RESPONSE OF SOUTHERN MIXED GRASS PRAIRIE TO STOCKING RATE

By

JOHN ARTHUR ECKROAT

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Oklahoma State University

Stillwater, Oklahoma

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Thesis Approved:

Robert L. Gillen
Thesis Adviser

TJ Bidwell

David M. Engle

Thomas C. Collins
Dean of the Graduate College

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CHAPTER I

INTRODUCTION

Grazing management is the heart and soul of rangeland management. Restoration of depleted rangeland by reseeding is difficult if not impossible. Fertilization is usually impractical. Cultivation is often impossible. The primary productive capacity of rangeland lies in animal products produced by the efficient utilization of its only suitable crop, native vegetation. When income-producing livestock are the grazing animals, grazing management could be defined as the determination and use of a stocking rate and grazing system that renders the most economically advantageous conversion of forage to saleable product while maintaining the rangeland resource. Grazing management is also one vegetation manipulation factor that the manager can control.

The growth and disappearance of vegetation is continuous on most ecological sites and is sensitive to different stocking rates. In order to compare the effects of different stocking rates on herbage production and species composition, consideration must be given to several other factors that also affect production and composition during the grazing season. Herbage growth is greatly affected by the time, intensity, and duration of precipitation. Herbage disappearance may occur by grazing, trampling, defecation, decay, weather, or other causes (Scarnecchia and Kothmann 1985). The interaction of stocking rate with other variables should be considered before a conclusion is made. A change in vegetation may occur regardless of stocking rate, and as a result, this change may mask the effects of stocking rate.

Multiple steady states may exist within an ecological site (Westoby et al. 1989). A change in grazing management may not be all that is required to achieve a change in rangeland vegetation. If the vegetation on an ecological site is highly resistant to change, the manager may be disappointed by the slow vegetative response to changes in stocking rates. The ecological site may have low production capacity, poor grazing distribution qualities, or other inherent growth limitations that must be considered along with stocking rate.The ecological site may be in a high seral state in which the dominant plant species tend to buffer vegetative change (Gillen et al. 1990). To properly manage a mixed-grass rangeland, the manager must understand what causes changes in the vegetation under his control. This study offers the results of seven years of response data that the manager might consider in making stocking rate decisions on southern mixed-grass prairie.

The following chapter is a review of some 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 Managment*.

CHAPTER II

LITERATURE REVIEW

Many experiments have monitored vegetation response to grazing. These studies often measure forage production in response to different stocking rates, or address changes in species composition over time under different stocking rates. Stocking rate alone may or may not affect standing crop and species composition over time. Many variables are involved in the formation of an ecological site.

In a study of the effect of stocking rate on cattle gains and native shortgrass vegetation in west-central Kansas, the vegetation of the experimental pastures changed considerably during the experiment (Launchbaugh 1957). At the beginning of the study, the pastures were nearly identical in terms of composition and ground cover. The ground cover was approximately 80% in 1946 and was made up primarily of buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] which forms a dense sod. Blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.] was present in each pasture and made up 3 to 7% of the cover. Western wheatgrass (*Agropyron smithii* Rydb.), because of its tendency to produce scattered single stalks, did not have a high ground cover in

1946 (2 to 5%), but scattered islands of this grass contributed greatly to the total forage.

During the period of 1946 to 1949, buffalograss decreased in all pastures. The greatest decrease occurred in the lightly grazed pasture and the smallest in the heavily grazed pasture. Blue grama increased approximately 10% in all pastures during this period. Western wheatgrass increased under moderate and light grazing and decreased under heavy grazing by 1949.

During the period of 1950 to 1955, the cover of buffalograss decreased to 5% in the lightly grazed pasture, 10% in the moderately grazed pasture, and 32% in the heavily grazed pasture. Blue grama decreased slightly in all pastures; however, the greatest loss resulted from heavy grazing. Western wheatgrass nearly disappeared in the heavily grazed pasture and decreased to less than 2% in the moderately grazed pasture. There was a slight loss of western wheatgrass in the lightly grazed pasture.

The increase in blue grama and the great decrease in buffalograss on all pastures during the 11 year period was influenced more by weather than by grazing intensity. Grazing intensity had more effect on the degree of change than on the trend except in the case of western wheatgrass. The heavier intensities of grazing maintained a higher percentage of buffalograss, reduced the percentage of western wheatgrass, and had very little effect on the percentage of blue grama until the last year. The trend of cover change from buffalograss to western wheatgrass and blue grama is an indication of rangeland improvement. Forage production will be higher on western wheatgrass and blue grama pastures when compared to similar pastures where buffalograss is the dominant forage grass.

In a 10 year continuation of the above study, Launchbaugh (1967) reported that the average frequency of buffalograss was 35% at light stocking rates compared to 95% at heavy stocking rates. Blue grama decreased from 66 to 60% under the same circumstances. Japanese brome (*Bromus japonicus* Thunb. ex Murr.) decreased from 9% at light stocking to a trace at higher stocking rates. Red threeawn (*Aristida longiseta* Steud.) decreased from 3 to 0.1%. Purple threeawn (*Aristida purpurea* Nutt.) decreased from 0.9% to a trace as stocking rates increased. Sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], decreased from 0.4% to a trace. Western ragweed (*Ambrosia psilostachya* DC.) decreased from 7% to a trace as stocking rates increased. Total herbage production was greatest at light stocking rates.

In stocking rate studies conducted at Hays and Manhattan, Kansas, forage production decreased as stocking rate increased (Launchbaugh and Owensby 1978). Overstocking shortgrass rangeland near Hays, Kansas throughout the growing season for seven years reduced soil moisture intake on a clay upland site. The loss of productive capacity from overgrazing and decreased water penetration due to soil compaction interacted to change plant species composition and to reduce total forage production. The most efficient and economical stocking rate was one that left 40 to 60% of the current years forage ungrazed at the end of the growing season. Forage production was inversely related to stocking rate. Low and moderate stocking rates maintained desirable plant communities.

In a southern mixed-grass study, Heitschmidt et al. (1989) found that standing crop in heavy continuously grazed pastures was dominated by warm-season shortgrasses and Texas wintergrass (*Stipa leucotricha* Trin. & Rupr.). Moderately grazed pastures were dominated by Texas wintergrass. Above-ground standing crop dynamics were similar in both treatments. The quantity of available forage was greater in the moderately grazed pastures but the quality of the forage was generally greater in the heavily grazed pastures.

Brown and Schuster (1969) studied the vegetation and soil characteristics of an ungrazed butte compared with those of an adjacent high plains area open to grazing. Both study areas are located 97 km southeast of Lubbock, Texas. The study was limited to shallow hardland sites.

There was considerable difference in the vegetation between the ungrazed butte and the grazed area, both in quantity of forage produced and species present. The ungrazed butte supported 14 woody plant species compared with only 8 species on the grazed area. Redberry juniper (*Juniperus pinchoti* Sudw.) was the dominant species on the butte, but other plants such as shinnery oak (*Quercus havardii* Rydb.), narrowleaf yucca (*Yucca angustifolia* Trel.), mesquite (*Prosopis glandulosa* Torr.), and skeleton goldeneye (*Viguiera stenoloba* Blake.) added considerable cover. Mesquite dominated the grazed area. Total woody plant cover was twice as high on the butte as on the grazed area.

The absence of several palatable species such as skeleton goldeneye, vine ephedra (*Ephedra antisyphlitica* Berland. ex C. A. Meyer), and elbowbush (*Forestiera pubescens* Nutt.) are explainable by grazing pressure. The presence of shinnery oak, feather dalea (*Dalea formosa* Torr.), and narrowleaf yucca on the ungrazed butte and not on the grazed area is not explainable by stocking rate. Stocking rate is apparently not the only factor determining the species composition of a specific area.

The butte produced 710 kg/ha more oven dry herbage than the grazed area. Sideoats grama, rough tridens (*Tridens elongatus* Buckl.), and blue grama were the most productive species on the butte producing 70% of the herbage. Of these species, only blue grama occurred on the grazed area.

Buffalograss was the most productive species on the grazed area making up 65% of the herbage production. Tobosa [*Hilaria mutica* (Buckl.) Benth.] and vine mesquite (*Panicum obtusum* H.B.K.) were the next most productive species. These 3 species contributed 85% of the total herbage on the grazed area.

Low stocking rates did not greatly influence the relative amount of blue grama on sandhill rangeland of eastern Colorado (Sims et al. 1976). Light grazing, however, resulted in a general decrease in the proportion of prairie sandreed [*Calamovilfia longifolia* (Hook.) Scribn.], from 34 to 23% and a corresponding increase in needle-and-thread (*Stipa comata* Trin. & Rupr.) from 9 to 26%. Light grazing did not appreciably influence other grasses or forbs.

