Factors contributing to grassland implementation and multifunctionality at field, farm and community levels in Marion County, Iowa

by

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ABSTRACT

Cow-calf operations in grass-based agricultural systems in Marion County, Iowa, are multifunctional in their provision of agronomic, ecological, economic and social uses. However, since 1992, pastureland and cow-calf operations have decreased, leading to a speculative loss of some beneficial functions. This study uses farming systems research and evaluation to investigate grassland multifunctionality at farm, field, and community levels. At the farm and community levels, themes from semi-structured interviews and a with focus group with cow-calf operators suggest that the relevance of profit from a cow-calf operation is mediated by a wide range of livelihood and lifestyle choices, and that operators have diverse criteria regarding the suitability of land for pasture. At the field level, on-farm research investigates the feasibility of a multifunctional pasture management strategy in response to the operator's need for an organically certifiable warm-season species paddock. The implementation of native grasses and legumes into fallow pasture without the use of herbicides under flash grazing, mowing, and unmanaged control treatments tests their differences in species establishment and pasture composition. After three seasons, no significant differences between grazing and mowing were evident in total seeded species establishment, but there was a trend toward greater native legume establishment in the control over the managed treatments. Total species abundance after three seasons of management significantly differed between each treatment, with the control bearing the highest species abundance. At the community level, policies rewarding field and farm diversity will facilitate greater support of grass-based systems from local institutions.

Chapter One. General Introduction

Introduction to Grassland Multifunctionality

Dispersed within the 98.6 million acres of cropland in the Corn Belt region of the U.S. are 14.1 million acres of grassland pasture and range, occupying roughly 9% of the Corn Belt region in 1997 (Vesterby, 2003). Frequently located on residual acreage not suitable for higher value production, the land is often used for cattle (Cashman, 2002). The row crop, poultry, and swine sectors of the agricultural arena are currently marked by concentration, integration and industrialization, as associated with changes in scale and capital intensiveness (Welsh, 1996). Although the structure of the fed cattle market corresponds with these trends, the cow-calf sector of the cattle industry, dependent on grassland forage, is currently dominated by small farms (Cashman, 2002) which generally function autonomously of vertical integration and coordination (Hindrichs and Welsh, 2003). The majority of beef operations are classified as small (those with between 130 to 2,047 acres and 24 to 172 cows by the USDA Small Beef Farm typology), part-time, and derive most of their income from other sources (Cashman, 2002). To these and the full-time small beef operations using cattle in mixed row-crop and cattle enterprises, managing cows may reflect pluriativity in which the farm plays a strategic role in the income generated by the household (Jervell, 1999).

Small farms may benefit social parameters beyond the household. In 1944, Goldschmidt (1978) found that rural communities surrounded by a large number of small family farms appeared to have a higher quality of life as suggested by the presence of indicators such as schools, parks, churches and playgrounds; this was substantiated with work by Lyson and Guptill (2004) regarding "civic agriculture" years later. Ikerd (1998) and Thompson and Haskins (1998) suggested that smaller livestock operations produce higher total economic benefit compared to larger ones, and Goldschmidt (1978) and Lobao (1990) found that small operations spend a higher percentage of their production expenditures locally than large ones.

Farm operators are increasingly recognized as *de facto* land managers whose economic decisions have ecological implications and vice versa, and who significantly influence external parameters such as open spaces or agriculture-related pollution (Collinson, 2000). In fact, cow-calf operators manage the synthetic replacement of the original native prairie ecosystem of the region, the complex pasture systems with many trophic layers of species interactions (Watkinson and Ormerod, 2001). Corn Belt region grasslands are generally recognized as critical for grassland bird abundance and richness (Ryan et al., 1998) native species perseverance (Pammel et al., 1901; Rosburg and Glenn-Lewin, 1992), and habitat for wildlife originally dependent on ungulate-grazed grass complexes (Frisina and Mariani, 1995). Grasslands are promoted as perennial conservation cover practices by resource conservation agencies for soil conservation, water quality and wildlife habitat enhancement (Iowa-NRCS, 1998; Missouri-NRCS, 1998; NRCS, 1997).

The concept of multifunctionality recognizes that although the primary role of agriculture is to produce food and fiber, many other functions are important, such as land conservation, maintenance of landscape structure, sustainable management of natural resources, biodiversity preservation, and the contributions to the socioeconomic viability of rural areas (Josling, 2002; Maier, 2001). Policies in Japan, South Korea, Norway and Switzerland have supported the concept that small- to moderate-sized independent farms can affect the economic, environmental and social health of rural areas and preserve cultural heritage (Brunstad et al., 2001).

While European Union polices are placing monetary value on the non-market benefits of agriculture, such as biodiversity preservation, various American studies have suggested that current commodity-production policies could be shifted to provide more environmental, social, and economic benefits (Batie, 2003; Boody et al., 2005) and that Americans are increasingly recognizing the public benefits embedded in private agricultural systems (Kline and Wichelns, 1996).

Examining grassland multifunctionality in Marion County, Iowa

Substantial literature suggests that the small, grassland-based, cow-calf and mixed farm operations cited previously may currently be serving multifunctional roles in the Corn Belt region. The objective of my thesis was to explore this potential multifunctionality on several levels. At the farm field level, particular management practices can substantially influence the biodiversity and nutrient cycling within pastures and hence more thoroughly contribute to ecosystem services (Altieri, 2005; Sanderson et al., 2004). Using on-farm research protocols, I evaluated the use of three organic management practices on the establishment of a diverse, native warm-season paddock within a working cow-calf pasture system. At the farm household level, I explored how and why grass-based operations on marginal lands in Marion County, Iowa, continue their systems despite significant structural and demographic pressures to change or leave. I conclude with an integration of the perspectives gleaned from the field and household studies to comment on the multifunctional impact of grass-based, cow-calf systems on the Marion County community.

Marion County, Iowa, characteristics

Marion County is located in south-central Iowa (Fig. 1) within commuting distance of the state capital, Des Moines. In 2002, approximately 60 percent of farm operators in Marion County claimed farming as their principal occupation (USDA-NASS, 2002). Thirty-one percent of the farm operators maintained cows and heifers that had calved in 2002 (USDA-NASS, 2002). More than half (64 percent) of Marion County farms are under 180 acres, and farm size tends to follow a bimodal distribution, with an increasing portion of farms between 10 and 50 acres, a decreasing portion of medium size farms (50 to 1,000 acres), and a slight increase in larger farms (over 1,000 acres) (Table 1).

As part of the region's Combined Metropolitan and Micropolitan Statistical Area (U.S. Census Bureau, 2004), Marion County has a high degree of social and economic integration with the surrounding counties including the metropolitan state capital of Des Moines, as measured through commuting ties. Most of the county population of 32,766 residents (U.S. Census Bureau, 2004) is dispersed among two cities and seven smaller towns. Manufacturing provided more than 50 percent of employment earnings in the county in 1998, compared to the state average of approximately 20 percent (Hanson and Imerman, 2000). As one economic development professional commented, "We're in a golden circle. We have with lots of accessible jobs." The 9,000-acre Red Rock Reservoir, created for flood control of the Des Moines River by the Army Corps of Engineers, also provides recreational and tourism employment and opportunities.

Marion County is part of a broad plain into which the Des Moines and Skunk Rivers and other tributaries have created fertile valleys, with bottomlands associated with the waterways making up about eight percent of the county land, nearly level to gently undulating lands make up about 15 percent, and the rest is gently rolling to very steep soils on uplands (Russell and Lockridge, 1980). Although only one percent of the county population is employed in farming, fishing and forestry occupations (Hanson et al., 2002), the 1,051 farms in Marion County occupy more than 78 percent of the land (USDA-NASS, 2002). The suitability of the land for row crops varies substantially. Mayer and Mensching (2002:2) wrote regarding changing farming practices, "[Marion County is an area] where soil resources are in transition: while the soils on the upland ridges support intensive agricultural production, the side slopes change to steeper hillsides, sharper ridges and more eroded soils…Producers have tended to disregard the yield capability and erosivity of these marginal soils, and continue to intensively row crop these areas. Cash rent arrangement and landowner expectations further complicate the problems." Agricultural land use also competes with investment and hunting interests. In four counties immediately south of Marion County, a survey conducted with landowners participating in USDA farm programs showed that 38 percent of landowners lived out of the county, of which 57 percent cited investment and six percent cited private hunting as their primary reason for land ownership (Gupta and Otto, 2004). Southern Marion County has experienced similar trends.

