WESTERN RAGWEED GROWTH AND
COMPETITIVENESS ON MIXED
AND TALLGRASS PRAIRIE

By

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Bachelor of Science

Oklahoma State University

Stillwater, Oklahoma

1994

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
May, 1997

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ACKNOWLEDGMENTS

I am grateful to Drs. Robert L. Gillen, David M. Engle, and Terrence G. Bidwell for introducing me to the science of rangeland management and later serving as my advisory committee.

Dr. Gillen has been the quintessential mentor through his calculated thought, insistence on quality work and dedication to students. Dr. Engle has provided opportunities to use and learn about fire as a management tool that would not have been readily available elsewhere. Dr. Bidwell has shared his insight on rangeland wildlife and graciously provided me with a place to study these wildlife apart from my thesis work. They are all greatly valued for their input into my graduate experience.

I appreciate the Department of Agronomy for the use of their facilities and financial support, John Weir for his management of the cattle in my study, Dr. Eugene G. Krenzer for the loan of panels for my project and my office mates for the philosophical discussion and exchange of ideas throughout our stay together.

I am very thankful for the love of my family and their never-ending expectation of me to excel. I thank my wife, Leah, for being my partner in data collection, best friend and greatest supporter, and God for blessing me with the gift I have found in her

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CHAPTER I

INTRODUCTION

A current trend in natural resource sciences is to study and manage entire systems as a single unit, somewhat de-emphasizing autecology. However, an important step in good management of rangelands, like any business, is to know the cost of each element affecting that business.

Most often, because forbs comprise a small percentage the total production and at the same time the greatest percentage of species, they are studied and managed as an inclusive group on rangelands. Yet, Weaver (1954) showed that variations in growing season, rooting depth and root morphology can drastically alter plant interactions. Conclusions based on average responses of a complex group of plants may be incomplete and misleading.

Studying the individual contributors to the species composition of rangelands will allow researchers to better understand which species present the greatest need for specific management. Cook (1983) called for greater knowledge of the true status of forb species in the structure and function of ecosystems. This thought was echoed by Cussans et al. (1987) who found it absurd that we know so much about killing weeds and comparatively little about their influence on desired species.

Western ragweed [*Ambrosia psilostachya* DC.] is distributed from south-central Canada through Mexico and may be found in most of the contiguous United States with the exception of the Rocky Mountains and a few states east of the Appalachians (Stubbendieck et al. 1993). Western ragweed contributes 70 to 80 percent of the forb component in high-seral grazed tallgrass (Gillen et al. 1991). Such abundance and distribution suggest western ragweed is worthy of study, but few have studied its ecology in grassland communities.

The objective of this study is to provide information on the ecology of western ragweed in tallgrass and mixed prairies under moderately heavy grazing and in the absence of grazing in order to enhance the ability of land managers to make sound management decisions. We studied western ragweed in grazed and ungrazed tallgrass and mixed prairies with regard to growth curves by height and dry weight, changes in density during the growing season, and the influence of western ragweed density and standing crop on the standing crop of other forbs, grasses, and total herbage.

The following chapter is a review of the literature used for this study. The results of the study are presented in chapter III and formatted for immediate submission to the *Journal of Range Management*.

CHAPTER II

LITERATURE REVIEW

Western ragweed [*Ambrosia psilostachya* DC.] has been designated as the most harmful weed in Oklahoma pastures (Elder 1951), the most-used year-round quail food in Oklahoma (Baumgartner et al. 1952), and a useful gauge of proper grazing management (Brummer et al. 1994). These attributes suggest specific knowledge of the plant's ecology would be desirable, but such information is lacking.

The authority for western ragweed was most likely not a cattleman as *Ambrosia psilostachya* is translated as "food for the gods" and "smooth ear of grain" (Mitich 1996). Bassett and Crompton (1975) cite *A. coronopifolia* T.& G. as the most common synonym and provide some information on its survival strategies. Seed production is secondary with rhizomes serving as the primary source of colonization. When seedlings are established, they will not flower or produce additional shoots the first growing season. The second year, additional shoots will develop, forming a clone. Damage to the main stem of an established plant in the first half of the growing season will result in a short bushy plant with many branches rising from the base.

Weaver (1958) classified forbs into four groups based on their root systems. The group containing western ragweed has a general distribution of main roots throughout the soil to a depth of 1.5 to 1.8 m and absorbs moisture vigorously from the surface. Most of the dominant grasses have more than 90 percent of their root mass in the top 60 cm of soil (Weaver 1954). Soil depth may be a strong factor influencing the level of competition with grasses. Western ragweed was considered one of the most abundant and worst weeds in native pasture.

Considerations for Weed Control

Cussans et al. (1987) believed it absurd that we know so much about killing weeds and comparatively little about the damage they do. Cook (1983) called for more information on the true status of forbs in the structure and function of ecosystems, stating that life forms should not be rated by preferences of a herbivorous species.

Currently, decisions for control are most often based on appearance. Land managers need specifics to reach the best conclusions, especially considering the current concern for the environmental impact of applying agrochemicals (Cousens 1987). Competitive and economic thresholds must be determined to implement the most cost-effective and environmentally sound containment program. An unfortunate side effect of weed control is that it often affects a large number of species in addition to those targeted. However, spot treatment may not be a good option as cattle may be attracted to herbicide-treated areas (Scifres et al. 1983).

Ralphs and Pfister (1992) warned that management decisions should not discount cattle use of forbs, noting that cattle are opportunistic and may select forbs at levels exceeding their proportion in the standing crop. Though it is not a preferred species, cattle will graze young ragweed plants in early spring (Elder 1951). Thilenius et al. (1975) found cattle gains to be the same on forb-dominated pastures and those treated with 2,4-D with grass composition being 27 and 81 percent, respectively.

Feeding mixtures of native forbs and shrubs known to be selected by cattle with low-quality grasses can have an effect on nitrogen retention similar to feeding alfalfa and may increase intake (Arthun et al. 1992). Therefore, the maintenance of palatable forbs may reduce the need for supplementation to meet nitrogen and phosphorus requirements of livestock (Cook 1983).

Distribution and Habitat

Western ragweed is distributed from south-central Canada through Mexico and throughout most of the contiguous United States with the exception of the Rocky Mountains and a few states east of the Appalachians (Stubbendieck et al. 1993). Its extensive range suggests that it is a plant adapted to many environments. In addition to its wide distribution, western ragweed can be found on clayey or sandy soils ranging from droughty to wet and at all levels of fertility.

In mixed prairie, Heitschmidt et al. (1989) found western ragweed to be a sub-dominant on a Clay Loam range site. Launchbaugh (1967) noted low ragweed yields following spring drought and high yields when soil moisture exceeded levels that could be utilized by grasses in spring and early summer. Bovey et al. (1966) observed heavy infestations where overgrazing and drought had deteriorated grass stands in sandy Nebraska prairie. Western ragweed was vigorous and highly competitive on shallow claypan soils in Oklahoma, increasing with low May precipitation (Hazell 1965). In Canada, Bassett and Crompton (1975) described its habitat as abandoned fields, sandy alkaline soils and alkaline sloughs, noting that it prefers sandy or gravelly, well-drained soils. Elder (1951) determined that western ragweed grows on soils of all fertility levels and will grow on sandy soils, but thrives on heavier soils.

Competitiveness

Studies of the relationship between western ragweed and grass production show variable results that are often confounded by the influence of other forbs. Dwyer (1958) found a 56 and 54 percent reduction in the above and below-ground production of big bluestem, respectively, in the presence of western ragweed with a mean density of 65 stems/m^2. Samples contained big bluestem alone, or big bluestem and western ragweed alone and were not randomly selected. Since this study was conducted on tallgrass prairie with no grazing or disturbance for many years and sampling was non-random, soil differences may have existed between samples. Rice and Stritzke (1989) and Powell et al. (1982) showed an increase in grass production slightly more than 1 kg/ha for every 1 kg/ha of forbs removed on loamy tallgrass prairie. However, on claypan soils, the increase in grass production was 10 to 30 percent less than the reduction in forbs (Powell et al. 1982). On sandy soils, removal of western ragweed at 247 kg/ha increased grass production 58 kg/ha (Reece et al. 1994). Control of western ragweed at 189 kg/ha the second year yielded a 156 kg/ha increase in grass standing crop. Estimates of the effects of western ragweed on sandy mixed prairie following removal were confounded by the presence of shinnery oak (*Quercus havardii* Rydb.) although western ragweed was the dominant forb (Dahl et al. 1989). Control of forbs, mostly western ragweed, between 350 and 795 kg/ha increased grass yields up to 800 kg/ha.