Moderate stocking rates resulted in a general increase in blue grama from 36 to 70% of the total production by the tenth year. Over the same period of time, prairie sandreed declined from 35 to 14%. Moderate stocking rates did not cause significant production changes in needle-and-thread or the miscellaneous grass category. Forbs declined under moderate grazing intensity but fluctuated with precipitation.

High stocking rates caused marked changes in the relative percentages of the key species in the sandhills of eastern Colorado. Blue grama almost doubled in percent contribution to the total production. Prairie sandreed declined from 34% at the beginning of the study to only 5% of the total production in the last year of data collection. A similar trend was exhibited by needle-and-thread, which declined from 12 to 1%. Forbs remained somewhat static in the heavily grazed pastures.

The time of heavy grazing was deemed the most important factor in bringing about key responses on shortgrass range (Hyder et al. 1975). Repeated heavy grazing from April through September created about 3 times as many key responses as repeated heavy grazing in the months when plant growth was dorrmant. Blue grama increased with repeated grazing in April or June but decreased when grazed in February. July grazing was marginal for increase and August and September were marginal for decrease. Blue grama, the dominant forage in shortgrass plains, decreased with low precipitation and increased with high precipitation.

Brand and Goetz (1986) studied the vegetation in 4 livestock exclosures in the mixed-grass prairie of southwestern North Dakota. Species composition was a more reliable indicator than growth form dominance for understanding the successional status of a plant community and the potential for vegetative change. The most consistent results were the lower production of blue grama and greater production of sedges (*Carex spp.)* on the ungrazed plots. Site characteristics apparently limited the development of the potential vegetation with the exclusion of grazing. Site potential should be evaluated before assuming that a reduction in grazing pressure will increase the dominance of the midgrass and tallgrass total yield.

Gillen et al. (1990) studied plant community responses to short duration grazing in tallgrass prairie. They concluded grazing schedule and stocking rate had little effect on the high seral tallgrass prairie plant community observed in this study. Three reasons were given as to why there was no real effect on the plant community. First, precipitation was well above average in 4 out of 5 years of the study. Second, spring burning was applied in the year before treatment initiation and in the first 4 years of treatment application. Finally, the plant community was in a high seral state initially and there was little potential for any upward trend, and the vigor of the dominant species would tend to buffer any downward trend. The authors suggested a return to average or below average precipitation levels might eventually trigger different vegetation changes.

Climate may be the major factor controlling plant growth in the Great Plains. Olson et al. (1985) reported that each species reacted to precipitation regimes and grazing treatments in a distinctive manner. They concluded that a species may respond differently to precipitation under different stocking rates. When precipitation regimes change substantially, the dominance of certain species may change.

Van Poolen and Lacey (1979) reported that mean average herbage production increased 13% when grazing systems were implemented. However, increases were larger (35% and 27%) when stocking rates were reduced from heavy to moderate and from moderate to light respectively.

Conclusion

Stocking rate directly affected the rate of change in Great Plains grasslands in both forage production and species composition. Low to moderate stocking rates or the absence of grazing may cause succession to culminate in a plant community with a relatively stable composition (Laycock 1991).

Climatic conditions and site potential affect the rate of change on ecological sites and can overshadow the effects of stocking rate on vegetation in the short term. Total precipitation during the growing season may have been the most influential factor on standing crop and species composition in these studies. Good growing season moisture increased plant vigor and forage production and tended to buffer stocking rate influences on vegetation.

CHAPTER III

RESPONSE OF SOUTHERN MIXED-GRASS PRAIRIE TO STOCKING RATE

Abstract

This study quantified the response of standing crop dynamics of herbage and species composition of the plant community to stocking rates on southern mixed-grass prairie in western Oklahoma. Long term average precipitation is 770 mm per year. Growing conditions were generally favorable for the study period. Yearling cattle grazed at 6 stocking rates ranging from 23 to 51 AUD/ha from April 15th to September 15th. The currently suggested year-long stocking rate is 30 AUD/ha. Herbage standing crop was measured in July and September every year. Species composition was determined in July of 1990 and 1996. Sideoats grama [*Bouteloua curtipendula* (Mich.) Torr.] averaged 20% of the herbage standing crop and had a positive correlation with stocking rate. This relationship, however, was present at the initiation of the study in 1990 and remained unaltered by the 7th year of the trial because there was no interaction between

stocking rate and year. Shortgrasses, buffalograss [*Buchloe dactyloides* (Nutt.) Engelm.] and blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.]), averaged 25% of the standing crop and had a significant negative relationship with stocking rate. Tallgrasses increased as stocking rate decreased but averaged only 3% of the total composition by 1996. Red threeawn (*Aristida longiseta* Steud.) and purple threeawn (*Aristida purpurea* Nutt.) increased in percentage composition (5.2 to 13%) when averaged over all stocking rates over the term of the study. Threeawns had a greater increase in percent composition at the lower stocking rates over time. Forbs were prominent, contributing 20-25% of the standing crop, but were not consistently affected by stocking rate or year. These mixed-grass rangelands showed little response to stocking rate over 7 years.

Introduction

The understanding of vegetation dynamics under different stocking rates is crucial to the management of rangelands. There are many interactions of variables involved in the formation and stability of a plant community. The rangeland manager must have good ecological site information to ensure soundness of management decisions.

Mixed-grass vegetation in west-central Kansas changed considerably with stocking rate in experimental pastures studied by Launchbaugh (1957). Stocking rate did affect species composition to some degree, but the increase in blue grama [*Bouteloua gracilis* (H.B.K.) Lag. ex Steud.] on all pastures during the 11 years was influenced more by weather than by stocking rate.

Dramatic vegetation changes occurred as stocking rate increased in the sandhills of eastern Colorado (Sims et al. 1976). Percent composition of blue grama increased over all stocking rates but increased more at the high stocking rate. By the end of the study, there was very little difference in blue grama production between moderate and high stocking rates.

Brown and Schuster (1969) reported a significant difference in vegetation when an ungrazed butte was compared to a grazed high plains area southeast of Lubbock, Texas. Total woody plant cover was twice as high on the butte than on the grazed area. The butte produced 710 kg/ha more herbage than the grazed area.

The specific objective of this study was to measure the effect of cattle stocking rate on standing crop and species composition on a southern mixed grass prairie.

Materials and Methods

Study Area

The study area is located 15 km southwest of Clinton, Oklahoma on the Marvin Klemme Range Research Station (35^{0} 50' N, 99^{0} 8' W). The Klemme Station is operated by the Oklahoma Agricultural Experiment Station. The area consists of approximately 630 ha of upland rangeland, typical of the Rolling Red Plains Resource Area of west-central and southwest Oklahoma. The elevation is 490 meters (Gillen 1992).

The nearest reporting station for long-term climatological data (1961-1990) is located at Clinton, Oklahoma (35^0 22' N, 99^0 04' W). The average annual precipitation is 770 mm, ranging from 510 to 817 mm. The average precipitation from April through September is 523 mm or 69% of the annual precipitation. The average frost-free growing period is 206 days from April to October but can range from 184 to 228 days. The average mean temperature is 16.1^0 C. The coldest month is January with a mean temperature of 8.9^0 C. The hottest month is July with an average temperature of 28.4^0 C.

The predominant soil (95% of the land area) mapped on the Klemme Station is Cordell silty clay loam. Cordell soils are 0 to 43 cm in depth. Rocky outcrops, which are hard red siltstone, make up 0-25% of each mapping unit. The main plant growth limitations of Cordell soils are shallowness, low available water holding capacity, and moderately slow permeability.

The Cordell series is classified as a red shale ecological site. This site supports mixed-grass prairie as the potential natural vegetation with an annual forage production capability of 1,010 to 1,120 kg/ha. The major plant species include sideoats grama, blue grama, hairy grama (*Bouteloua hirsuta* Lag.), buffalograss [*Buchloe dactyloides* (Nutt.) Englem.], silver bluestem, red threeawn (*Aristida longiseta* Steud.), purple threeawn (*Aristida purpurea* Nutt.), little bluestem [*Schizachyrium scoparium* (Michx.) Nash], and sand bluestem (*Andropogon halli* Hack.) Major forbs include western ragweed (*Ambrosia psilostachya* DC.), and curlycup gumweed [*Grindelia squarrosa* (Pursh) Dun.]. Scattered populations of the half-shrub broom snakeweed [*Gutierrezia sarothrae* (Pursh) Britt. & Rusby] were also present.