Exhibiting a broad range of farm sizes and types and a diverse set of competing pressures on agricultural land, Marion County provided a useful setting to examine the broad scope of influences on farms using grass-based, cow-calf agricultural systems.

Thesis organization

This thesis has five chapters. The first chapter introduces the conceptual framework of the thesis, and relates the agroecological and socioeconomic study components to this framework. It also provides relevant background information about Marion County Iowa, the thesis study site. Chapter 2 provides a general introduction and literature review about the ecological and agronomic aspects of "prairie pasture" establishment. Chapter 3 is a manuscript to be submitted to *Agriculture and Human Values* describing my research on the sociocultural and economic parameters sustaining existing cow-calf operations in Marion County, Iowa. Chapter 4 is a manuscript to be submitted to *Crop Science* and reports my findings on the establishment of native species in existing pastureland using organic management practices. Chapter 5 integrates findings from both studies to draw general conclusions about grassland multifunctionality in Marion County, Iowa.

Table 1. Farm size and distribution among Marion County, Iowa, farms in 1997 and 2002.[z]

Farm size	1997	1997	2002	2002
	Total farms (1,059)	Percent of total farms	Total farms (1,051)	Percent of total farms
<10 Acres	45	4.25	34	3.24
10 to 49 Acres	187	17.7	258	24.6
50 to 179 Acres	403	38.1	385	36.6
180 to 499 Acres	242	22.9	212	20.2
500 to 999 Acres	127	12.0	101	9.61
1000+ Acres	55	5.19	61	5.80
Average Acres	280		263	

[z] Data acquired from USDA-NASS, 2002.

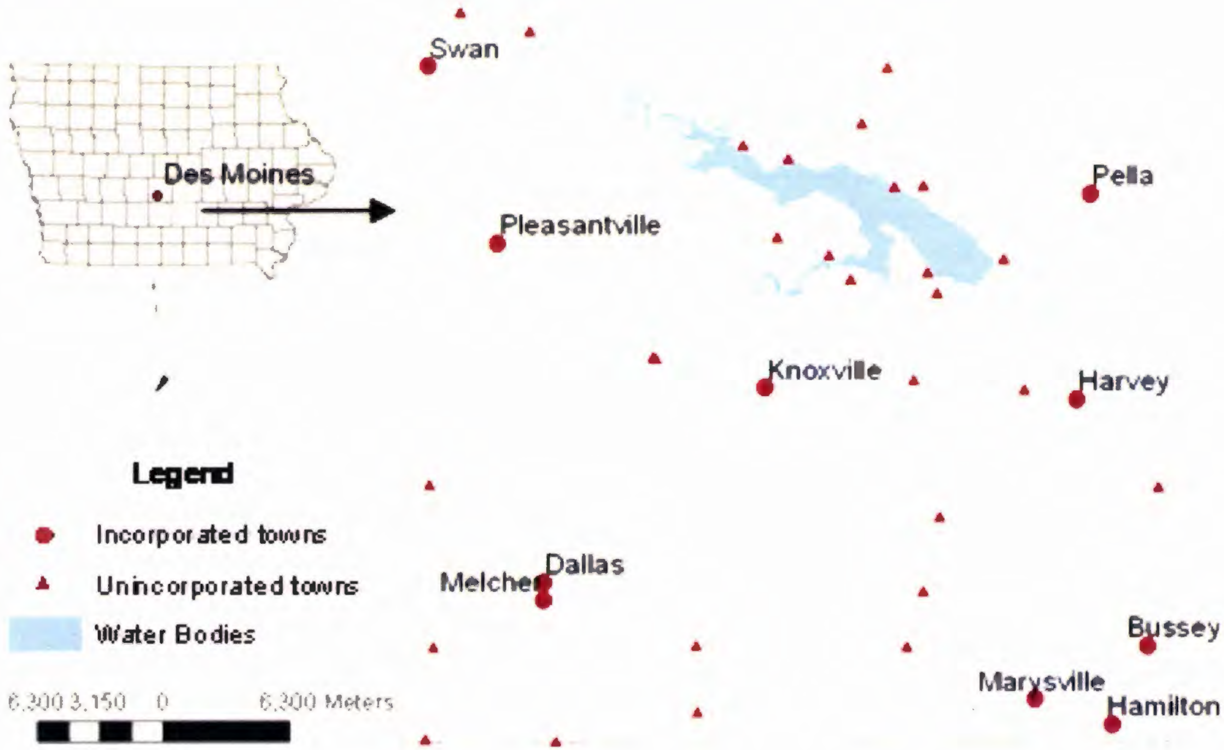

Figure. 1. Marion County, Iowa location, towns and land characteristics. It is located at located at R18W-T74N at NAD 1983 UTM Zone 15N. Data acquired from the Iowa DNR GIS library at http://www.igsb.uiowa.edu/./nrgislibx/. Map created by Karie Wiltshire in November, 2005.

Chapter Two. Agroecological Overview

A prevailing theme in a study conducted of cow-calf operators regarding why pastureland works in their operation was a reference to the "marginality" of their pastureland. They articulated a common justification of using a particular area for pasture as "it should be used as pasture." This response summarizes a combination of land characteristics including steep slope, infertility, limited topsoil, inaccessibility due to surrounding timber or riparian systems, and previous abuse or lack of use.

Several respondents used rotational grazing systems on these lands to match the carrying capacity of the land in light of the landscape constraints. In rotational grazing systems, pastures are subdivided into paddocks and animals are moved from one paddock to another at intervals, providing limited access to a pasture area for a short period of time (Beetz, 2001). Numerous studies have determined that good grazing management can transform poor grazing land into productive pasture (Turner, 1974), but others such as Elmore (1992:450) emphasize site suitability: "The effectiveness of a given system depends on how well it fits both the ecological conditions of the grazing area and the management requirements of the livestock enterprise. Too often a grazing system developed for a specific application has been used elsewhere without adequate consideration of local site conditions."

Matching site conditions with appropriate management can be a challenge in resource-poor regions such as many pastures in the focus of this study, Marion County, Iowa. Lying on the Southern Iowa Drift Plain landform, soils in Marion County are characterized by moderate loess cover over weathered glacial drifts and paleosols with an integrated drainage network (Prior, 1991). Erosional processes have carved hills ranging from gentle (1 to 9% slope) to steep (9% or greater) on which the loess mantle has eroded to reveal late-

Sangamon paleosol, often seen as thick clay or residuum formed from shale (Russell and Lockridge, 1980).

Site characteristics, including gentle to steep slopes on soil with limited available phosphorous and organic matter, limit row crop potential, and after breaking the native tallgrass sod or removing savannah vegetation, early settlers often seeded these lands to species such as Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundicacea* Schreb.) for use as pasture and forage. Through the first half of the Twentieth Century, these introduced forages were deteriorating, having been left without management and under continuous grazing, leading authorities to recognize the need for better pasture management (Scholl et al., 1955). Agricultural institutions began recommending diverse pasture mixes and fertility programs, and improvements by these methods led to two-fold increase in animal weight gains over unimproved pastures as much as two-fold (Scholl et al., 1955).