Launchbaugh (1967) concluded forb standing crop on Kansas mixed prairie, almost entirely western ragweed, had to exceed 1,230 kg/ha before grass production was negatively affected. At such levels, each kilogram of forbs reduced grass production by 0.4 kg/ha. Below 1,120 kg/ha of forb standing crop, there was either no effect or a slightly positive correlation with grass production.

Control

Powell et al. (1982) showed forb production to decrease with increasing rates from 0.28 to 1.68 kg/ha of 2,4-D [(2,4-dichlorophenoxy)acetic acid] giving 53 to 77 percent control, respectively. A single application of 2,4-D at 0.56 kg/ha was sufficient for control into a second season (Bovey et al. 1966, Rice and Stritzke 1989). McCarty and Scifres (1972), however, found western ragweed to be tolerant of 1.12 kg/ha of 2,4-D and occasionally unresponsive to a rate of 2.24 kg/ha. Picloram (4-amino-3,5,6-trichloro-2-pyridinecarboxylic acid) at 1.12 kg/ha provided more uniform and reliable control. In a shinnery oak vegetation type, 0.28 kg/ha of picloram increased grass production for three years and the same rate of dicamba (3,6-dichloro-2-methoxybenzoic acid) was also effective for ragweed control, but both may cost more than can be returned from the treatment (Dahl et al. 1989). Therefore, 2,4-D was suggested as the most cost-effective herbicide under ideal growing conditions. Powell et al. (1982) concluded that the greatest economic returns from application of 2,4-D would occur on the most productive sites.

Continuous mowing during the summer is necessary to prevent flowering and must be done for several years to reduce clones by starving the rhizomes (Bassett and Crompton 1975). Elder (1951) stated that mowing alone would not eradicate western ragweed, but rest from grazing reduced densities by 63 percent. In Nebraska, a single year of rest reduced western ragweed standing crop 50 percent and weight per shoot 59 percent (Brummer et al. 1994).

The variability of western ragweed response to prescribed spring burning suggests other factors may have a greater role than the fire itself. In northern mixed prairie, ragweed density was not consistently affected positively or negatively by burning (Biondini et al. 1989). Following prescribed burns, Gillen et al. (1987) observed 50 to 90 percent reductions in heath aster [*Aster ericoides* L.] and western ragweed in one study, and no significant decline in a second study the following year. Despite 5 annual spring burns, Gillen et al. (1991) recorded continued increases in ragweed frequency on grazed pastures and no notable changes in ungrazed controls.

Response to Grazing Pressure

In tallgrass prairie, Elder (1951) noted that western ragweed begins its colonization in pastures that have been grazed closely for several years. Because the amount of ragweed was inversely related to the amount of grass, conditions were considered favorable when grasses were heavily utilized around ragweed stems. Sims and Dwyer (1965) concurred, showing ragweed to increase with heavy grazing and declining range condition although it may also be abundant within high-condition pastures where spot-grazing occurs. Gillen et al. (1991) showed annual increases for western ragweed frequency despite high range condition, even during years when forb composition was at its lowest. Frequencies were 20 to 30 percent in ungrazed controls and 37 to 70 percent in grazed pastures where western ragweed contributed 70 to 80 percent of the forb component over a 5-year period.

Brummer et al. (1994) and Reece et al. (1994) found that ragweed production increased as vegetation removal occurred earlier in the growing season, but ragweed density was not affected within the same growing season. Reece et al. (1994) concluded that perennial grasses were superior competitors if they had high vigor, or grazing was delayed until after July. Yet, intensive-early stocking, May 1 through July 15 at twice the moderate stocking density, plus spring burning has reduced perennial forb cover compared to season-long stocking (Smith and Owensby 1978). Forb standing crop, predominantly western ragweed, was 46 percent lower under IES than SLS by mid-July, but did not differ between IES and SLS by the end of the growing season (McCollum et al. 1990).

Light availability appears to be a strong limiting factor for ragweed in tallgrass prairie. Fahnestock and Knapp (1993) observed that western ragweed was 47 percent taller in ungrazed plots, but 40 percent heavier in grazed plots. At mid-canopy, light availability was 40 percent greater in the grazed plots and at ground level, grazed plots received 40 percent full sunlight while ungrazed plots received only 5 percent.

In mixed prairie, western ragweed has been classified as a decreaser. Launchbaugh (1967) showed frequency to decrease as stocking rate increased and Heitschmidt et al. (1989) found western ragweed rank indices to be higher under moderate continuous grazing than under heavy continuous grazing. The limiting factor in mixed prairie may be water rather than light, as Launchbaugh (1967) observed more ragweed production in wet years. The result of more remaining forage may be an altered microenvironment through reduced wind speeds and temperatures, which in turn would reduce water loss.

Conclusion

The response of western ragweed to management practices and its effect on surrounding vegetation appear to be quite different in mixed and tallgrass prairies. Before the best management decisions can be made, more will have to be known about the ecology of this forb. The objective of this study is to develop growth curves for western ragweed, monitor density changes throughout 2 growing seasons, and determine the level of competition imposed upon its neighbors under the influences of grazing and rest.

CHAPTER III

WESTERN RAGWEED – AGGRESSIVE COMPETITOR OR CAPABLE SURVIVALIST?

Abstract

This was an investigation into the ecology of western ragweed (*Ambrosia psilostachya* DC.) on mixed and tallgrass prairies. We sought to determine the relationships between the standing crops of ragweed, other forbs, grass, and total herbage. The effects of moderately heavy grazing and rest on ragweed densities, growth and morphology were also evaluated. The study consisted of 8 sites, 4 in tallgrass and 4 in mixed prairie, each containing an exclosure and a plot open to grazing. Ragweed stems were collected every 2 weeks during the growing season to develop a growth curve. Density of western ragweed was determined in early June, mid-July, and early September. Standing crops of western ragweed, other forbs, and grasses were clipped in early September. Ragweed standing crop and density were positively correlated with grass and total standing crops in mixed prairie, but no significant relationships existed in tallgrass. Ragweed density did not differ by vegetation type, but was reduced to a greater extent in grazed plots than those in ungrazed plots during the growing season. Ragweed stems

were taller in ungrazed plots compared to grazed plots, but weights were not significantly different. In ungrazed plots, ragweed diverted more energy toward increasing height at the cost of potential leaf growth as shown by lower weights per unit of height.

Introduction

Forbs comprise a small portion of the standing crop and the majority of species in the Great Plains, and are therefore commonly managed and studied as an inclusive group Western ragweed [*Ambrosia psilostachya* DC.] warrants individual study because it often dominates the forb component. It has been considered one of the most harmful weeds in rangelands (Elder 1951), a gauge to proper grazing management (Brummer et al. 1994), and is the most important year-round bobwhite [*Colinus virginianus*] food in Oklahoma (Baumgartner et al. 1952).

Western ragweed has been labeled a strong increaser in tallgrass prairie (Elder 1951, Sims and Dwyer 1965). In mixed prairie, research has shown ragweed decreased as stocking rates increased (Launchbaugh 1967, Heitschmidt et al. 1989). Brummer et al. (1994) and Reece et al. (1994) observed increased ragweed production when grazing was initiated early in the growing season, yet intensive-early stocking has significantly reduced ragweed standing crop by mid-July (Smith and Owensby 1978, McCollum et al. 1990).

Estimates of grass response to forb control in herbicide studies are often confounded by the presence of other forbs affected by the treatment (Dahl et al. 1989, Powell et al. 1982, Rice and Stritzke 1989). Western ragweed reduced grass production in tallgrass prairie (Dwyer 1958), but a positive relationship existed in mixed prairie if forb production did not exceed 1,230 kg/ha (Launchbaugh 1967).

The objective of this study is to provide information on the ecology of western ragweed in tallgrass and mixed prairies under moderately heavy grazing and in the absence of grazing in order to enhance the ability of land managers to make sound management decisions. The information provided for grazed and ungrazed tallgrass and mixed prairies includes: growth curves by height and dry weight, changes in densities during the growing season, and the influence of western ragweed density and standing crop on the standing crop of other forbs, grasses, and total standing crop.