Approximately 30% of the Klemme Station was cultivated at one time. Most of these old fields were reseeded to mixtures of native grasses in the late 1960's. Approximately 33% of the fields revegetated naturally. Old fields range in size from 3 to 27 ha and are scattered across all portions of the station.

Methods

Six pastures averaging 65 ha in size were selected for comparison in this study. Stocking rates of 23, 26, 34, 41, 48, or 51 AUD/ha were randomly allocated to the pastures.

Cattle were allocated to pastures with the goal of equalizing average weight per head across pastures. The cattle were typical crossbred yearlings weighing approximately 216 to 240 kg. The cattle were received, conditioned, and turned out to graze the pastures around April 15. The cattle were gathered and weighed July 20 and again on September 24 when they were removed from the pastures.

Herbage standing crop was measured on July 20 and September 24. Fifty plots were clipped to determine total standing crop in each pasture. The 0.1 m^2

plots were systematically located along pace transects that sampled the entire pasture.

Species composition was determined in 1990 and 1996, the first and last years of the study. Species composition was measured in mid July using the dry-weight rank method (Gillen and Smith 1985) with 100 plots per pasture. The 0.1 m^2 plots were systematically distributed across the pastures on paced transects. The species groups were: sideoats grama, shortgrasses (buffalograss, blue grama, and hairy grama), tallgrasses (little bluestem and sand bluestem), threeawns (red threeawn and purple threeawn), silver bluestem, other perennial grasses , annual grasses which was primarily Japanese brome (*Bromus japonicus* Thunb. ex Murr.), forbs and broom snakeweed.

Analysis

Standing crop and species composition data were analyzed using indicator regression. The dependent variables were standing crop and percent species composition of 9 categories of vegetation. The independent variables were stocking rate and year. Stocking rate was expressed as animal unit days per unit land area. The qualitative variable year was coded as 0 or 1 (Neter and Wasserman 1974). The initial regression model contained terms for stocking rate (linear), year, and the interaction of stocking rate and year. Non-significant variables were dropped from the model until all remaining variables were significant (P = 0.10). This allowed us to determine if standing crop or species composition had changed over years in response to stocking rate.

Results and Discussion

Precipitation

The long-term average precipitation for the Klemme Station from April through September is 523 mm. The average April through September precipitation during this study was 587 mm (Table 1). The Klemme Station averaged 64 mm more precipitation during the growing season than the long term average, however, 4 of the 7 years were below average. Growing conditions were favorable during the study period.

The average long term annual precipitation is 770 mm. The average annual precipitation during the study was approximately the same as the long term.

Standing Crop

Standing crop and stocking rate had an inverse relationship as would be expected because of greater total forage demand at higher stocking rates. Standing crop decreased about 17.5 kg/ha for every AUD/ha increase in stocking rate. (Fig. 1). No interaction between stocking rate and year was found. This indicates that there was no change in the relationship between standing crop and stocking rate over time. No change in plant vigor and forage production capacity was observed at any stocking rate over the term of the study.

Standing crop fluctuated on a yearly basis (Fig. 2). This effect was probably due to precipitation during the growing season and agrees with the results of Heitschmidt et al. (1985) in which abundant May rainfall increased standing crop over all stocking rate treatments. Sims et al.(1976) concluded that stocking rate affected standing crop in the short term but weather was probably more of an influence over time than stocking rate.

Standing crop was similar in July and September (Fig. 1). This relationship remained relatively constant over the study. Standing crop was approximately 2,400 kg/ha at the beginning of every grazing season. July standing crop ranged from 1,450 kg/ha to 2,510 kg/ha. September standing crop ranged from 1,090 kg/ha to 2,380 kg/ha.

Species Composition

Sideoats grama was the most abundant single species, comprising approximately 20% of the herbage. Sideoats grama increased as stocking rate increased. This positive relationship with stocking rate was present in 1990 at the initiation of the study and remained for the 7 years (Fig.3). This fact is unusual in that sideoats grama is usually considered a decreaser in mixed-grass prairies. Sideoats grama is specifically listed as a decreaser in the evaluation guide for a Red Shale ecological site (USDA - SCS 1960). Good growing conditions (precipitation) may have been the reason sideoats grama did not decrease in this study.

The shortgrasses were prominent in all pastures making up approximately 25% of the vegetation. Shortgrasses decreased as stocking rate increased during the grazing period (Fig. 4). As a result of no interaction between stocking rate and year, shortgrasses did not change in percent composition over the 7 years and remained relatively stable. Launchbaugh (1967) reported that an increase in blue grama and great decrease in buffalograss on all pastures in an 11 year study in western Kansas was due more to weather than to stocking rate. Stocking rate was important and did affect shortgrass vegetation in the Launchbaugh study but the magnitude of its affect was overshadowed somewhat by good weather conditions.

In 1990, tallgrasses remained constant over all stocking rates comprising about 2% of the vegetation. Between 1990 and 1996 tallgrasses increased at lower stocking rates but decreased at higher rates (Fig. 5). Tallgrasses comprised only 3% of the total vegetation in 1996. The pastures were probably in the process of recovering from years of continuous heavy grazing which accounts for the small percentage of tallgrasses. From 1990 through 1996 the tallgrasses began to increase as the stocking rates were reduced from previous years.

Silver bluestem increased as stocking rate increased (Fig. 6). Like sideoats grama, this relationship was present at the beginning of the study.

There was no relationship between year and no interaction between year and stocking rate. Silver bluestem percent composition remained unchanged over the 7 years of the study. This agrees with the report of Heitschmidt et al. (1989) in which the percent composition of silver bluestem did not change with stocking rate in mixed-grass prairie.

Threeawns increased from 5% in 1990 to 13% in 1996 when averaged over all stocking rates, however, threeawns responded to stocking rate by increasing more at lower stocking rates than at higher stocking rates over years (Fig. 7). This agrees with a Central Great Plains study in which threeawns increased under light stocking rates (Klipple and Costello 1960). Hyder et al. (1975) reported that threeawn increase in a pasture coincides with favorable weather, which relates to favorable conditions for reproduction.

Other grasses were about 10% of the vegetation. Sand dropseed [*Sporobolus cryptandrus* (Torr.) Gray], and tall dropseed [*Sporobolus asper* (Michx.) Kunth] were the major other grasses. There were no reactions to stocking rate or year, and no interaction between stocking rate and year (Fig. 8). Species composition percentages for the other grasses remained stable during the study and were not influenced by stocking rate.

The annual grass category was primarily Japanese brome. Japanese brome fluctuates greatly over years (Launchbaugh and Owensby 1978). The annual grasses were not affected by stocking rate but reacted to year, declining from 2.8% to less than 0.1% during the study.

Forbs were prominent in this study making up 20 to 24% of the herbage. Forbs were not affected by stocking rate or year (Fig. 9). This supports Sims et al. (1976) who reported no consistent difference in forb production due to stocking rates. Launchbaugh and Owensby (1978) found that forbs increased as stocking rate decreased. For a better understanding of the forb relationship with stocking rate, individual species within this group should be studied by themselves because different forbs may react differently to stocking rate.

The half-shrub broom snakeweed was not affected by stocking rate (Fig. 10). Broom snakeweed increased from 4% in 1990 to 5% in 1996. This agrees with Klipple and Costello (1960), who reported that broom snakeweed was not affected by stocking rate and was cyclic in nature and may increase or decrease in percent composition for no apparent reason.

Conclusions

Standing crop was not reduced under the conditions of this study at the end of the 7 years. Within years, standing crop decreased with an increase in stocking rate during the grazing period as would be expected. NRCS guidelines report that a Red Shale ecological site will produce 1120 kg/ha forage during favorable years and 560 kg/ha during unfavorable years (USDA -SCS 1960). The forage demand of this study ranged from 270 to 600 kg/ha for 23 and 51 AUD/ha stocking rates respectively. The average forage demand was 440 kg/ha. The average standing crop measured in September was 1870 kg/ha. Forage demand and September standing crop equal 2310 kg/ha forage production with no consideration for other losses by trampling, senesence, weather, or other means. This indicates that the NRCS estimate of forage production may be in error by at least 50%.

There were also notable discrepancies between published ecological site guides and the results of this experiment in terms of plant species reactions to grazing. The NRCS range condition guide denotes sideoats grama as a decreaser in a Red Shale ecological site (USDA - SCS 1960). Sideoats grama percent composition remained steady in this study. The site guide classifies threeawns as increasers for this ecological site. Threeawns decreased at higher stocking rates during this study. The site guide classifies silver bluestem as an increaser on a Red Shale ecological site. In this research, silver bluestem remained unchanged.