However, the increased management and input required by such poor sites to achieve productive conditions suggested that the process of matching site characteristics and management regimes as suggested by Elmore deserved attention. Hart (2000) complements his suggestion by arguing system performance should be judged by not only productivity but also parameters including stability and system/existing resource interactions. Extant individuals of warm-season species native to the original vegetation on such sites have frequently been observed on cool-season species pastures, however. Rosburg (1990) inventoried ten pastures near the study site with similar soil and topographic conditions and enumerated seven native warm-season grasses and eleven native forbs at variable abundances among seeded cool-season species, consistent with earlier work identifying various frequencies of native grasses, forbs and legumes (Pammel et al., 1901; Pammel and King, 1926).

Soil characteristics may be explaining the presence of absence of native species in pasture across many zones. Introduced species were found to be associated with nutrient rich soils in western Australia (Hobbs and Atkins, 1988), California (Hunneke et al., 1990), and Minnesota (Wilson and Tilman, 1991), and soil under native prairie, in contrast, was found to have low availabilities of nutrients relative to modified systems dominated by introduced species (Inouye et al., 1987). There is evidence from experimental literature that native prairie species may be favored on soils with low nutrient availability (Biondini and Redente, 1986; Wilson and Tilman, 1991; Whitford, 1988). Other studies suggest warm season grasses use phosphorous (Panciera and Jung, 1984) more efficiently than smooth brome.

Some argue that native species have been overlooked as a potential forage source in the tallgrass prairie region because these species are typically found on sites that have little opportunity for high yields due to low fertility (Stubbendieck and Nielsen, 1989). Native perennial warm-season grasses (characterized by C_4 photosynthesis) have been found to be drought tolerant and are highly productive during the summer season (Hall et al., 1982; Jung et al., 1978; Krueger and Curtis, 1979). A Nebraska grazing study showed that rotating animals from cool-season to warm-season and back to cool-season paddocks resulted in higher average gain than leaving animals on cool-season grasses during the entire period (Conard and Clanton, 1963). Experiments on rotating herds between native and introduced species in Iowa and other locations bore similar results (Wedin and Fruehling, 1977; Samson and Moser, 1982). The use of warm-season species in paddocks as “prairie paddocks” on marginal sites may match the farmer’s needs for summer forage under low input, limited site biophysical characteristics, and constraints such as limited access, small available area, and a desire to protect natural resources.

On-farm research has been used to develop recommendations that are representative of regional dynamics with location specificity (Tripp, 1991). This approach incorporates aspects affecting whole farm management such as land and labor availability, cost of practice, effect on adjacent fields and on neighbors, and farming system objectives (Shaner et al., 1981). Native prairie pastures could be developed through on-farm research to match site-specificity with the farming system objectives, as discussed in this thesis.

Prairie pastures and biodiversity

The implementation and facilitation of native prairie species in pasture may serve landscape conservation functions as well. Between 80 and 85% of Iowa was originally covered by tallgrass prairie (Smith, 1998), and today less than 0.2 % of the former prairie ecosystem remains in a few state preserves and numerous, mostly undocumented and unprotected fragments (Smith, 1992). Tallgrass prairies are known to support high plant species richness and diversity of vegetative and animal populations (Frisina and Mariani, 1995; West, 1993). In light of the fragmentation and rarity of tallgrass prairie systems, some advocate that every remnant habitat within the agricultural matrix be recognized (Jackson, 1999). Conservation theory predicts that species within native habitat islands will lose genetic diversity due to small population sizes and the difficulties of re-colonizing distant remnants once a species has been extirpated (Primack, 1993). With pasture occupying more than 10% of Iowa land and more than 14% of Marion County land (using pastureland of all types; USDA-NASS, 2002), pasture, cow-calf systems and prairie paddocks can provide opportunities to contribute to native habitat diversity.

Native species establishment

Prevailing literature regarding warm season species establishment in cool-season pasture suggests management practices resulting in rapid existing species elimination. Through tillage methods, the pasture is mechanically cultivated and seeded with the desired species to facilitate establishment before existing species regrow (Cox and McCarty, 1958; Wilson and Tilman, 1991). Through chemical methods, either a non-selective herbicide such as glyphosate is sprayed on germinating or newly emerging vegetation to provide a clean seedbed before seeding the warm-season species (Malik and Waddington, 1990; Wilson and Gerry, 1995), or selective herbicides such as 2,4-D or atrazine are applied to strategically eliminate broadleaf species (Anderson, 1994). Desired species are subsequently seeded to decreased neighboring vegetation and competition.

While both approaches rapidly prepare pastures for desired species establishment, each also has drawbacks. The use of tillage methods on the slopes of marginal pastureland often contributes to soil loss and compromised soil quality as well as the potential loss of desired native species. When non-selective herbicides are used on existing pastureland with intermittent remnant native species, desirable species such as legumes or palatable forbs may be reduced or eliminated (Bragg and Sutherland, 1989; Rosburg and Glenn-Lewin, 1992; Seguin et al., 2001); native species richness decreased (Bragg and Sutherland, 1989; Gillen et al., 1987); community equitability decreased (Seguin et al., 2001); and residual herbicide carried over for months after application, resulting in compromised establishment of some seeded species (Bragg and Sutherland, 1989). Use of herbicides also limits marketing options. For operators interested in raising and/or marketing their livestock as certified organic, all land used for forage production must be free from prohibited substances such as synthetic herbicides for at least three years immediately prior to certification (USDA-AMS, 2005).

Current conventional agricultural production systems are heavily dependent on pesticides for weed and insect control leading some weed scientists and agronomists to pay increasing attention to the manipulation of ecological phenomena such as competition, herbivory and soil disturbance towards the control of weeds in crop systems (Liebman and Dyck, 1993; Wyse, 1994). Liebman and Gallandt (1997) call these alternative approaches ecological weed management, and these principles could be of use in the control of undesired cool season grasses in the prairie paddock context. Among the strategies of ecological weed management are understanding weed niche characteristics (Liebman and Gallandt, 1997), the use of crop and weed life history information (Liebman and Gallandt, 1997), and acquiring information concerning competition as generated through measures of resource capture, growth and allocation processes in mixed crop and weed species stand competition experiments (Berkowitz, 1988).

C_3 vs. C_4 plant traits

Niche information about desirable or undesirable species can be developed by quantifying weed and crop germination and growth responses to variations in biological, physical and chemical factors (Liebman and Gallandt, 1997). Such measurements help define the range of ecological conditions to which different species are best and least adapted. As suggested previously, warm-season C_4 grasses differ from cool-season C_3 grasses by their periods and duration of growth. This difference is related to specific biochemical pathways in the reduction of CO_2 in the photosynthetic process, with the pathway in C_3 grasses generally bettered adapted and more efficient in cool environments than in warm environments. At high temperatures, oxygen competes with carbon in C_3 grass mesophyll cells during the reaction with Rubisco and carbon, leading to unused molecules in photorespiration and lowered sugar production and subsequent growth (Ogren, 1984). The C_4 grasses have specialized bundle sheath cells that receive CO_2 translocated from mesophyll cells, concentrating the CO_2 near the reaction site, leading to a negligible amount of photorespiration, and a CO_2 uptake that is up to 40% higher than for C_3 grasses. This permits rapid sugar production and plant growth at high temperatures (Nelson and Moser, 1995). Understanding the optimal growth periods of the cool-season compared to warm-season grasses can aid in the development of defoliation strategies.

Seedling and adult niche environments

The developmental stages of germinating and seedling warm-season grasses and native forbs are significantly influenced by a broad set of environmental factors. Individual species generally require certain levels of soil moisture and soil temperature (Ambrose and Wilson, 2003; Briggs and Knapp, 2001; Potvin, 1993; Sala et. al., 1988) and generally react negatively to the presence of litter (Bargelson, 1990; Damhoureyeh and Hartnett, 1997; Ehrenreich, 1959; Knapp, 1984; Tix and Charvat, 2005). Seedling growth stages also interact with light penetration (Suding and Goldberg, 1999; Olff et al., 1994; Tilman, 1993), and competition from existing vegetation (Bragg and Sutherland, 1989; Foster, 1999; Foster and Gross, 1997; Potvin, 1993; Suding and Goldberg, 1999; Tix and Charvat, 2005).