Materials and Methods

Study Area

Study Area I is located in north-central Oklahoma on the Oklahoma State University Research Range about 21 km southwest of Stillwater (36° 04' N, 97° 13' W). The continental climate allows a 204 day frost-free growing period from April to October (Myers 1982). Mean temperature is 14.8°C. The hottest month is July with a mean temperature of 27.6°C (NOAA 1993). Average annual precipitation is 831 mm with 65 percent falling as rain from May to October.

The area is high-seral tallgrass prairie with predominantly shallow and loamy prairie range sites producing an average of 6,930 kg/ha in recent years (Gillen et al. 1991). Dominant plant species include big bluestem [*Andropogon gerardii* Vitman], little bluestem *Schizachyrium scoparium* (Michx.) Nash], Indiangrass [*Sorghastrum nutans* (L.) Nash], and tall dropseed [*Sporobolus asper* (Michx) Kunth].

Study Area II is in southwest Oklahoma on the Marvin Klemme Range Research Station near Clinton (35° 22' N, 99° 04' W). The average frost-free growing period is 205 days from April to October. Mean temperature is 16°C. The hottest month is July with a mean temperature of 28.8°C (NOAA 1993). Average annual precipitation is 701 mm with 69 percent falling as rain from April to September.

The area is typical upland range located near the center of the Rolling Red Plains resource area and is classified as a red shale range site supporting mixed grass prairie with an average annual forage production of 1,010 to 1,120 kg/ha. Dominant species include sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] and blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.].

Methods

Four locations, 9 x 13 m, were selected for each study area and located in different pastures grazed from late April to September by yearling cattle. Stocking rates were relatively heavy, 2.9 AUM/ha on tallgrass and 1.6 AUM/ha on mixed prairie. In the tallgrass prairie, grass utilization was 65 percent and total utilization was estimated at 59 percent. Grass and total utilization in mixed prairie was 49 and 45 percent, respectively. Each location was divided into 2, 3 x 7-m plots separated by a 5-m alley and 1 plot was randomly selected to be grazed, leaving the other ungrazed. The corners of grazed plots were marked with wooden stakes driven to near-ground level so cattle movement would not be altered. Ungrazed plots were fenced with a 1-m border inside as a buffer. The 4-m alley between the fence and grazed plot reduced the effect of cattle traveling the fence. Plots were sub-divided into 21, 1 m^2 subplots and 15 were used for experimental treatments. To facilitate access and prevent trampling damage, subplots were arranged in an "S" pattern with 3 on the odd rows and 1 on the even rows.

Vegetation height was the same for grazed and ungrazed plots when the study was initiated. In early March of the second year, while vegetation was dormant, all plots were mowed to a height of 14 cm to maintain equal height. We were interested in testing the effects of growing season deferment on the vigor of western ragweed rather than the effects 2 years of mulch accumulation from complete rest, which is a less feasible management option.

Western ragweed density was determined by counting all stems in each subplot in early June, mid-July and early September. Following density counts in September, standing crop was measured from 0.1 x 1-m quadrats located within each subplot. Narrow quadrats were used to minimize the effects of clipping so the plots could be used for 2 years. Standing crops for western ragweed, other forbs, and grasses were sampled individually from each quadrat. The height of one ragweed stem from each subplot was also measured and weight was recorded after the plant was oven-dried. Means were calculated by whole plot for comparisons between grazing treatments.

Every 2 weeks from mid-May through the first of September, 80 western ragweed stems were collected from each vegetation type to develop a growth curve. Twenty stems were sampled along transects in each pasture utilized in the study. Each stem was measured from the ground to its highest point, clipped, and oven-dried to calculate the mean dry weight for each vegetation type.

Analysis

Regression analysis was used on data from ungrazed plots to determine relationships between standing crop components (ragweed, grasses, other forbs) and between ragweed density and standing crop components. Each vegetation type was considered separately. Ragweed densities were transformed to natural logarithms and were compared for differences by month, year, grazing treatment, and vegetation type using GLM (SAS 1990). Indicator regression was utilized to determine differences in rates of change in density from June to September by vegetation type and grazing treatment. Analysis of covariance was applied to detect differences in growth curves for ragweed height, weight, and weight/height ratios between vegetation types and differences on specific dates were determined using contrasts. Ragweed stem height, weight, and weight/height ratios at the end of the grazing season were transformed to their natural logarithm and tested for differences by grazing treatment by applying one-way analysis of variance. Where differences occurred ($P < 0.05$), means were separated by least significant differences.

Results and Discussion

Precipitation

Annual precipitation (September through August) was far greater than normal in 1995 with high levels during both the May-August and September-April periods for both locations (Fig. 1). Drought from fall through spring of the second year was severe enough to bring the annual total below average despite near-normal precipitation from May through August. In the mixed prairie, May-August precipitation was 69 and 14 percent above the long-term mean in 1995 and 1996, respectively. At the tallgrass location, rainfall from May through August was 53 percent above the mean in 1995 and 2 percent below the mean the following year.

Standing Crop Relationships

Ragweed standing crop in mixed prairie ranged from 33 to 613 kg/ha. These levels of production had a positive association with grass and total standing crops (Fig. 2, Table 1). Total forb standing crop including western ragweed was between 244 and 1,349 kg/ha and positively related to total standing crop as well (Table 1). No significant relationships existed between forbs other than ragweed and grass or total standing crops. Launchbaugh (1967) concluded forb standing crop, almost entirely western ragweed, had to exceed 1,230 kg/ha before grass production was reduced on clay uplands. On sandy sites, Dahl et al. (1989) found gains of up to 1 kg of grass with control of each 1 kg of forbs dominated by western ragweed, but shinnery oak (*Quercus havardii* Rydb.) was controlled as well and may have influenced the release of grasses.

Forbs may alter the microenvironment to favor increased grass production by providing shade and reducing wind speeds which in turn reduce evapotranspiration (Whitham 1971). The positive association between ragweed and grass could also be a function of short and mid-grasses existing in different proportions. A shortgrass turf forms a shallow, but dense network of roots that can take advantage of moisture before it reaches the deeper roots of ragweed (Weaver 1954, 1958). The more productive mid-grasses have root systems more similar to that of western ragweed and often have more exposed soil between plants. The threshold of 1230 kg/ha, set by Launchbaugh (1967), suggests ragweed will occupy sites that may otherwise be uninhabited.

Ragweed densities between 6 and 41 stems/m^2 also had positive linear relationships with grass and total standing crops (Fig. 3, Table 1). Variations in grass production were equally well explained by ragweed density or standing crop, but total standing crop was more highly correlated with ragweed standing crop.

In tallgrass prairie, no relationship ($P < 0.05$) existed between grass or total standing crops and ragweed standing crops ranging from 26 to 1,031 kg/ha (Fig. 4). While the data appear to suggest a threshold, quadratic regression models were not significant. Ragweed standing crops were between 26 and 692 kg/ha with the exception of one sample mean of 1,031 kg/ha, but the exclusion of that datum did not produce a significant regression model. The only significant relationship was between ragweed density and ragweed standing crop (Fig. 5). Correlation coefficients of 0.93 and 0.87 suggest density will provide good estimates of ragweed standing crop in tallgrass and mixed prairie, respectively.

On loamy prairie with forb standing crops similar to our data, Rice and Stritzke (1989) and Powell et al. (1982) found grass production increased about 1 kg for every 1 kg of forbs controlled. Increased grass production was 10 to 30 percent less than the reduction in forbs on claypan sites (Powell et al. 1982) These results, however, are confounded by the varying degrees of reduction for forbs other than western ragweed with the use of herbicide. The presence of other forbs, such as heath aster [*Aster ericoides* L.], in each of these studies makes it difficult to determine which species are most responsible for grass response following control.

Dwyer (1958) found a 56 and 54 percent reduction in the above and below-ground production of big bluestem, respectively, in the presence of western ragweed at 753 kg/ha and a density of 65 stems/m^2. Samples contained either big bluestem alone, or big bluestem and western ragweed. The area had no grazing or major disturbances for many years, yet the high levels of ragweed suggest sample differences were not due to ragweed levels alone. Because samples were not randomly selected, soil differences may have existed between samples.