Although there were statistically significant changes in species composition over the term of this study the pastures were, for all practical purposes, unchanged at the end of the study.

Southern mixed-grass prairies are slow to change. This statement must be qualified by stating that this study had good growing conditions during the 7 years. The growing season precipitation was 12% more than the long term mean.

The maximum net returns from cattle operations were realized at a stocking rate of 44 AUD/ha (Gillen 1992). This stocking rate would not result in major changes in the plant community under the conditions of this study.

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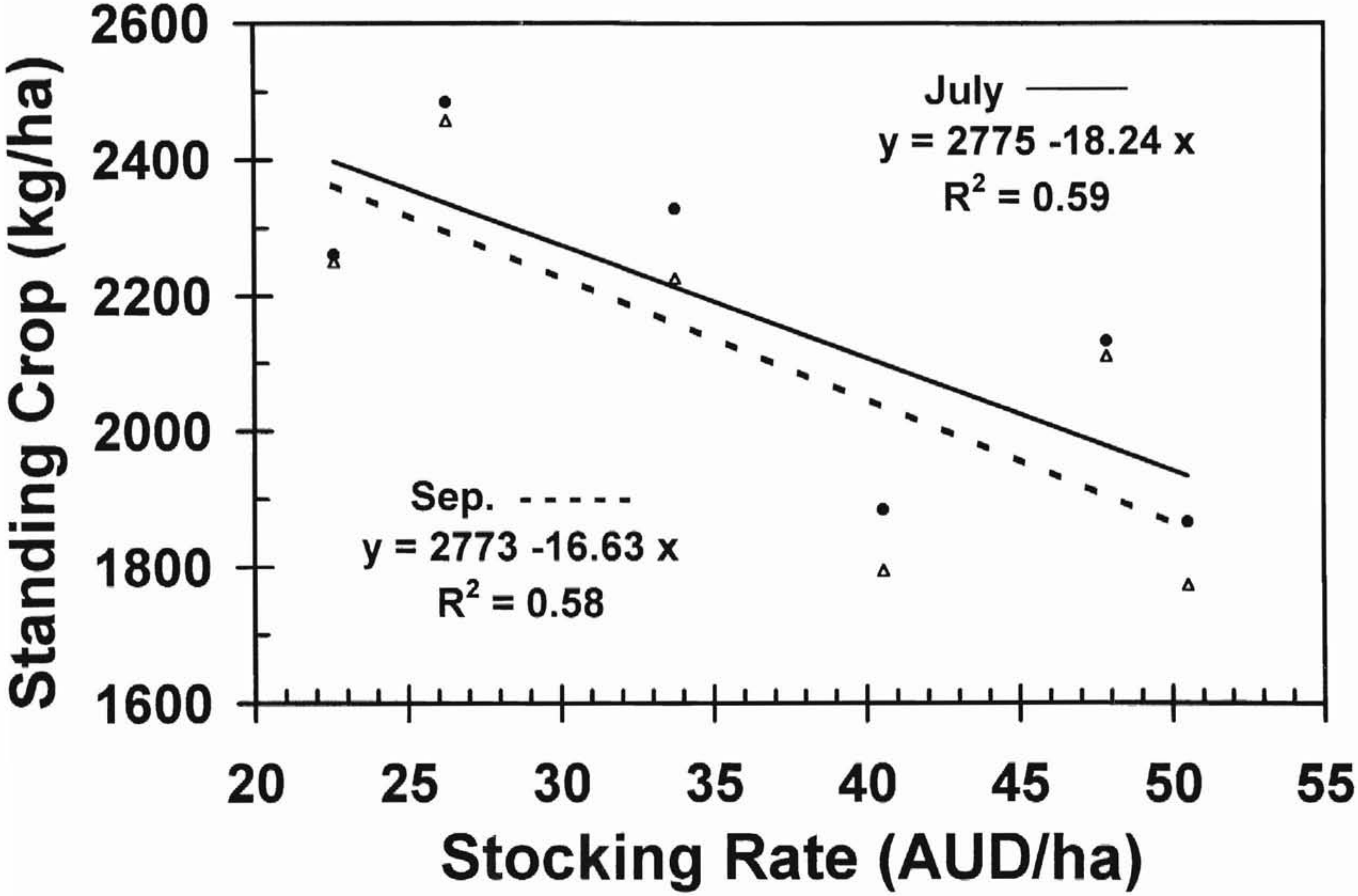
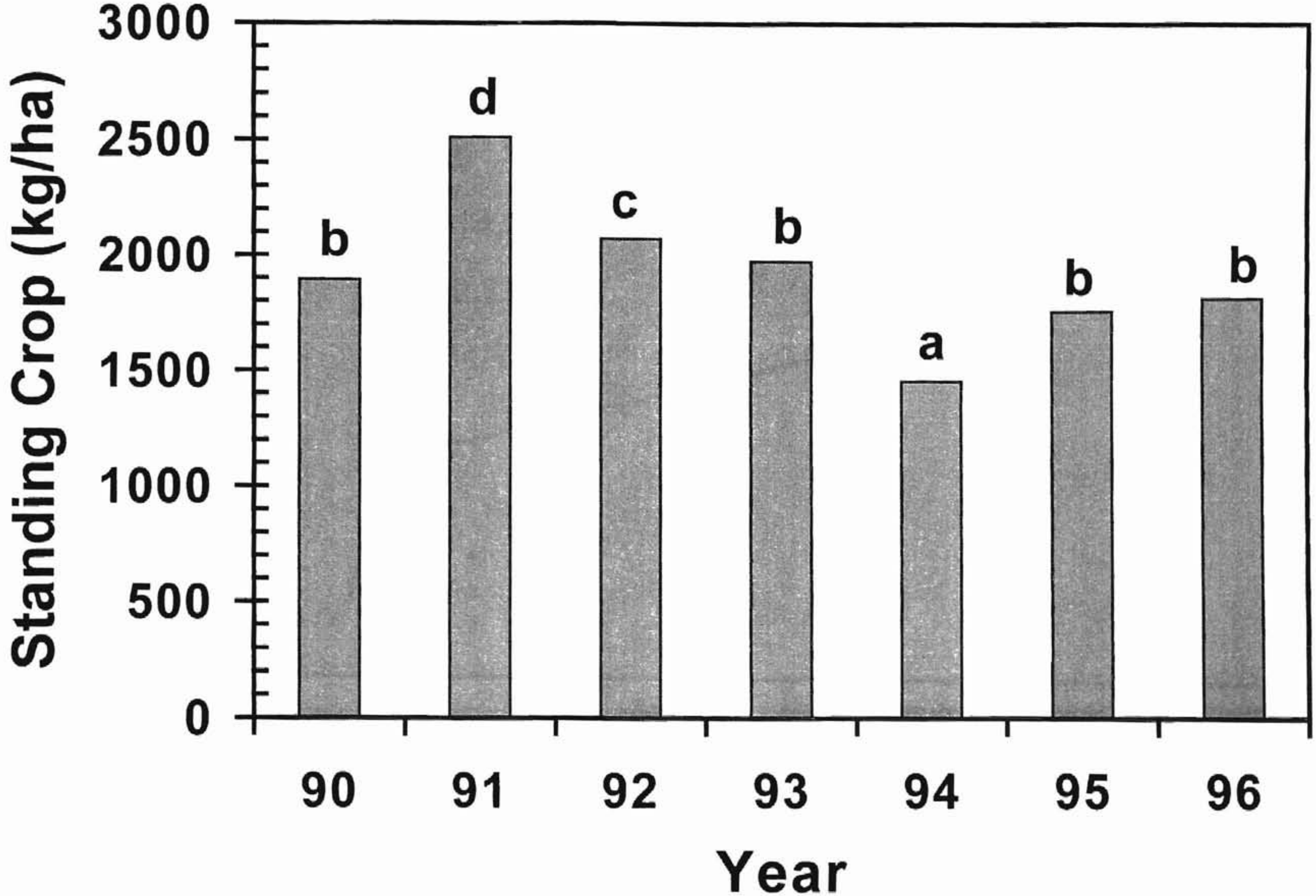
APPENDICES