Some studies suggest that the relationship between neighboring vegetation and native seedlings is variable, however. Seedling establishment may be more sensitive to aboitic stress than other life history stages (Callaway and Walker, 1997), and "safe sites" suitable for germination and establishment exist as species-specific "regeneration niches" (Fowler, 1986; Grubb, 1977). Such sites may bear seedlings or juveniles of multiple species, which Fowler found as indicative of an environmentally favorable germination site in which the neighbor competition was outweighed by the benefits of the particular site (Fowler, 1986).

Experiments with transplants have demonstrated that warm-season adult survivorship is less sensitive to litter than germinating and emerging seedlings (Foster, 1999). However, adult productivity is strongly influenced by soil temperatures (Damhoureyeh and Hartnett, 1997; Hulbert, 1988; Knapp, 1984; Tix and Charvat, 2005; Xiong and Nilsson, 1999) and the removal of litter (Hadley and Kieckhefer, 1963; Old, 1969).

Life history characteristics

In general, developmental morphology is similar among grass species with minor differences separating growth forms such as cool-season or warm-season species (Briske, 1991; Mitchell and Moser, 2000). The basic sequence of events in the development of most grasses from spring to fall is a period of leaf production in early spring, followed by internode elongation and elevation of the height of the apical meristem, a transition of the apical meristem from vegetation to reproductive, inflorescence emergence, flowering, and seed set (Hyder, 1974; Sanderson, 2000). The level of carbohydrate energy stored in roots and plant crown tissues is generally inverse to rapid aboveground growth, with levels high during abundant leaf photosynthetic production, low levels at internode elongation, and high levels at flowering (MacAdam and Nelson, 2003; Smith et al., 1986). The balance of these processes determines plant health and vigor. Defoliation manipulates carbohydrate reserves and can decrease plant health by removing photosynthetic leaf area, depleting reserved energy and causing potential root area death. When defoliation occurs repeatedly or at points of low carbohydrate reserves, the plant growth rate is slowed because maintenance of a minimal level of food reserves in the storage organs is necessary for vigorous growth (Probasco and Bjugstad, 1977).

Defoliation during apical meristem elongation also affects plant vigor. If the apical meristem is removed, which is most likely during internode elongation relative to earlier growth stages, then hormonal control over axial buds is reduced and new tiller growth develops from new axillary tillers, which may or may not be present (MacAdam and Nelson, 2003). This tillering may be suppressed if the lower canopy is shaded, and the process uses root carbohydrate reserves and decreases plant vigor.

Species commonly dominating marginal southern Iowa pastures include smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundicacea* Schreb.). Reynolds and Smith (1962) and Eastin et al. (1964) demonstrated that smooth brome tiller vigor is decreased by grazing or cutting after internode elongation began in spring. These results were explained by reduced secondary tillering by axillary meristems following growing point removal. Willson and Stubbendieck (1997) determined that smooth brome tiller density is also reduced by burning at tiller heading and flowering as well, which corresponds with studies showing decreased carbohydrate storage at panicle emergence and floral development. Rosburg (1990) determined that burning pastures in late March significantly decreased the relative frequency of tall fescue, consistent with other work (Probasco and Bjugstad, 1977). Towne and Owensby (1984) found that burning at any developmental stage out of dormancy essentially eliminated Kentucky bluegrass. Warm-season species are similarly susceptible to depleted carbohydrate reserves due to untimely or repeated defoliation (White, 1973; Willson and Stubbendieck, 2000), and, in general, forbs and many native legumes have an elevated apical meristem after growth begins and are thus susceptible to injury by defoliation as well (Ehrenreich and Aikman, 1963). The optimum time to begin grazing was determined to be during the period of rapid growth just before stem elongation or flowering to manage for optimal forage quality, quantity and health (MacAdam and Nelson, 2003). However, understanding vulnerability points can also lead to control of undesirable plants.

Facilitation

Adult warm-season grasses begin developmental stages earlier, and progress more rapidly with increased soil temperatures (Rice and Parenti, 1978). However, Grubb et al. (1982) suggested that the growth of juveniles or adults may not always be the critical parameter for determining patterns of distribution and abundance, and effects of plant-plant interactions may differ consistently between life history stages and demographic parameters.

Many studies have suggested that events occurring during seed dispersal, germination, and seedling establishment determine the fates of individual plants (Foster and Gross, 1997; Grubb, 1977; Harper, 1977), and that the environment and neighbors immediately surrounding a seedling are of critical importance in determining the composition of plant communities (Fowler, 1988; Foster, 1999). Facilitating the conditions most amenable to native species germination and emergence is likely to facilitate successful establishment.

The influence of competition

Measurements of the influence of competition can be generated through studies of resource capture, growth, and allocation processes in crop and weed species growth in single-species stands and in mixtures (Berkowitz, 1988). Differentiating between crop tolerance of competition and crop suppression of competition (Goldberg and Landa, 1991) may help predict a crop response to changing environmental conditions.

Site pre-emption

In existing old-field pasture communities, Bargelson (1990) found that the spatial pattern of plants in one generation may alter the competitive interactions between plants by affecting the survival of competing individuals in that generation and by influencing the success of seedlings in the next generation. In work consistent with this pre-emption theory, Kemp and Williams (1980) suggested that because introduced cool-season grasses grow faster and begin growth earlier than native warm-season species, they possibly exploit resources and prevent warm-season species establishment on shared sites. In situations marked by such site pre-emption, dominants may remain competitively superior under either competitive tolerance or suppression (MacDougall and Turkington, 2004). This suggests that changing competitive conditions through methods such as burning, tilling, mowing or grazing shifts competitive interactions (Kleijin, 2003; MacDougall and Turkington, 2004).

In an experiment in which the competitive dominance was shifted by management practices in favor of warm-season grass establishment over smooth brome, Willson and Stubbendieck (2000) determined that the competitive effect of suppression by native grasses was not strong enough for complete suppression at a low tiller density. Increased tiller density of warm-season species was correlated with increased inhibition of smooth brome tillering, which is consistent with other studies, however (Hertz, 1962; Willson and Stubbendieck, 2000).

Competition gradients

The intensity of competition is hypothesized to be low in unproductive environments and increase with more productive environments due to greater amounts of neighbor biomass and frequency of interactions (Grime 1979; Huston 1979; Keddy, 1989). Alternatively, others hypothesized that competitive intensity may remain constant across productivity levels, although it may shift from belowground resources to aboveground resources relative to which are most limiting (Grubb 1977; Newman, 1973). In examining warm-season species seedling establishment along a moisture gradient in sand hills, Potvin (1993) observed that plant survival at higher nutrient concentrations was significantly less than at low concentrations, which she correlated with low seedling competitive ability. This is consistent with work by Foster (1999) in old-field communities in which he determined that native grasses might be restricted to low productivity habitats and strong competitive interference with establishment by existing vegetation in the most productive sites. These results and others (Goldberg and Novoplansky, 1997) suggest that the establishment and survivorship of these native species may be at a competitive disadvantage at high-productivity gradients.

Approaches to consider

Liebman and Gallandt (1997) suggest that this information on crop and weed niches, life history and competition characteristics can be used to develop selective and non-selective management strategies. Selective strategies are defined as "those that exploit differential responses between crop and weed species to control tactics such that the crop is favored and weeds are placed at a disadvantage," (Liebman and Gallandt, 1997:295) and may include strategically timed prescribed burns (Davison and Kindscher, 1999; Ehrenreich and Aikman, 1963; Hartnett et. al., 1996; Hulbert, 1988; Willson, 1990; Willson and Stubbendieck, 1997) or strategically planned herbicides (Beran et al., 2000; Bragg and Sutherland, 1989; Jackson, 1999; Rosburg and Glenn-Lewin, 1992; Wilson and Gerry, 1995).

