Johnson (1965) estimated maximum rooting depths of 2.1 to 3.6 meters in eastern Nebraska and Kansas, and 1.5 meters in eastern Colorado. In agreement with Weaver they noted that dry soils produced more branching and shallower penetration of roots than did moist soils. However, other factors besides moisture were found to affect rooting depth; for example, soil type and topographical position.

Reproductive capacities of *A. smithii* have been little studied. Mueller (1941), working in eastern Nebraska, reported that rhizomes grew a meter or more with branching by the time the flower stalks were mature. This growth is correlated with growth of the tops and begins as soon as the tops are capable of supplying food. Weaver (1942) found that rhizomes attained lengths of from 15 to 90 cm and noted, in agreement with Mueller, that growth was correlated with that of the tops. Concerning seed reproduction capabilities, Hoover *et al.* (1948) gave an estimate of approximately 1×10^7 seeds per acre being produced under conditions which are presumably optimum for the species. Out of this number of seeds, 80 percent were estimated to be viable. Yields of seed are increased by high soil fertility, abundance of moisture and low temperatures during the flowering period.

Ecesis of a taxon depends upon favorable environmental conditions as well as upon reproductive potential. Judd (1937) noted that *A. smithii* spreads rapidly by rhizomes and seeds but in areas which are occupied by shortgrasses, establishment is curtailed. In areas where competition is removed, *A. smithii* moves in rapidly. Establishment of *A. smithii* in cheatgrass-dominated localities appears to be retarded by slow germination of wheatgrass seeds (Rummell 1946). Immediately after an *A. smithii* plant has passed the crisis of germination it is susceptible to destruction by conditions which probably do not have a severe effect on a mature plant. Mueller and Weaver (1942), studying the drought resistance of seedlings, found that *A. smithii* seedlings were intermediate in drought resistance among ten dominant species of prairie grasses. The *A. smithii* seedlings were also found to be relatively more susceptible to high temperatures than seedlings of the other grasses. This problem appears to be minimized by the fact that *A. smithii* germinates and completes most of its growth before the heat of summer arrives.

Most researchers agree that the principal growth period of *A. smithii* is in the spring when weather is cool and moist, with a decrease or cessation of growth in the summer (Weaver 1941; Weaver 1950; Hoover *et al.* 1948; Mueller 1941; and Holscher 1945). Flowering ordinarily takes place in late spring or early summer depending on the locality. People working in the prairie regions, including Benedict (1940) and Weaver (1941), agree that flowering occurs in June after the major period of vegetative growth is over. The distribution of precipitation throughout the growing season may have considerable influence on growth and flowering of *A. smithii*. Mueller (1941) states that growth curves follow those of rainfall and that growth occurs any time in the fall or summer when sufficient moisture is available. Holscher (1945) has determined that in southeastern Montana the main vegetative growth period is from April 20 to June 15, but may continue later providing moisture is available. He noted that maintenance of stands depends upon precipitation from March to July. Flowering apparently depends on moisture present during the spring. Coupland (1961) states that a considerable amount of moisture must be present during May in order that cool-season mid-grasses growing in the northern Great Plains, including *A. smithii*, can flower.

Some research has been carried out concerning food storage in *A. smithii*. Work done by McCarty (1935) with *Elymus ambiguus* shows that most carbohydrates are stored at the bases of stems and in roots. The amounts of carbohydrates stored are highest when herbage growth is the least. This information may or may not be applicable to *A. smithii*. Mueller (1941) indicates that during drought periods, the greatest amount of food is kept just behind the terminal buds of rhizomes in *A. smithii*. Rauzi and Dobrenz (1969) working near Cheyenne, Wyoming, report that protein content declines steadily after the main growth season and does not increase in the fall even if growth resumes.

Studies in Nevada by Robertson (1947) indicate some effects of competition between sagebrush and *A. smithii*. Using three intensities of sagebrush competition -- intense, reduced, and none -- he found that for at least 2 years following the beginning of the study the yields for *A. smithii* were higher for reduced competition than intense competition, and still higher with no competition. Dry weights per plant increased as competition decreased from intense to none. Hedrick *et al.* (1966), working in central Oregon, found that areas where sagebrush was treated dried earlier than those where it wasn't. This effect was noted for 8 years after treatment. Their explanation was that the increased growth of perennial grass, including *A. smithii*, more than used up the moisture which presumably had been made available upon death of the sagebrush.

DESCRIPTION OF STUDY AREA

The study areas, located in Petroleum and Fergus Counties, Montana, are situated near the eastern edge of the "high plains" area of the east central part of the State (Helburn *et al.* 1962). The topography is characteristic of the western part of the northern Great Plains. The region is mostly rough and sharply stream-dissected, with some relatively flat upland areas and flat floodplains and terraces adjoining major streams. The two sites in northern Fergus County are situated in extremely rough "breaks" country which is the characteristic topography along that portion of the Missouri River. Relief varies from approximately 15-60 meters in areas around Winnett to 15-90 meters in the Missouri Breaks of northern Fergus County. Pleistocene continental glaciers advanced into the region where the Missouri Breaks study sites are located (Reeves 1927), but all topographical effects of glaciation in the immediate vicinity have subsequently been obliterated by stream dissection. The study areas around Winnett were not affected by the continental glaciation (Reeves 1927). Underlying all areas in question are marine shales primarily of Cretaceous age. In the Missouri Breaks these shales are part of the Bearpaw formation and the shales around Winnett are in the Colorado formation (Reeves 1927). The shales contain large amounts of soluble salts, therefore many of the soils in the area are saline, alkaline, or both. Most of the soils are fine-textured, being classed as clays or clay loams. Soil orders represented are Entisols, Aridisols, and Mollisols (SCS 1968). Many areas have "slick spots" or micropits which are sites of high sodium effects.

The climate of the region is semiarid with long, cold winters and short, warm summers. Two climatological stations were used to supply data for Table 1; one near Flatwillow (see Figure 1) and another (Valentine), closed down sometime since 1941. The Valentine station was about 16 km (10 miles) south of the Missouri Breaks, and it had a record of 30 years as of 1941. Another station, located near Roy, has not been in existence long enough to supply reliable means of climatic data.

Additional climatic data are presented in Figures A-1, A-2, A-3, and A-4 in the Appendix.

TABLE 1. SUMMARY OF TEMPERATURE AND PRECIPITATION DATA FOR FLATWILLOW AND VALENTINE, MONTANA AS OF 1941.*

	Flatwillow	Valentine
Lowest Temperature Recorded	-44.5°C (-48°F)	-45.5°C (-50°F)
Highest Temperature Recorded	42°C (107°F	43°C (110°F)
Length of Frost-free Season	130 days	125 days
January Mean Temperature	6°C (21.1°F)	9°C (16.2°F)
July Mean Temperature	21°C (70.2°F)	22°C (70.8°F)
Mean Annual Precipitation	271 mm (11.8")	252 mm (10.9")
Percent of Annual Precipitation Falling from April Through September	75	77

*Data from U. S. Department of Agriculture (1941).