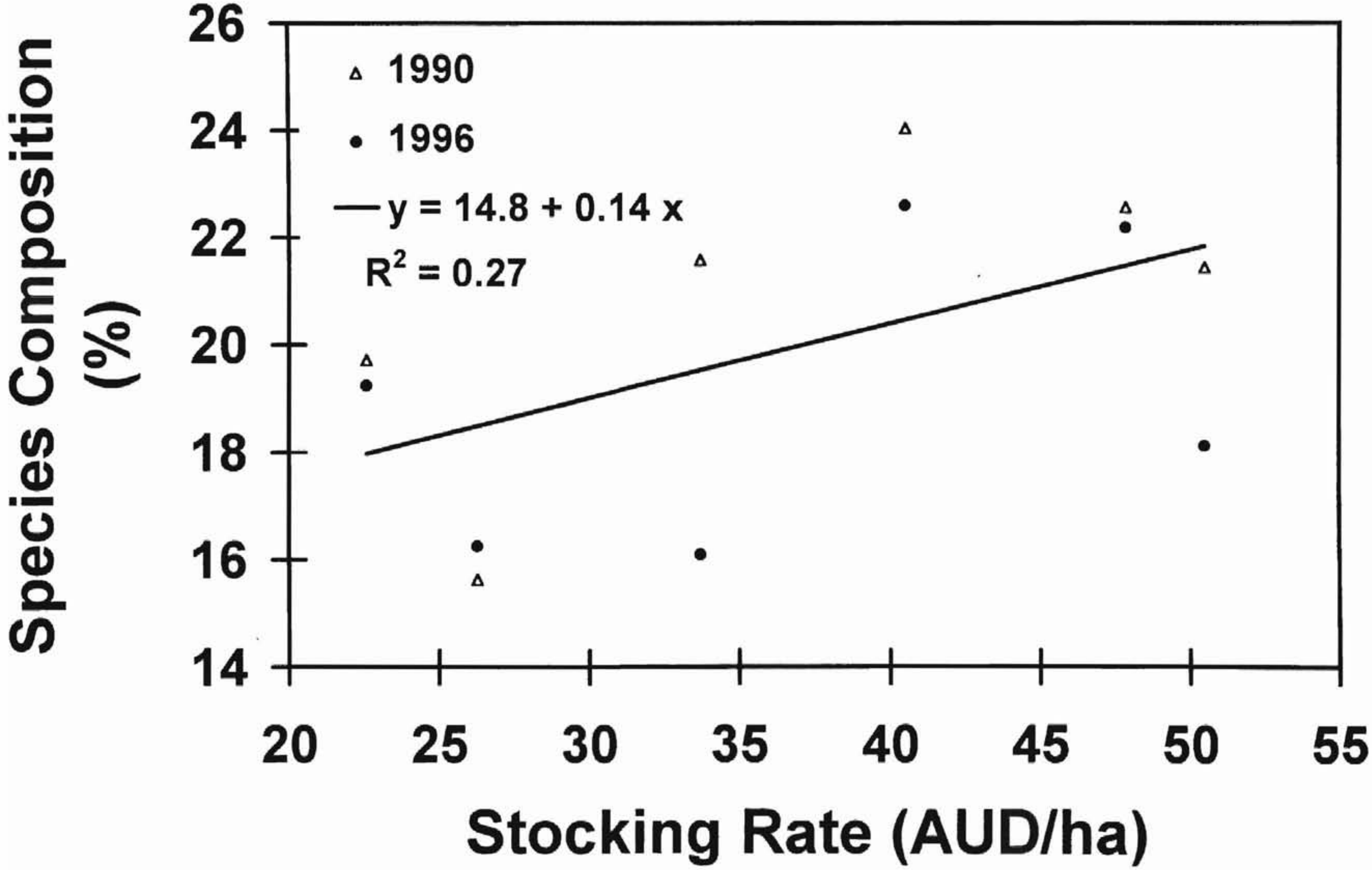
APPENDIX A
TABLES

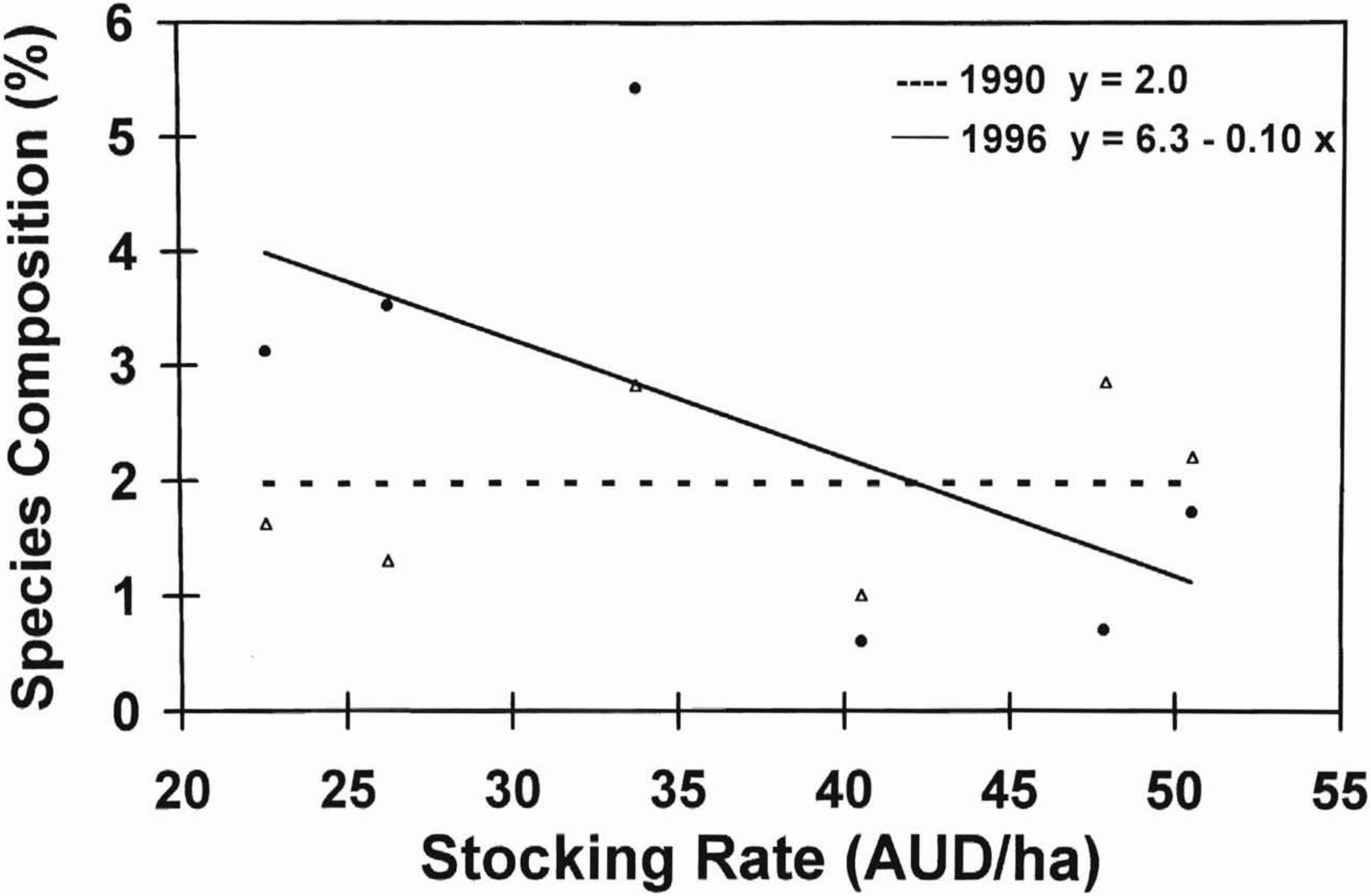
Year	Precipitation	
	Annual	Apr. - Sep.
	------------------------- (mm)	-------------------------
1990	541	514
1991	701	535
1992	851	509
1993	692	495
1994	512	361
1995	1250	919
1996	842	780
Study Avg.	770	587
Long-term Avg.	770	523