Nonselective strategies are defined as "a reduction in weed numbers, growth and reproduction through general herbivory, competition, mowing, tillage or use of broad-spectrum herbicides," (Liebman and Gallandt, 1997:295). They may include timed mowing (Bishop and Nagel, 1999; Bragg and Sutherland, 1989; Collins et. al., 1998; Davison and Kindscher, 1999; Ehrenreich and Aikman, 1963; Johnson, 1989), or controlled grazing (Berg, 1990; Bishop and Nagel, 1999; Collins et. al., 1998; Hartnett et. al., 1996; Howe, 1994; Jackson, 1999). All strategies may differ in their effect on the existing and establishing vegetation, and their impacts are frequently significantly mediated by highly variable climate and site biotic characteristics (Abrams et. al., 1986; Hartnett et. al., 1996; Towne and Knapp, 1996).

Chapter Three. Factors Influencing Sustained Grass-Based Farming Operations on Marginal Lands in a Peri-Urban Context

A paper to be submitted to *Agriculture and Human Values*

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INTRODUCTION

Within a landscape dominated by corn and soybean fields are scattered islands of grasslands, the intended home of cows and ungulates, and often an unaccounted mélange of wild plants and animals. Grasslands managed as pasture occupy more than 10 percent of Iowa land, among pastureland of all types (USDA-NASS, 2002) although acreage has declined since 1992, with fewer farms and total land covered by perennial graminioid vegetation. Multiple studies in sociology and economics have associated changes in agricultural land use with competing uses (Moak et al., 1994), farm sector structural changes (Offutt, 1997), and changing farm-occupation opportunities (Hines and Rhoades, 1994). Few studies, however, have examined the factors contributing to the sustained use of grasslands in agricultural systems.

When specifically asked why their pastureland works in their farms and lives, three cow-calf managers in Marion County, Iowa, gave markedly divergent perspectives:

> "I came back to the farm because I like to hunt and fish, and I had a lot of fun working with cattle as a kid. But it was really about the ownership, the feeling of being part of the land."

A second operator said,

> "I believe in utilizing the ground, in getting the most efficiency out of it that you can. I'm not so interested in squeezing every dime out of the ground, because I think keeping the ground fit is more important than that. But by the same token, I don't see any reason to waste some efficiencies in the management, and if you can get use out of it, why not?"

A third perspective was manifested by this respondent:

> "The biggest reason we're in this business is because we enjoy the people, the satisfaction of raising cattle that other people want to buy for a premium. To be honest, from the sheer profitability standpoint, we cannot afford to have these cows and run this kind of operation without other jobs."

These voices are among a declining population of farm operators running grass-based systems on their farms in Marion County. They counter a trend noted by resource conservation professionals who wrote, "Producers have tended to disregard the yield capability and erosivity of marginal soils, and continue to intensely row crop these areas...As a result of intensive row cropping of these poorer soils, soil erosion has increased, soil quality has decreased, water quality is negatively impacted, wildlife habitat is destroyed, and economic returns are not sustainable," (Mayer and Mensching, 2002:2).

In a project designed to promote the use of grass-based practices and to develop an understanding regarding those who convert their pastureland, the Marion County Soil and Water Conservation District (SWCD) conducted a survey of producer attitudes in 2002. While the survey sought to reveal the attitudes and limitations among those who do not maintain a grass-based practice, it suggested several interesting features among those who do. Notably, under the assumption that profitability under increased forage rotation would equal the profitability of their current corn/soybean system rotation, 84 percent of those who responded would be willing to include forages because it is a "more environmentally sound use of the land," and 32 percent indicated that they would be willing to change because it would lessen risk (Hanson et al., 2002).

Land use decisions may be mediated by a broad range of social and political, as well as, economic parameters. Amid the decision-making regarding the use of marginal land among those surveyed are trends reflecting changes in the structure of agriculture as they know it. Farm scale is changing, with increasing farm size and decreasing farm ownership. Between 1982 and 1992, there was a 14 percent decline in the total number of U.S. farms, with a 7 percent increase in the number of large, industrialized farms (Albrecht, 1997). The trend continued between 1997 and 2002 (U.S. Census Bureau, 2004). Mirroring these trends is a state-level decline in rural population and an increase in mean farmer age in Iowa (U.S. Census Bureau, 2004). Changes extend beyond the farmscape level. Hendrickson et al. (2001) document increasing vertical and horizontal integration in the retail and processing sectors of the U.S. agricultural industry and state that 20 feedlot firms now feed 50 percent of the cattle and are directly connected to the processing firms that control 81 percent of the beef processing either by direct ownership or through formal contracts.

In the course of these transformations, small operations still produce the majority of beef cattle in the U.S., and control 74 percent of the land dedicated to beef cattle production. Three-quarters of the nation's beef cattle spend at least some portion of their life on a small farm (Cashman, 2002). Although Cashman's typology of "small farm" cannot automatically be extended to the Marion County survey respondents due to lack of information, several respondent characteristics, such as median farm acreage and herd numbers, qualify as "small farm" characteristics.

The survey question last cited used a justifying statement through "the assumption of equal profitability between grass-based and row crop systems;" it may be a statement that demands attention. Throughout agricultural extension publications and agricultural business magazines, grass-based systems are advertised by a "profit" slogan such as those found in the following recent examples, which are headlines identified from an internet search:

- "Rotational Grazing of Alfalfa Can Improve Beef Profitability" (Heald, 2000),

-"Rotational Grazing: Will It Pay?" (Anderson et al, 2004)

I do not intend to discount the legitimacy of expecting and deriving profit from a farming operation, but am curious about the resonance of this statement among the grass-based farming operations in light of the dramatic structural and social changes occurring around them.

Neoclassical theory in economics has served as the guiding paradigm for agricultural development in the United States since the 1950s (Norman, 2000). However, the exchange value inherent in this system requires markets or observable trades, and the value of services and intangibles such as risk that are embedded in farm management are much more difficult to measure (Farber et al., 2002). It may also neglect the consideration of gender, household resource allocation, farmer preference, partnership, local institutional dynamics and communication systems (Stroud et al., 2000), the norms and values, formal and informal leadership and organization, and vertical and horizontal social relations of producers and communities (Doorman, 1991), and the feedback mechanisms between agribusiness, government and capital with farmers (Imerman, 1999). Norman (2000: 294) argues that the positivist approach accompanying farm management economic studies has led to a productionist stance in farm research. As a result, he says that an implicit assumption has been that "farmers had to be thrifty, hard working and were driven by profit. Much of the farm management literature has emphasized what farmers should do to be successful, *rather than trying to understand the logic of the farming practices that most farmers are using* [italics added]." This observation calls into question the necessity of hypothetically equalizing the profit derived from row crops and forage systems to predict row crop conversion.

Johnson (1994) argues that recognizing a dichotomy in farm sizes is critical to understanding U.S. farming systems and how they negotiate profit. Some call attention to the fact that current agricultural policy and support systems were designed when American agriculture was more homogenous. Today, a relatively small number of large, highly specialized farms produce the majority of the nation's agricultural output and generally use business models based on high capital expenses, hired labor, and purchased inputs, and a marketing system based upon contracts. The other segment of the agricultural sector, representing the majority of American farms including those with grass-based operations, consists of small and mid-sized operations that are more diversified, and emphasize family relationships while relying less on hired labor (Winrock International, 2001).

The government support structure, by offering payments based upon volume of output (Gardner, 1990) and promoting greater output per acre or animal unit through research and extension programs (Flora and Francis, 2000), also implicitly benefits larger operations. This level of government support, "meant that extension met the needs of powerful and vocal farmers and agricultural processes, rather than those of the politically disempowered (Flora and Francis, 2000:141)." Zabawa (1989), who researched limited-resource farmers in Alabama, also verified this perspective. Norman (2000:298) insists that for such small farmers throughout the world, "A need exists to empower farmers so that they have a voice… where a genuine interest in sustainability issues exists."