Ragweed Density

No differences in ragweed density were attributed to grazing treatment for either vegetation type, but grazed and ungrazed plots experienced decreases between June, mid-July and early September sampling periods (Table 2). In mixed prairie, densities across grazing treatments increased from 12 stems/m^2 the first year to 20 stems/m^2 the second year ($P < 0.01$). This appears to contradict the concept that ragweed increases following drought and deterioration of grasses as put forth by Bovey et al. (1966) considering the above-average growing season rainfall. Both excess moisture and the situation described by Bovey et al. (1966) could reduce competition. The removal of water as a limiting factor may benefit both grasses and forbs, while the deterioration of grasses reduces competing species, benefiting only the remaining forbs. There was no significant grazing treatment by year interaction in the tallgrass prairie. This does not conform to the findings of Elder (1951) who observed a 63 percent reduction in ragweed density following rest. This too may be the result of above-average precipitation during our study.

The relationship between ragweed densities in June and September did not differ between vegetation types. The change in ragweed density from June to September was affected by grazing treatment (Fig. 6). A greater percentage of ragweed stems survived to September in ungrazed plots at the higher densities. This suggests a number of stems may be trampled or grazed. Elder (1951) observed cattle grazing young ragweed although it was not preferred and Ralphs and Pfister (1992) stated that management decisions should not discount cattle using forbs. With the heavier grazing pressure of intensive-early stocking, McCollum et al. (1990) found forb standing crop, mostly western ragweed, to be 46 percent lower than under season-long stocking by mid-July, but no differences existed by the end of the growing season. We found 5 and 13 percent of the ragweed had the terminal portions of stems removed in mixed and tallgrass prairies, respectively, throughout June.

Growth and Morphology

Growth rates for ragweed height were the same for both vegetation types (Fig. 7). The rates of change in weight and weight per unit of height over time were greater in the mixed prairie than in tallgrass (Fig. 8). In the middle of the grazing season (July 15), ragweed height was no different by vegetation type, but ragweed stems in the mixed prairie weighed more and had higher weight/height ratios than those in tallgrass. The same was true on September 1, near the end of the grazing season.

Grazing treatments had significant effects on ragweed height and weight/height ratio in early September, but there were not weight differences by grazing treatment (Table 3). Ragweed stems in ungrazed plots were taller than those in grazed plots. Although grazing treatment did not affect ragweed weight, we found ragweed stems to weigh more per unit of height in grazed plots than those in ungrazed plots.

Fahnestock and Knapp (1993) considered availability of light a limiting factor to ragweed growth in tallgrass prairie and found the plants to be taller and lighter in ungrazed plots compared to grazed plots. Our results appear to fit the theory of light availability being a controlling factor for ragweed development. Light availability decreases from grazed prairie, to ungrazed mixed prairie, and finally ungrazed tallgrass. Plants with the most available light invest more energy into producing leaves and less into elongation of stems. Robust ragweed plants are likely a result of depressed grass standing crop rather than reduced grass production being a result of competition from ragweed.

If cattle damage ragweed by grazing or trampling, they may directly influence ragweed morphology. Damage to the main stem during the first part of the growing season will result in a short plant with many branches if it survives (Bassett and Crompton 1975). In either case, ragweed weight per unit of height is greatest where there is the most available light and the greater chance of stem damage.

Management Implications

Western ragweed has long been considered an aggressive competitor, but the results of our study contradict conventional wisdom by regarding it as a capable survivalist. Because of ragweed's prominence in the forb component, assumptions have probably been made in the past that the majority of grass response to forb control was a result of ragweed reduction.

Our study supports the findings of Launchbaugh (1967) that show a positive relationship between grass standing crop and ragweed standing crop below 1230 kg/ha in mixed prairie. An economic threshold for ragweed control in mixed prairie has not been proposed, but our results suggest a sizable presence of ragweed can be tolerated before control should be considered. Heitschmidt et al. (1989) classified western ragweed as a decreaser in mixed prairie.

Elder (1951) and Bovey et al. (1966) concluded that in tallgrass prairie, ragweed thrives where grass vigor has deteriorated from grazing or drought. Ragweed stems have been shown to be shorter and weigh more in grazed patches (Fahnestock and Knapp 1993) We were unable to confirm this relationship, but found grazing to influence ragweed growth form in a similar manner. An abundance of ragweed in tallgrass prairie is likely an indication that grasses are over-utilized, so if control is desired, attention should first be directed to the stocking practices employed.

We found no reduction in grass standing crop in ungrazed prairie that could be attributed to the observed levels of ragweed, making chemical control difficult to justify. Considering the clonal nature of ragweed, spot-treatment may be more economical than broadcast herbicide treatment, but cattle may be attracted to herbicide-treated areas (Scifres et al. 1983), which could aggravate grazing distribution problems. Future research should focus on determining competitive and economic thresholds for western ragweed in tallgrass and mixed prairies, which appear to be above the levels observed in this study.

Our study indicates livestock grazing can benefit a number of wildlife species by promoting a growth form of ragweed with greater leaf production and branching of stems. Western ragweed is an important forage for white-tailed deer [*Odocoileus virginianus*] in spring and summer (Gee et al. 1991) and serves as brooding habitat for wild turkeys [*Meleagris gallopavo*] (Guthery 1986). The seeds are also heavily utilized by bobwhites (Baumgartner et al. 1952) and mourning doves [*Zenaida macroura*] (Guthery 1986), and they have potential value as food for songbirds.

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APPENDICES

APPENDIX A

TABLES

Dependent variable	Independent variable	Slope	Intercept	R^2
Grass standing crop (kg/ha)	Ragweed (kg/ha)	2.96	2,031	0.56
	Ragweed (stems/m^2)	47.29	1,907	0.56
Total standing crop (kg/ha)	Ragweed (kg/ha)	4.05	2,525	0.62
	Ragweed (stems/m^2)	60.92	2,428	0.55
	Total forbs (kg/ha)	2.38	1,737	0.61

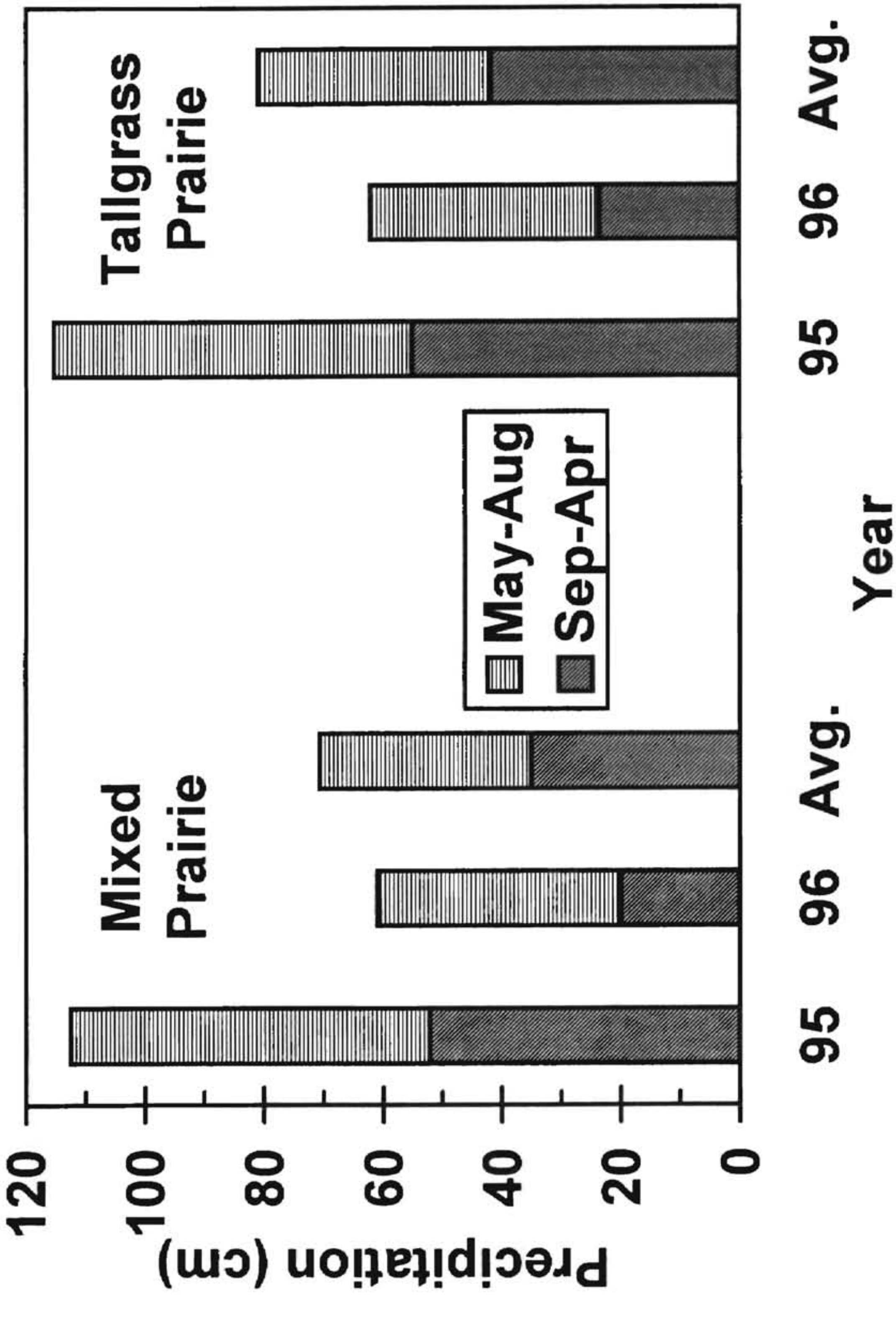
	Sampling Period		
Vegetation type	Jun. 1	Jul. 15	Sep. 1
Mixed prairie	18 a	15 b	13 c
Tallgrass prairie	30 a	20 b	17 c