APPENDIX B
FIGURES

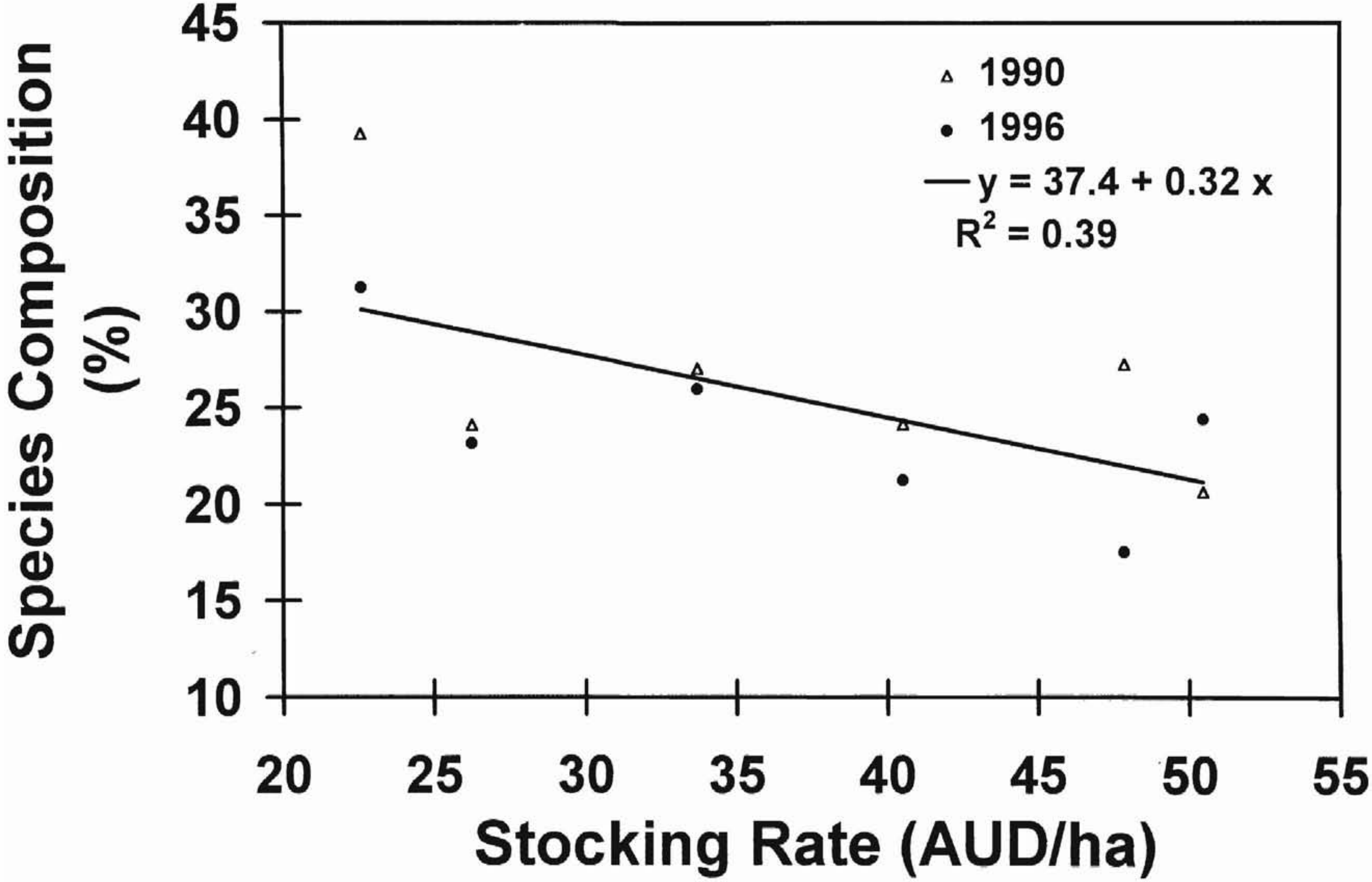

July
y = 2775 -18.24 x
R² = 0.59
Sep.
y = 2773 -16.63 x
R² = 0.58
Standing Crop (kg/ha)
Stocking Rate (AUD/ha)
2600
2400
2200
2000
1800
1600
20
25
30
35
40
45
50
55

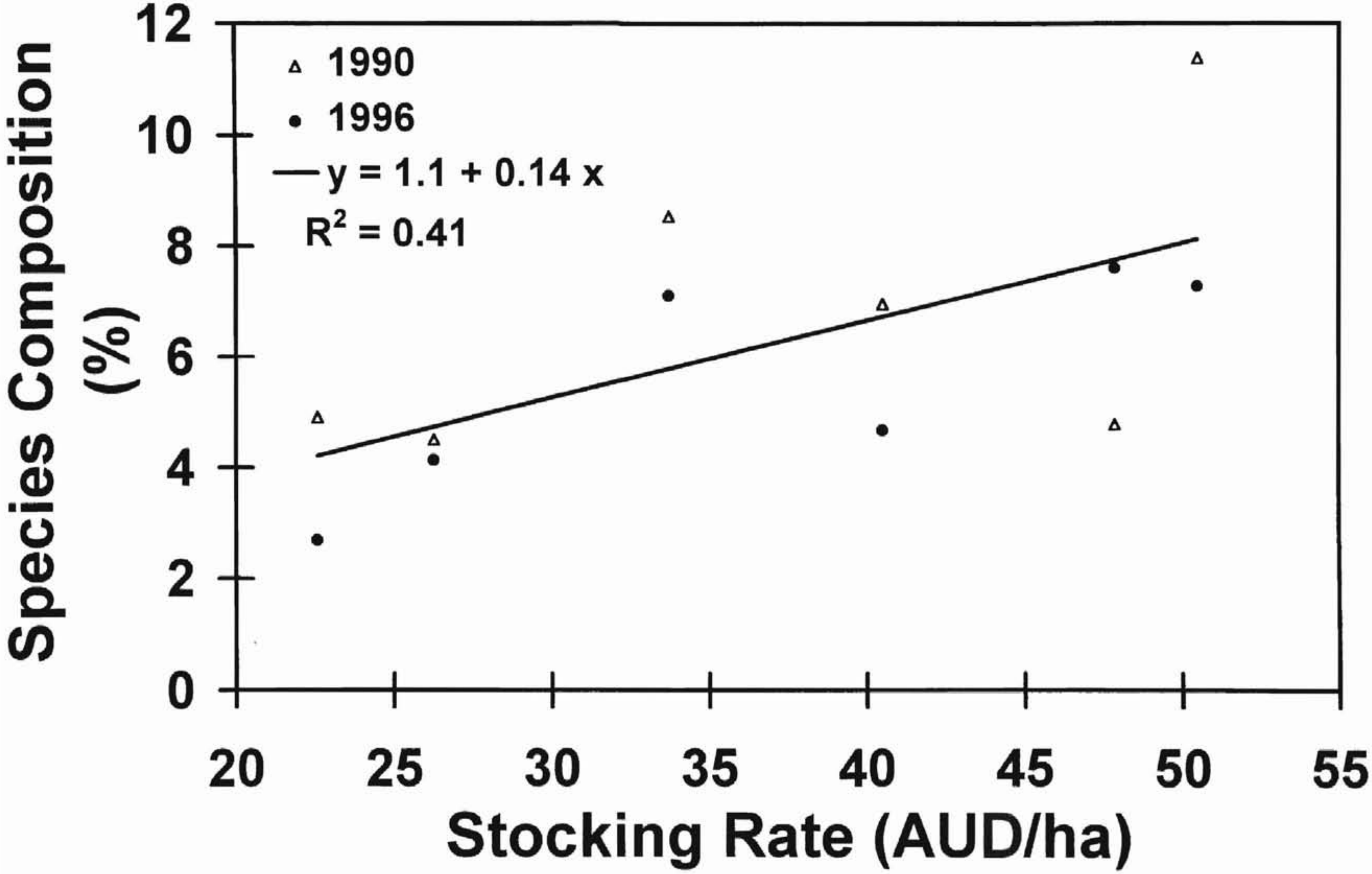

3000
2500
2000
1500
1000
500
0
Standing Crop (kg/ha)
b
d
c
b
a
b
b
90
91
92
93
94
95
96
Year