All of these perspectives, as well as the grass-based operator quotes from my survey, reveal that the decision to maintain pasture in farmland is multifaceted. The attempt to understand the dimensions and dynamics of these decisions may contribute to the formulation of more effective agricultural policies in the interest of sustaining these grass-based practices (Dixon, 2000).

Conceptual Framework

Farming systems research

Some contend that agricultural practices are best understood through the study of systems hierarchies in which processes at higher and lower scales are considered in addition to the field level (Collinson, 2000). Lightfoot and Noble (1995) argue that households should be the center of agricultural research, and that the "enterprise" focus of much agricultural research should change to a "livelihood" focus.

The observation that farmers do not manage cropping systems in isolation led researchers in the 1970s and 1980s to see that cropping systems of interest are only one of many subsystems on a farm (Shaner et al., 1981; Sutherland, 1987). The Farming Systems Research and Evaluation and/or Development (referred to as FSR) developed as an interdisciplinary research approach that views a whole farm as a system. FSR focuses on interdependencies between (i) those internal components under the control of members of the farm household, and (ii) how these components interact with the external biological, physical, and socioeconomic factors that are not under the household's control. FSR sees whole farms as interacting subsystems, which compares significantly to the conventional agricultural research perspective that separates farm components into progressively narrower subject areas to be studied (Shaner et al., 1981).

FSR particularly seeks to understand the processes used by small farmers whose objectives are clearly different from those of mainstream farmers and those of dominant crop researchers (Collinson, 2000). The modest size of operations using marginal pastureland in Marion County may relegate many operations to a "small farm" status, which implies that FSR may be useful to understand the operations.

Embeddedness

Complementary to FSR is the embeddedness perspective which holds that personal behavior is strongly associated with networks of interpersonal relations, counter to atomized actor explanations of such behavior (Granovetter, 1985). Authors in rural and economic sociology and cultural anthropology have examined the social determinants of economic action and their relationship to the broader context of livelihood and lifestyle dimensions (Hinrichs, 1998). These studies have analyzed social capital within immigrant communities (Portes and Sensenbrener, 1993), community relationships among entrepreneurs in the sea urchin industry (Lauer, 2005), motivations among hunters and trappers (Muth et al., 1996) and huckleberry gatherers (Carroll et al., 2003) and the cultural economy of maple syrup producers (Hinrichs, 1998). Embeddedness theories allow for non-economic motives of economic action, and emphasize, "how other work activities, household relations, and the surrounding community in the resource environment shape the possibility for and understanding of minor resource production activities" (Hinrichs, 1998: 510).

While FSR emphasizes how farms and farm families are members of complex, hierarchical institutional and social structures, embeddedness allows one to explore how individual relationships to these structures potentially influence the sociocultural relevance of apparent economic actions. It considers how production practices contribute to cultural identities (Bell, 1992; Fitchen, 1991; Hatch, 1992), informal exchange (Minione, 1991), and kinship ties (Richards and Creasy, 1996).

Research problem and questions

The embeddedness perspective and FSR offer a significant framework with which to more thoroughly identify and describe how and why grass-based agricultural operations are sustained despite significant contextual changes. This research uses these tools to understand and describe the perspectives, limitations, and outlooks of farmers using predominantly grass-based systems on marginal land in Marion County, Iowa. I specifically seek to identify the interdependencies within the household and the farming system and between the household, farming system and external biological, physical, and socioeconomic realms. I was guided by the following objectives: (i) identify and understand the motivation and limitations of farmers using grass-based systems; (ii) consider the impact and influence of existing local, state and national policy in relations to grass-based systems; and (iii) develop information that is relevant to policy formation by local, state, and national institutions regarding grass-based systems on marginal lands. The principal questions guiding this study were (i) what do marginal land grass-based farmers perceive as their motivation, incentives, and limitations within their farming systems; (ii) how do infrastructural institutions and general social relationships influence the farmers; and (iii) what internal household factors, and external biological, physical, and socioeconomic factors influence decisions, and how are these perceived in the light of risk?

Overview of the Social Study

This research uses participant observation and interviews with farmers and professionals engaged in grass-based, livestock, and mixed farming operations on marginal land in Marion County, Iowa, to understand and explore how and why these systems interact with their livelihoods and lifestyles. In the following section I provide a more detailed description of the study location, Marion County, and I describe the methodological approach I used in pursing this research. I next present the findings from Marion County in light of the social, economic, and cultural parameters that most influence the informants in the study. I also describe trends identified among different types of operations. I conclude with a consideration of how these findings can contribute to the development of local and state programs that enhance the opportunities for grass-based operations.

STUDY LOCATION AND METHODS

The research perspective

In this section, I first present information on Marion County, Iowa, and discuss why it was chosen as a study location. Secondly, I describe how informants were selected for this research. Thirdly, I describe the qualitative methodology used in this research. Next, I describe how the data were analyzed. Finally, I examine some ethical concerns raised by the research in relation to the use of using qualitative methodology.

The intention of my research was to generate accurate portrayals of stakeholder values and opinions, which is a context in which qualitative ethnographic research procedures have been demonstrated as accurate and effective (Chambers, 2003; Scrimshaw, 1985). I generated qualitative ethnographic data by employing a combination of focus groups, semi-structured interviews, and participant observations that I gathered through attendance at events and volunteering at county offices. I organized the responses and observations into typological categories that allowed me to form coherent vignettes. I drew upon methodologies from ethnographic and farming systems research as I gathered and analyzed my data.

Study location

In order to explore the dynamics of decision-making regarding marginal land in agricultural systems, I was interested in studying a heterogeneous place that exhibits a broad array of farm types and influences on existing agricultural systems.

I used the "ERS Farm Typology for a Diverse Agricultural Sector" (Hoppe et al., 2000) to differentiate farm types by considering the categories: small family farms (sales less than $250,000), limited-resource, retirement, residential/lifestyle, farming occupation/lower-sales, and farming occupation/higher-sales. To cover the remaining farms, the typology identifies large family farms, very large family farms, and non-family farms. I desired a location that supported all of these farm types.

I considered the following factors that influence agricultural systems: development pressure (Rusk, 1999), policy and market-driven pressure for expanded row crop production (Harl, 2003; Schertz and Doering, 1999), land ownership and demographic changes related to land ownership, such as acreages (country homes for urban people) and absentee-owned hunting preserves (Beem, 2004), and the proximity of accessible off-farm income (NCSF, 1998).

Marion County, located in south-central Iowa, incorporates all of these traits. In 2002, approximately 60 percent of farm operators in Marion County claimed farming as their principal occupation (USDA-NASS, 2002). Thirty-one percent of the farm operators maintained cows and heifers that had calved in 2002 (USDA-NASS, 2002). More than half (64 percent) of Marion County farms are under 180 acres, and farm size tends to follow a bimodal distribution, with an increasing portion of farms between 10 and 50 acres, a decreasing portion of medium size farms (50 to 1,000 acres), and a slight increase in larger farms (over 1,000 acres) (Table 1).

As part of the region's Combined Metropolitan and Micropolitan Statistical Area (U.S Census Bureau, 2004), Marion County has a high degree of social and economic integration with the surrounding counties including the metropolitan state capital of Des Moines, as measured through commuting ties. Most of the county population of 32,766 residents (U.S. Census Bureau, 2004) is dispersed among two cities and seven smaller towns. Manufacturing provided more than 50 percent of employment earnings in the county in 2000, compared to the state average of approximately 20 percent (Hanson and Imerman, 2000). As one economic development professional commented, "We're in a golden circle. We have with lots of accessible jobs." The 9,000-acre Red Rock Reservoir, created for flood control of the Des Moines River by the Army Corps of Engineers, also provides recreational and tourism employment and opportunities.