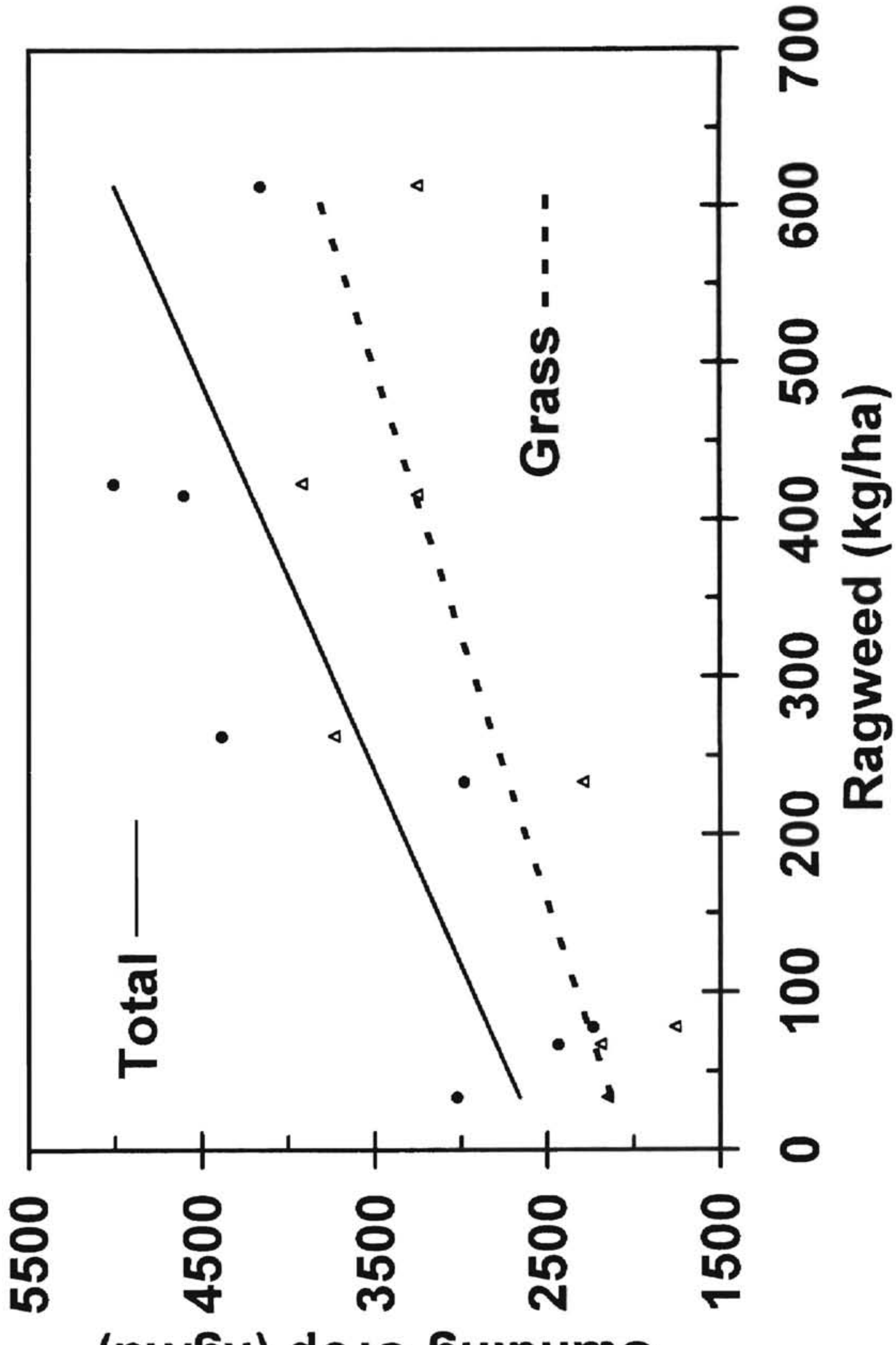
Within rows, means with different letters are significant at $P < 0.05$.

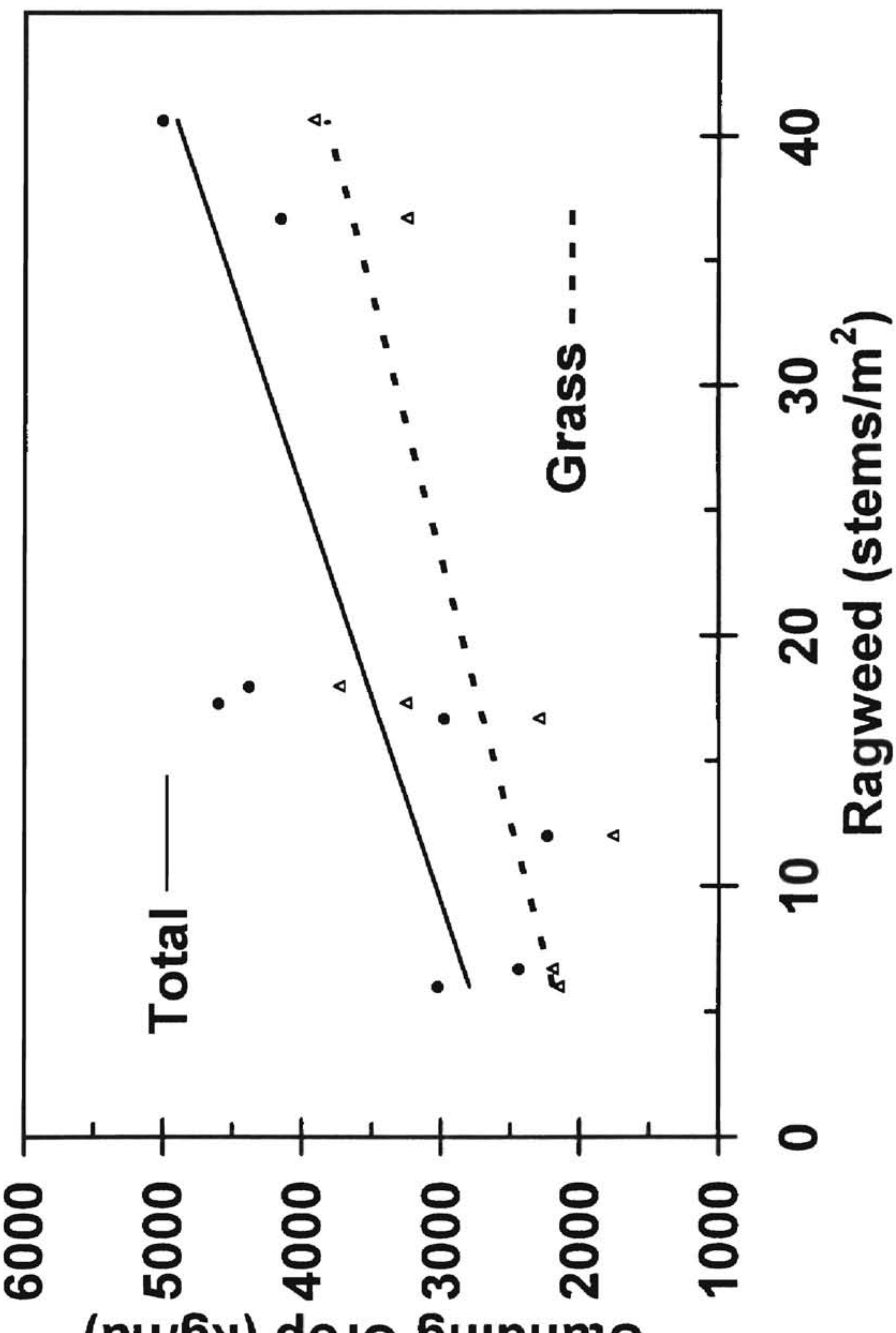
Measurement	Treatment		P
	Grazed	Ungrazed	
Stem height (cm)	23.1	30.0	0.02
Stem weight (mg)	1,286.9	857.3	0.12
Stem wt/ht ratio (mg/cm)	55.8	28.6	0.01