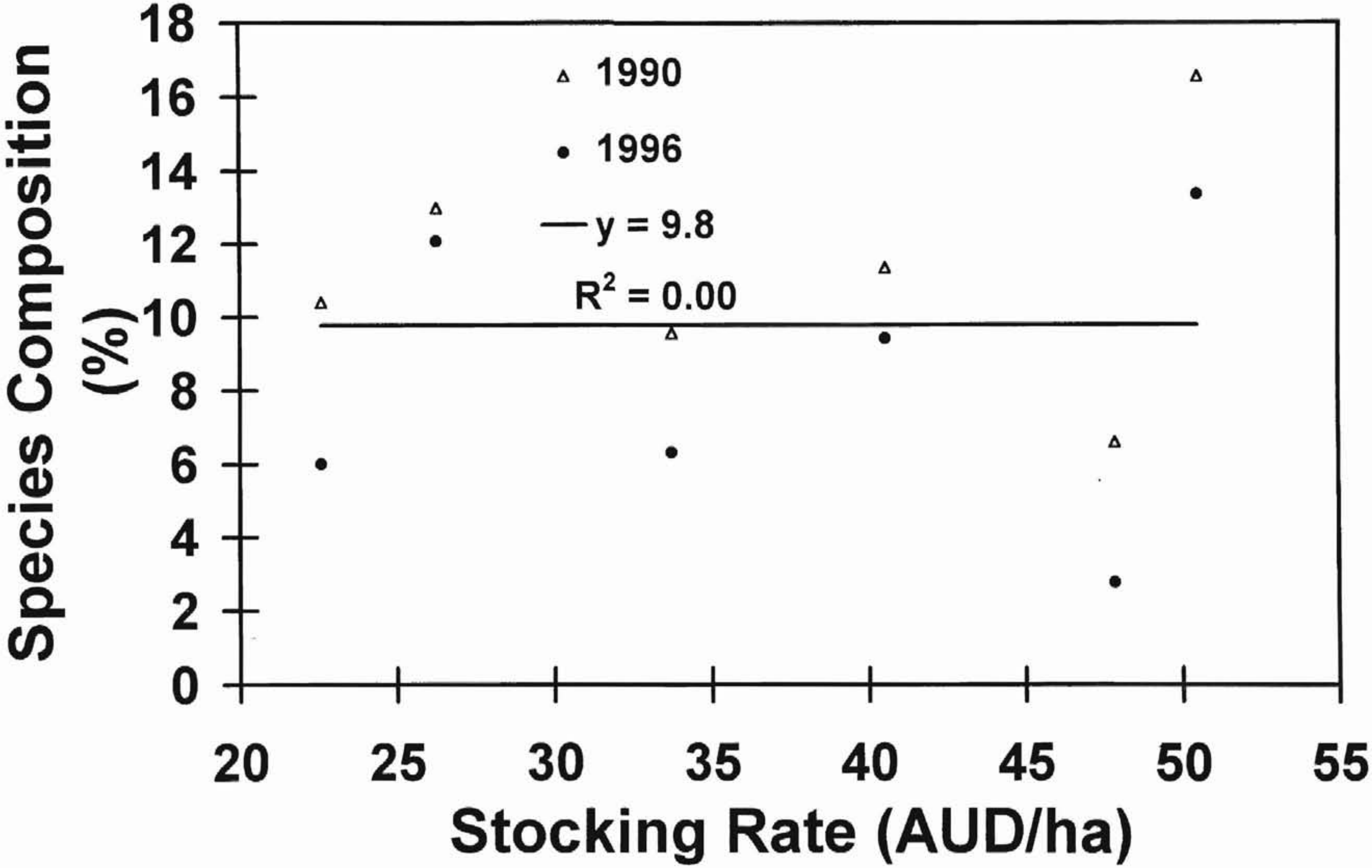

Species Composition (%)
26
24
22
20
18
16
14
1990
1996
y = 14.8 + 0.14 x
R2 = 0.27
20
25
30
35
40
45
50
55
Stocking Rate (AUD/ha)



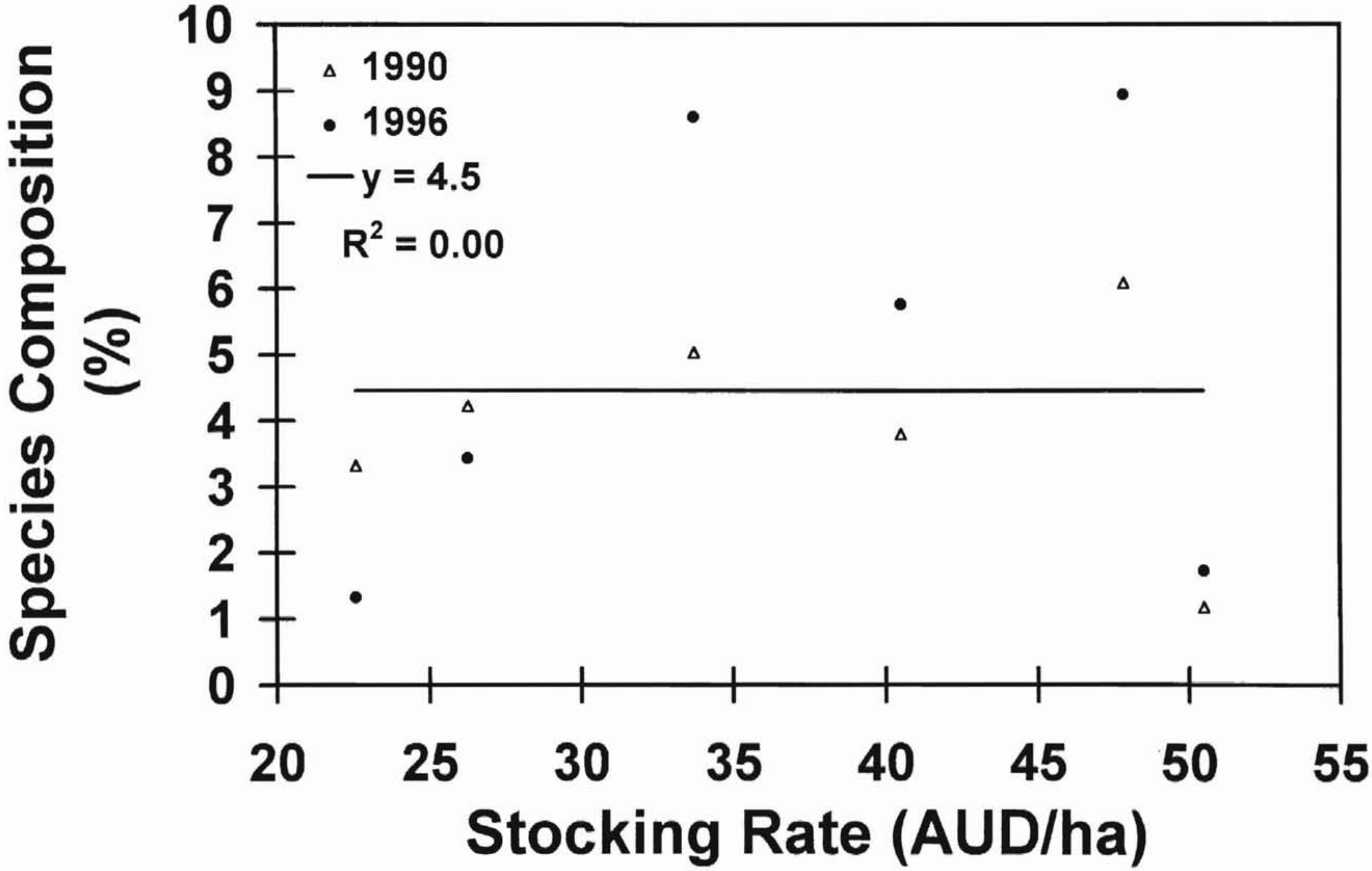
---- 1990 y = 2.0
1996 y = 6.3 - 0.10 x
Species Composition (%)
0
1
2
3
4
5
6
20
25
30
35
40
45
50
55
Stocking Rate (AUD/ha)