Marion County is part of a broad plain into which the Des Moines and Skunk Rivers and other tributaries have created fertile valleys, with bottomlands associated with the waterways making up about eight percent of the county land, nearly level to gently undulating lands make up about 15 percent, and the rest is gently rolling to very steep soils on uplands (Russell and Lockridge, 1980). Although only one percent of the county population is employed in farming, fishing and forestry occupations (Hanson et al., 2002), the 1,051 farms in Marion County occupy more than 78 percent of the land (USDA-NASS, 2002). The suitability of the land for row crops varies substantially. Mayer and Mensching (2002:2) wrote regarding changing farming practices, "[Marion County is an area] where soil resources are in transition: while the soils on the upland ridges support intensive agricultural production, the side slopes change to steeper hillsides, sharper ridges and more eroded soils...Producers have tended to disregard the yield capability and erosivity of these marginal soils, and continue to intensively row crop these areas. Cash rent arrangement and landowner expectations further complicate the problems." Agricultural land use also competes with investment and hunting interests. In four counties immediately south of Marion County, a survey conducted with landowners participating in USDA farm programs showed that 38 percent of landowners lived out of the county, of which 57 percent cited investment and six percent cited private hunting as their primary reason for land ownership (Gupta and Otto, 2004). Southern Marion County has experienced similar trends.

Exhibiting a broad range of farm sizes and types and a diverse set of competing pressures on agricultural land, Marion County provided a useful setting to examine the broad scope of influences on farms using grass-based, cow-calf agricultural systems.

Observation sites

Between June 2004 and August 2005, the farms, communities, and public infrastructural offices of Marion County, served as my observation sites for data acquisition. Specifically, l used the United States Department of Agriculture-Natural Resources Conservation Services (USDA-NRCS) Knoxville office as my "base" and the adjacent Iowa State University Extension Office as an additional observation point. I conducted a focus-group interview in this facility, in-depth interviews at either this facility or on farms within the county, and conducted participatory observation by attending conferences and events related to agriculture, pasture and cow calf management within and outside of the county.

Identification of informants

I identified and interviewed 30 individuals involved with grass-based, livestock, or mixed farming operations between June 2004 and August 2005 through snowball and purposive sampling (Neuman, 2003). These included 21 individuals for whom farming provided at least part of their income and nine individuals employed in agriculture-related professions such as supply stores and services. Initially, I focused on developing farm typologies. I asked agriculture professionals, whom I considered key informants, to select five people who had extensive but diverse experience working with cattle and farm operations in Marion County. These individuals came together for a focus group interview in

June 2004, the purpose of which was to develop a typology of grass-based and cow-calf operations (Table 2), using participatory group facilitation methods (Allen and Blythe, 2004). The participants also suggested potential informants for each cell in the typology.

I next used purposive sampling based on the focus-group suggestions as well as references from the key-informant professionals to interview farm operators and farm couples that fit the various typology categories. After each interview I asked informants to refer me to one operation they felt would be willing to be interviewed to initiate snowball sampling. These references did not necessarily reflect typology categories (many operations fit into many or new typology categories), reflecting observations by Sutherland (1987) regarding biases in typology development that under-represent disadvantaged and minority groups. I gradually refined the original typology categories to reflect the nuances of differences I was observing (Table 3).

Interspersed interviews with purposive and snowball sampling, I also attended conferences and workshops. At these functions, I met two individuals from Marion County who fit typology categories that I was otherwise lacking, and requested interviews from them as a part of my purposive sampling.

Qualitative Data Collection

Observation techniques

The study employed a combination of ethnographic research approaches including field research/participant observation, in-depth interviewing, and focus group interviewing. The approaches evolved as I proceeded in the project, and followed the suggestion by

Neuman (2003) that in qualitative research, conceptualization and data collection should happen simultaneously with conceptualization largely determined by the data. I executed my research with three simultaneous tactics: (i) reconnaissance and orientation; (ii) informant selection and concept operationalization; and (iii) in-depth interviewing. I will now discuss each of these tactics, paying attention to the specific techniques used in each. It should be noted that I use the phrase "farmer" to refer to the primary decision-maker on a farm within a farm household. However, as noted by Hinrichs (1998), the "primary decision-maker" is often a role allocated to an individual based on what type of decision is being made. Several household members often participated in an interview, but I generalize each informant household to "farmer" for ease of discussion.

Reconnaissance and orientation

I play the role of *participant observer* as classified on Junker's gradient (Neuman, 2003) as I volunteered during the 2004 and 2005 summers at professional agricultural offices and attended several agricultural events. The informal conversations and observations that resulted were a valuable complement to the formal data gathering. I developed argot within those sites from a previous job and extensive social relations in that county. For this research, I developed the role of an acceptable incompetent, seeking acceptance, as Neuman (2003:379) states, "A non-threatening person who needs to be taught." Fitting in at the offices was fairly easy, as employees recognized and trusted me from my previous work.

However, due to my previous, quasi-expert role at that office, I realized that assuming this role of incompetence could be difficult. During my previous employment at the office, I had worked to develop relationships of exchange and understanding, and never functioned as an enforcer or reporter. During my research, I always identified myself as a graduate student and monitored how my actions or appearance affected informants. I kept notes (as jotted and direct observations) about my perceptions regarding this situation and other issues. Over the year of research, I participated in and observed five county-level events and assisted with nine office activities. These experiences helped me identify, contrast and compare themes I noted through my other qualitative techniques.

Informant selection and concept operationalization

During my initial summer 2004 observations, I used the agriculture professionals as key informants to develop a focus-group interview. The focus group used facilitated participatory methods (Allen and Blythe, 2004) to derive a typology of the grass-based farmers on marginal lands and operationalized that concept. After typology development and operationalization, I began the Farming Systems Research procedure of "diagnosis" described by Sutherland (1987) in which informants were identified (as described in the previous section) for subsequent semi-structured interviews. Informant selection was continuous and reflexive, and as I adjusted concepts in the typology I interviewed more informants to operationalize the idea. I also increased the informant pool to maximize differences between typology classes and to minimize sources of variation within them (Collinson, 2000).

Semi-structured interviewing

After identifying informants for each original typology class, I proceeded with theoretical, snowball, and purposive sampling to acquire semi-structured interviews from at least one farmer from each typology class and the expanding typology concepts. Because I wore several badges (ISU extension, sustainable agriculture student, organic agriculture specialist, sociologist, grassland systems enthusiast, agricultural office volunteer), I consistently identified myself as a graduate student in agronomy and sociology.

Following an introductory phone call and request for an interview, I arranged to visit with informants where they were most comfortable. Most invited me to their homes or offices, but others preferred to visit at the local extension office or at a restaurant. After introducing myself, explaining and acquiring informed consent, and explaining standard interviewing procedures, I requested to use an audio recording device. I then began a semi-structured qualitative interview regarding their experiences in farming. The themes of questions were developed using Farming Systems Theory through a grid structure (Table 4) similar to that used by Sutherland (1987). I followed a basic protocol (Appendix A) to interview with uniformity, although each informant provided opportunities for additional site-specific questions. Question types were consistently context-oriented, descriptive, and structural in nature, and I concluded with contrast questions (Neuman, 2003).

Data recording, organization and analysis

I kept jots and direct observation notes during participant and field research, and used the Olympus® Digital Voice Recorder audio recording device for all but two of the semi-structured interviews. To protect informant identities, I never recorded the identity of people I communicated with during observation, and I immediately assigned each interviewed informant a random letter after an interview. I disposed of all records associating the particular discussion or interview with the informant's identity.

Audio-recorded interviews were transcribed with the assistance of an Olympus® Digital Wave Player (Olympus, 2000) and Dragon Naturally Speaking 8.0 software (ScanSoft®, Inc., 2004). I transcribed the first nine interviews word-for-word and analyzed them for dominant and relevant themes. I transcribed subsequent interviews word-for-word during reference to these previously identified themes, and paraphrased the rest. All transcribed interviews were saved under the informant's randomly assigned letter identity on computer files. I typed jots and observation notes as well as interview notes and saved them as computer files.