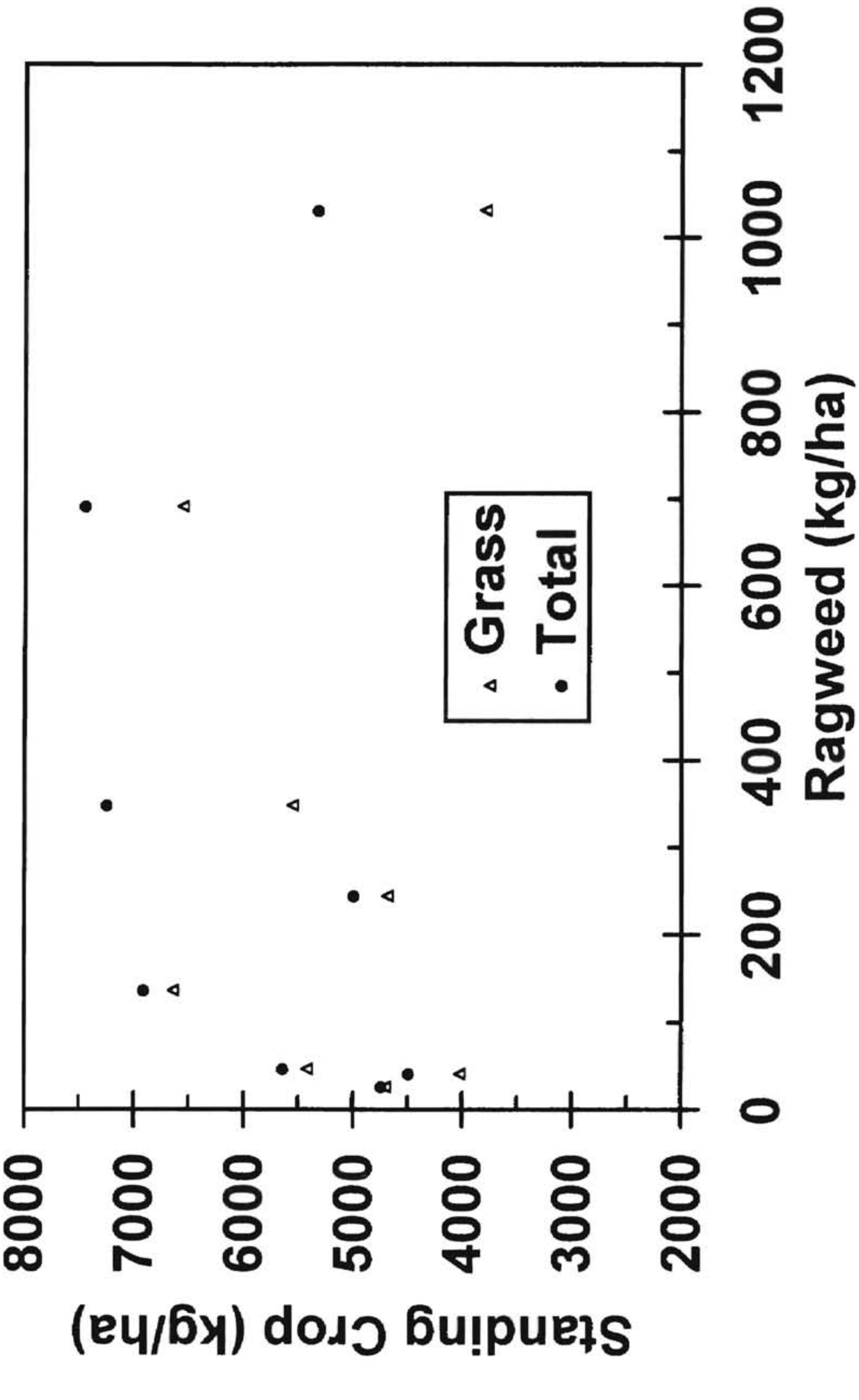
APPENDIX B

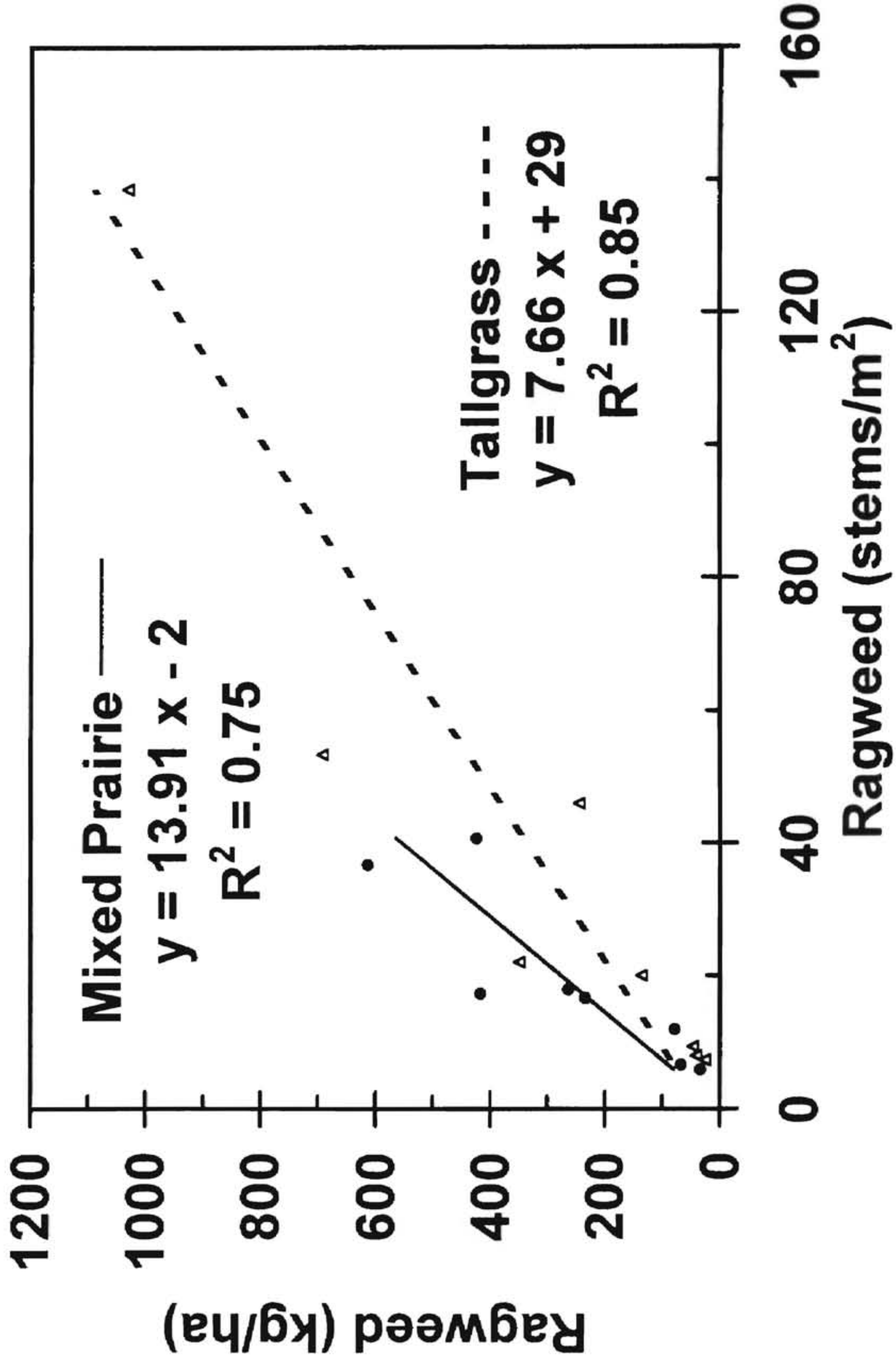
FIGURES

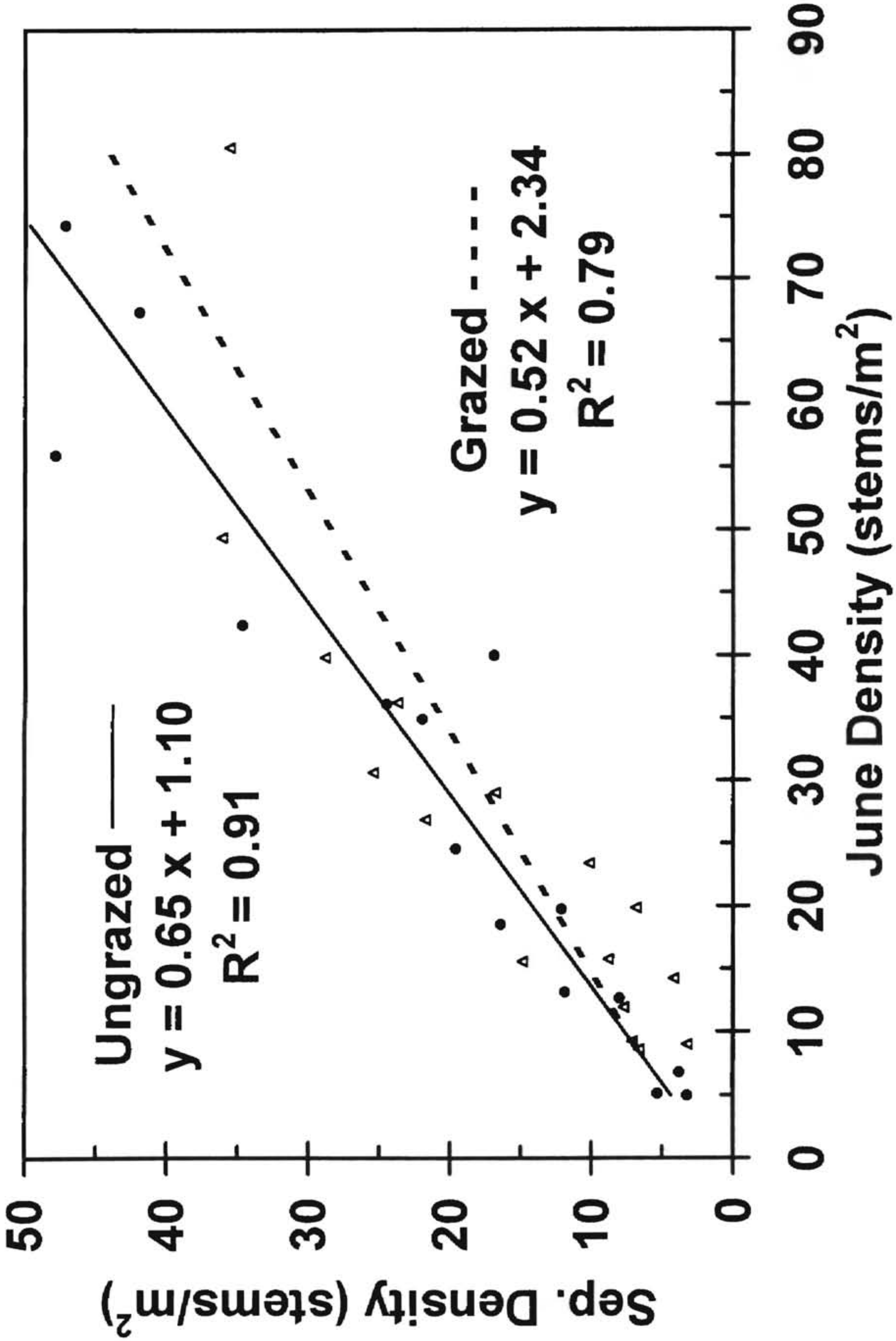

Precipitation (cm)
120
100
80
60
40
20
0
Mixed Prairie
Tallgrass Prairie
May-Aug
Sep-Apr
95
96
Avg.
95
96
Avg.