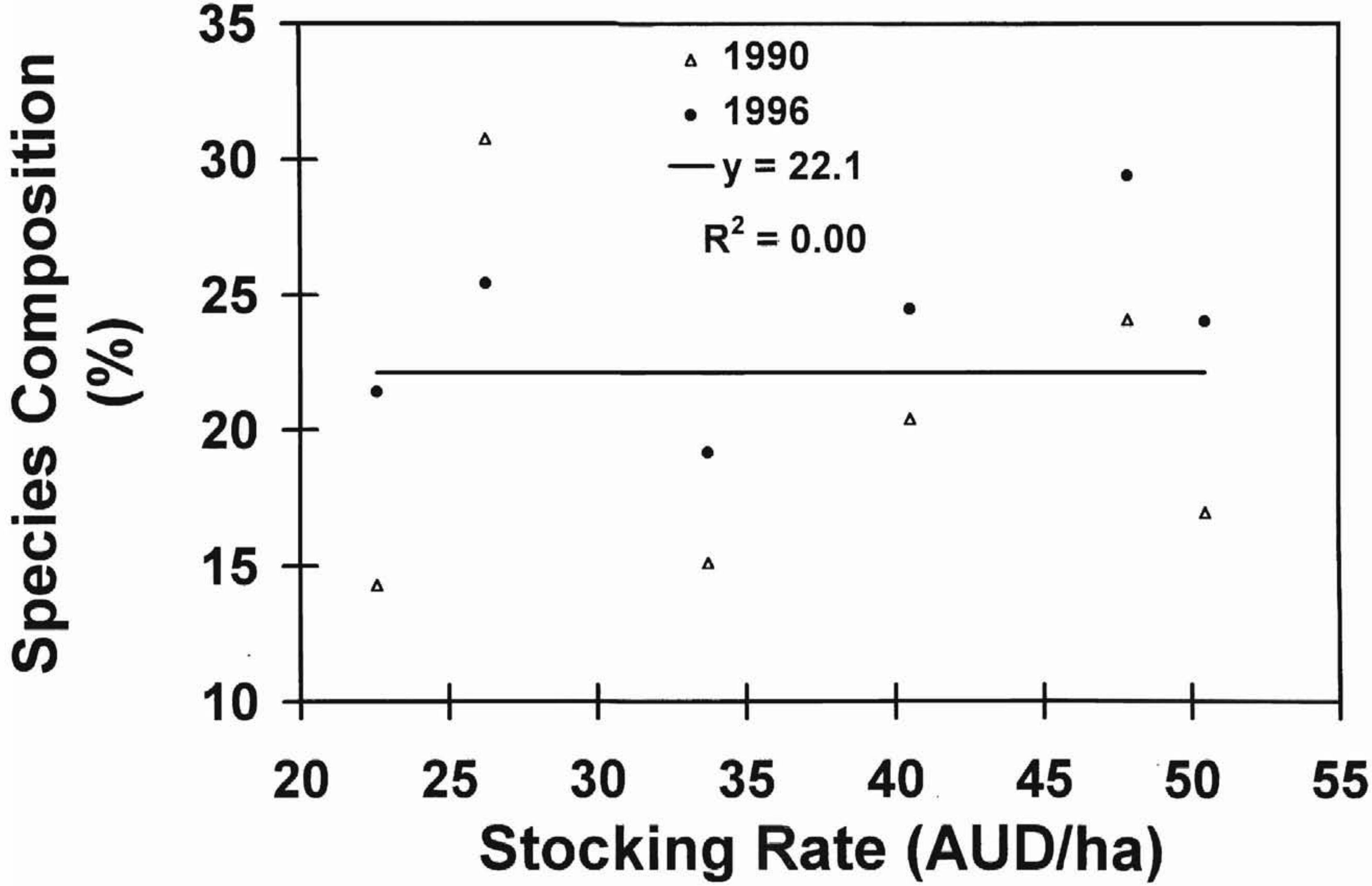

Species Composition (%)
45
40
35
30
25
20
15
10
20
25
30
35
40
45
50
55
Stocking Rate (AUD/ha)
1990
1996
y = 37.4 + 0.32 x
R^2 = 0.39


Species Composition (%)
12
10
8
6
4
2
0
1990
1996
y = 1.1 + 0.14 x
R^2 = 0.41
20
25
30
35
40
45
50
55
Stocking Rate (AUD/ha)

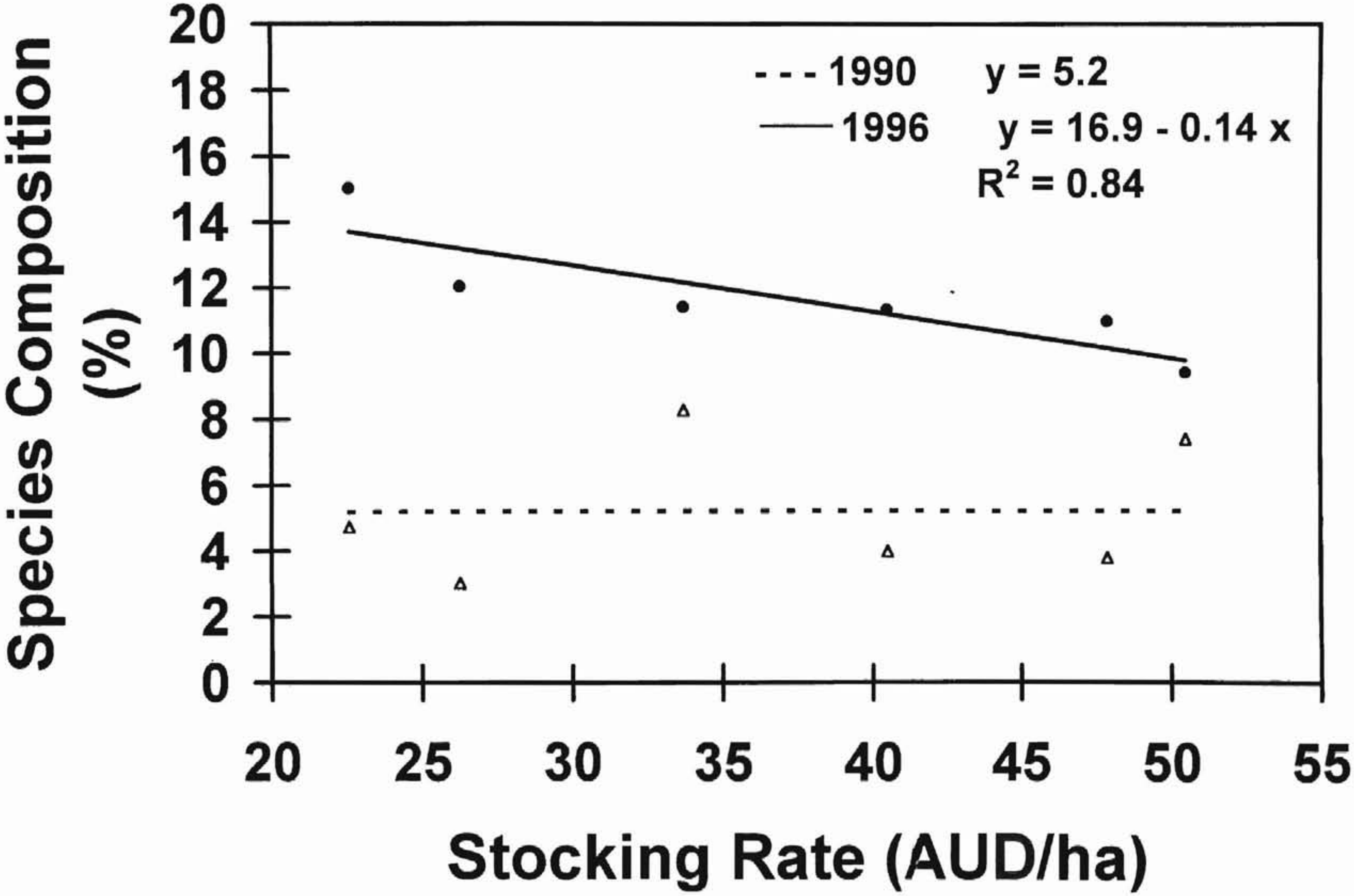


Species Composition (%)
18
16
14
12
10
8
6
4
2
0
1990
1996
y = 9.8
R2 = 0.00
20
25
30
35
40
45
50
55
Stocking Rate (AUD/ha)


Species Composition (%)
10
9
8
7
6
5
4
3
2
1
0
1990
1996
y = 4.5
R^2 = 0.00
20
25
30
35
40
45
50
55
Stocking Rate (AUD/ha)



35
30
25
20
15
10
20
25
30
35
40
45
50
55
1990
1996
y = 22.1
R² = 0.00
Species Composition (%)
Stocking Rate (AUD/ha)


--- 1990 y = 5.2
— 1996 y = 16.9 - 0.14 x
R2 = 0.84
Species Composition (%)
Stocking Rate (AUD/ha)
0
2
4
6
8
10
12
14
16
18
20
20
25
30
35
40
45
50
55

VITA

John A. Eckroat

Candidate for Degree of

Master of Science

Thesis: SOUTHERN MIXED-GRASS PRAIRIE RESPONSE TO STOCKING RATE

Majority Field: Agronomy

Biographical:

Personal Data: Born in Oklahoma City, Oklahoma, on April 2, 1943, the son of William M. and Kathryn E. Eckroat.

Education: Graduated from St. Gregory's High School, Shawnee, Oklahoma in May 1961. Received a Bachelor of Science degree in Agronomy from Oklahoma State University, Stillwater, Oklahoma in December 1966. Completed the requirements for the Master of Science degree in Agronomy majoring in Range Science at Oklahoma State University, Stillwater, Oklahoma in May 1997.

Professional Experience: Fertilizer plant organizer and builder, Standard Oil of Ohio, May 1966 to February 1968; Owner Eckroat Seed Co., Eckroat Inc., J & T Farms, 1968 to 1991; Real Estate Broker, sell farms and ranches in Oklahoma, 1991 to Present.

Professional Memberships: Board of trustees St. Gregory' College, Shawnee,Oklahoma; Registered Environmental Property Assessor; Oklahoma Real Estate Broker.