Year


Standing Crop (kg/ha)
5500
4500
3500
2500
1500
Ragweed (kg/ha)
0
100
200
300
400
500
600
700
Total
Grass

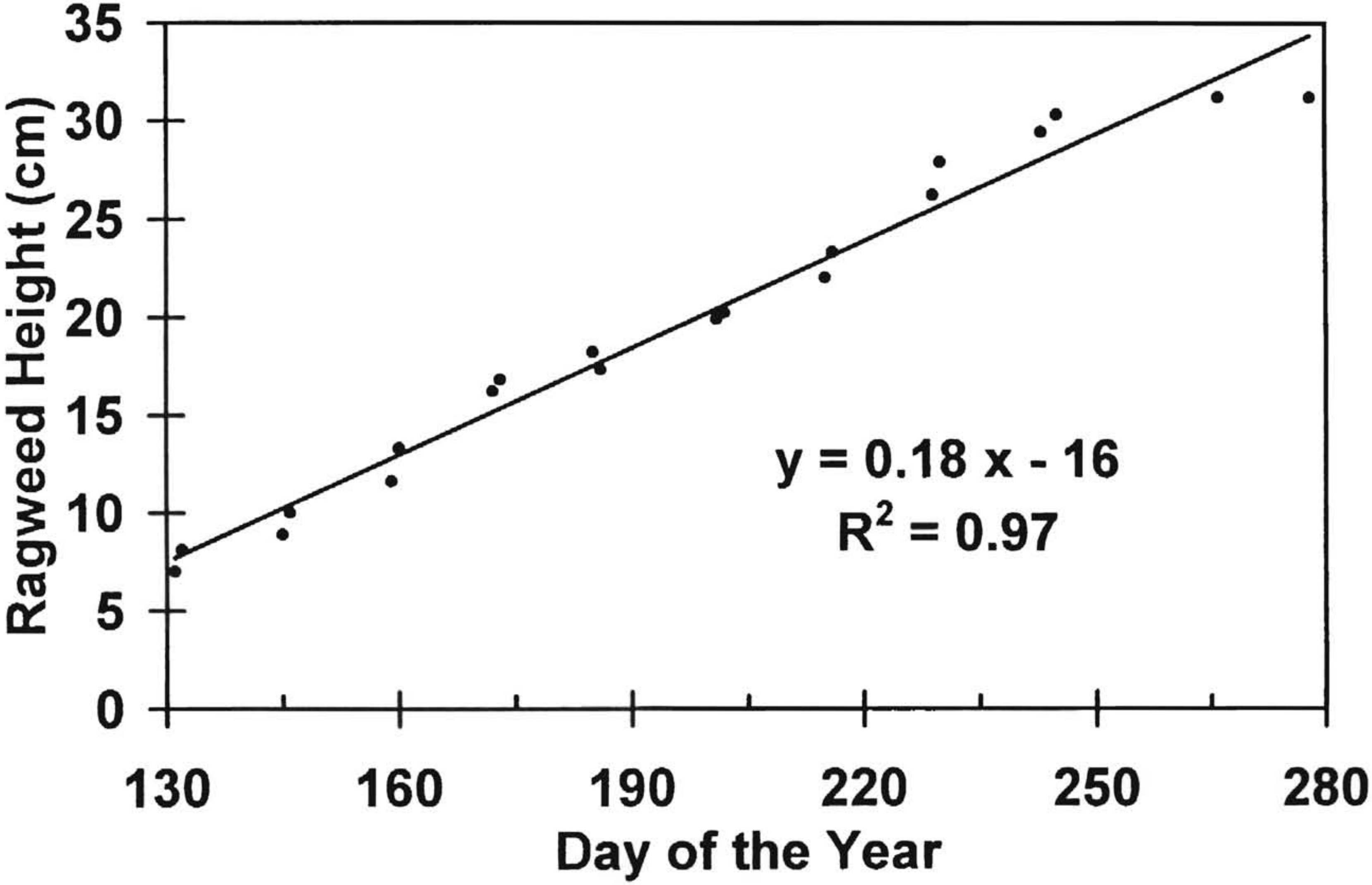

Standing Crop (kg/ha)
6000
5000
4000
3000
2000
1000
0
10
20
30
40
Ragweed (stems/m^2)
Total
Grass

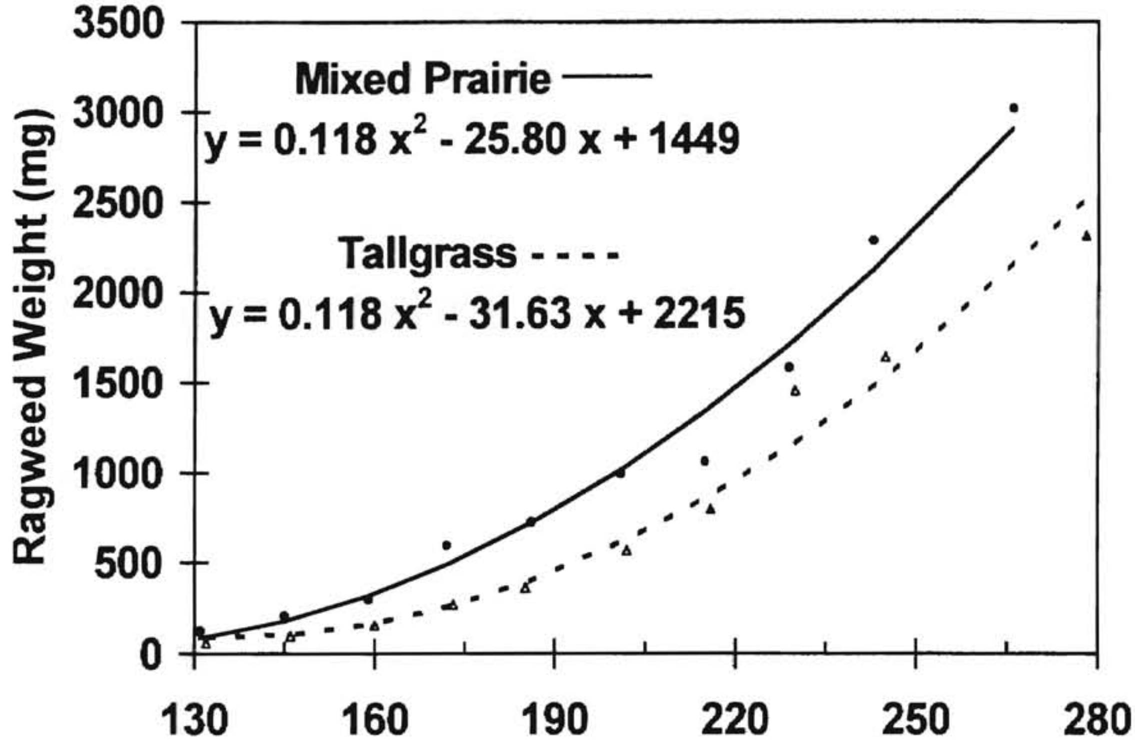

Standing Crop (kg/ha)
8000
7000
6000
5000
4000
3000
2000
Ragweed (kg/ha)
0
200
400
600
800
1000
1200
Grass
Total


Mixed Prairie ——
y = 13.91 x - 2
R2 = 0.75
Tallgrass - - - -
y = 7.66 x + 29
R2 = 0.85
Ragweed (kg/ha)
1200
1000
800
600
400
200
0
0
40
80
120
160
Ragweed (stems/m2)

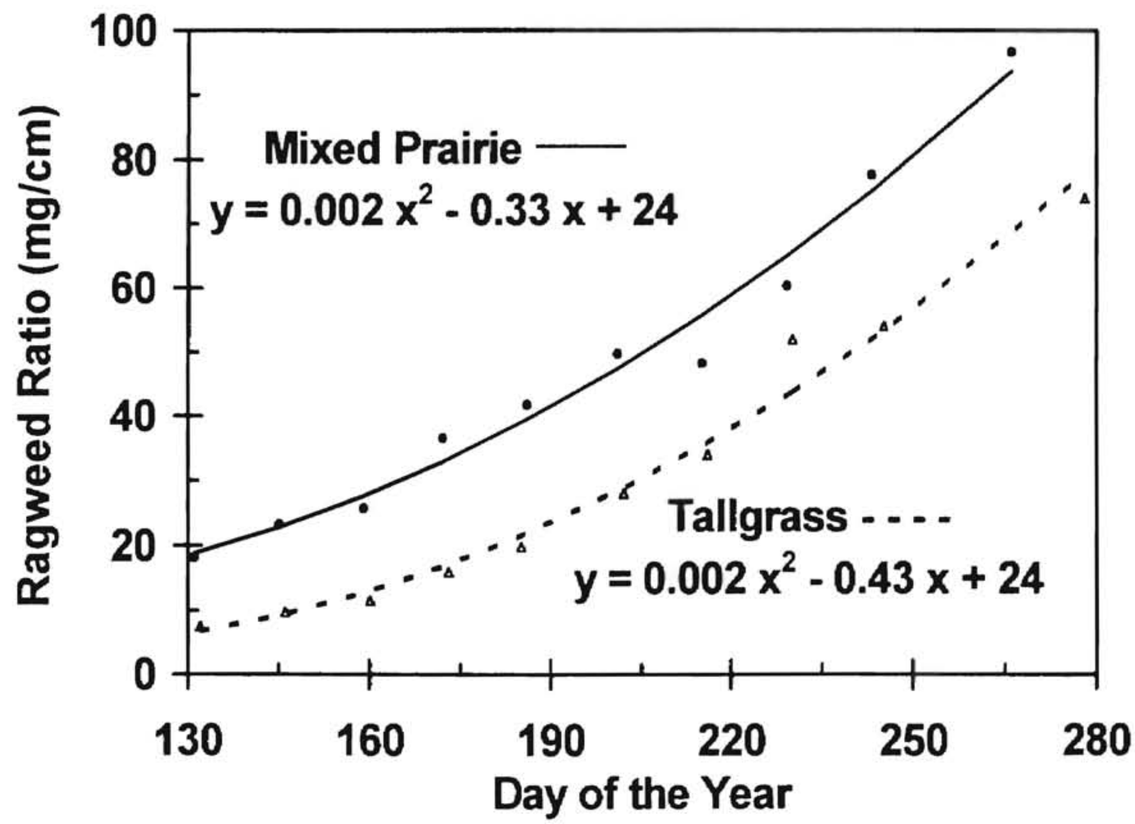


Ungrazed ——
y = 0.65 x + 1.10
R^2 = 0.91
Grazed - - - -
y = 0.52 x + 2.34
R^2 = 0.79
June Density (stems/m^2)
Sep. Density (stems/m^2)
0
10
20
30
40
50
60
70
80
90
0
10
20
30
40
50


35
30
25
20
15
10
5
0
Ragweed Height (cm)
130
160
190
220
250
280
Day of the Year
y = 0.18 x - 16
R2 = 0.97



3500
3000
2500
2000
1500
1000
500
0
Ragweed Weight (mg)
Mixed Prairie
y = 0.118 x^2 - 25.80 x + 1449
Tallgrass - - - -
y = 0.118 x^2 - 31.63 x + 2215
130
160
190
220
250
280



100
80
60
40
20
0
Ragweed Ratio (mg/cm)
Mixed Prairie
y = 0.002 x^2 - 0.33 x + 24
Tallgrass - - - -
y = 0.002 x^2 - 0.43 x + 24
130
160
190
220
250
280
Day of the Year

VITA

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