The first nine semi-structured interviews were analyzed with grounded theory open-coding and focused-coding for themes (Ryan and Bernard, 2003) using the Qualrus™ Intelligent Qualitative Analysis Program (Idea Works Inc., 2000). Thirty-six codes were identified under 13 themes. I manually identified and recorded the previously denoted codes and themes in the remaining interviews. Correlations were qualitatively identified between these themes and the previously assigned typology classes. Particular typology classes demonstrated strong salience with their associated themes and I determined that these typology classes were an effective way to summarize the data during subsequent analysis. I henceforth called these the "summarizing typology classes."

Analysis presentation: vignette case study research

Miles and Huberman (1994) suggest that the sets of themes or concepts identified in a body of research should be analyzed to identify linkages and relationships in a theoretical model. I used the themes in the summarizing typology classes to present results in a form of models as ethnographic collective case studies (Stake, 2003; Orum et al., 1991). Collective case studies are instrumental studies extended to several cases. Stake (2003:136) describes that, "Individual cases in the collection may or may not be known in advance to manifest some common characteristic. They may be similar or dissimilar, as redundancy and variety are each important. They are chosen because "It is believed that understanding them will lead to better understanding, perhaps better theorizing, about a still larger collection of cases." They are considered ethnographic due to the data collection methodology used (Chamber, 2003).

Each of the summarizing typology classes was a case, and informants classified as belonging in the typology class were the case members. Homogenous and contrasting codes within themes among these case members were compiled as generic "vignettes" about the typology case. Finch (1987:105) described vignettes as "short stories about hypothetical characters in specified circumstances." The vignettes included verbatim quotes from informants as exemplars of concepts, theories and negative cases (Ryan and Bernard, 2003).

These case vignettes were compared against other case vignettes to form the collective case study and facilitate understanding of the diverse agricultural community. This thesis takes a narrative approach to reporting the case vignettes (Becker, 1992). I did not try to explain causes of the findings but rather tried to tell a convincing story about why grass-based and cow calf operations function as they do on marginal land in Marion County and potentially other locales.

Data reliability and validity

As Neuman (2003:146) states, "Qualitative researchers are less concerned with trying to match an abstract concept to empirical data and more concerned with giving a candid portrait of social life that it true to the experiences of people being studied." Triangulation, or the use of diverse methods for the acquisition of information about the people and scenario, can facilitate validity, as can approaches suggested by Neuman (2003) such as ecological validity and natural history methods. Corbin and Strauss (1990) state that validity is embedded in the process of the research, and they emphasize the disclosure of research design criteria.

My work with interviews, a focus group, and participant observation among several different social groups, all contributed to the triangulation of my generated data. This triangulation of information about informants gave me increased external validity due to the multiple angles through which I could interpret the information. The secondary data from a survey conducted in 2002 regarding marginal land use in the region (Hanson, 2002) also provided some amount of check against my conclusions. I also engaged in member validation though my frequent informal communications with staff as I volunteered at agricultural offices.

Ethics, challenges and conclusions

Conventional ethical norms were followed throughout the research, including the full disclosure of my identity and intentions to informants and the development of an informed consent document. I emphasized confidentiality and anonymity to informants, and obtained consent for use of an audio recorder. Challenges encountered included the unease created when producers were asked sensitive questions such as such as herd sizes, and the extent of government program participation or income, which are sensitive topics identified by

Hinrichs (1998) as well. I responded to potential discomfort by reminding informants of their right to bypass any questions and I would quickly switch to new topics.

As discussed in the observation techniques section, I was previously employed by a major agricultural office in Marion County and have both professional and personal ties to the county. I was initially concerned that these links could compromise the objectivity of my research, either because of my "insider" approach to obtaining information and asking questions or because an informant might have an already formed perspective on my presence. I now conclude these concerns were unsubstantiated, as I had met very few people I knew previously, and actually felt my place-based knowledge facilitated access to many situations and perspectives.

FINDINGS AND DISCUSSION

Results and discussion of the ethnographic research are presented in the following chapter. I begin with a reiteration of my sampling procedure and then embark on three vignettes to provide the characteristics and trends of each typology class as I attempt to answer my principal question: *What do marginal land, grass-based farmers perceive as their motivation, encouragement, and limitations within their farming systems?* The vignettes are neither mutually exclusive nor absolute, but reflect general tendencies concerning the characteristics and strategies of grass-based and cow-calf operations. They are followed by analysis of key differences and commonalities among and between the typology classes. I conclude with a discussion about the implications of this research, paying particular attention to the role of policy in the findings.

I entered the field using the guidance of the focus group-derived typology but also allowed categories of informant types to emerge as I learned more about grass-based operations in Marion County. Through the course of the research, I found broad heterogeneity among the informants, and realized that informants could not be fit into prescribed typology "sets" in which all members share all characteristics. Rather, I determined that one typology category, "income relevance," had classes that grouped the most members cohesively although I still identified much heterogeneity among those classes. I structure the presentation of my findings with the four-fold table (Table 5) with each representative typology class analyzed under parameters of "livelihood system," "values and desired futures," and "integrating livelihood and values" as shown in Table 6.

Vignettes

Integrated cow-calf/corn-soybean operation full-time income source

Livelihood system

Ten informants maintain integrated cattle (any of a combination of cow-calf, calf to finish, stockers or feeders) and grain operations as full-time (principal occupation) income sources. Three of the interviewed members have spouses with off-farm jobs, while the rest manage their operations as the sole income for the family. Each of the farms depends on family members (spouses, children and occasional relatives) for labor and management, although several employ assistance and custom work intermittently. Most of the informants matched their cattle herd numbers to what they considered the available, suitable land base as well as to available labor. None felt constrained by land limitations and none pursued land acquisitions specifically to increase their herd sizes.

The full-time integrated operation informants are continuing a family farming tradition, and most farmed on the original family homestead. Growing up, seven "never thought of anything else" regarding their career choice as farmers. Most now identify themselves as full-time commodity farmers, and described membership in "conventional" agriculture groups such as Farm Bureau, grain interest groups, the Iowa Cattlemen's Association, and as leaders with local co-op boards, although one informant family engaged in full-time operations identified themselves with "alternative" agriculture as they work to provide sustenance for their family and their land.

The informants run cattle, raise commodity grains, and have hay operations in a complementary fashion through crop rotations and manure distribution, although the size of the operations managed by the integrated full-time class was highly variable and complete farm size information was not collected from each informant. Available information suggests that the informants manage a mixture of rented and owned land, although most own the majority of their pastureland. The range of herd sizes is 38 to 120 cows or 300 feeders, with an average of 96 head. The managed farmland size ranges from 200-4,500 acres with an average of 1,444 acres, and managed pastures range from 140-500 acres with an average of 288 acres (Appendix B). Four informants operate rotational grazing systems under the USDA EQIP (Environmental Quality Incentive Program) although most others manage their pastures under some type of rotational grazing system. Six of the informants primarily market their grains as commodities, while four use their grains as market commodities and as feedstuffs.

Although many of the informants negotiated contracts for their commodity grains, they considered convenience, proximity and trust when choosing marketing strategies for their livestock. These factors strongly influenced eight of the ten full-time integrated operation informants to use the regional sale barn, with four of them using it exclusively and four informants to either sell "bottom-line" cattle, access new purchasers or sellers, or sell in different seasons. Several spoke about loyalty to the sale barn,

> "I purposely try to patronize it to help keep them in business. All of our cattle go through there, and most of the cattle I buy come from there. It works well for my operation."

Even though several felt distaste for the sale barn atmosphere, each found the motivation or a friend to do the necessary work with the institution. Said one, "My father in-law loves it, so I'm lucky he goes for me. That's worked out really well." Despite the mixed attitudes, the sale barn is a dependable, competitive income source for the informants, and several said they have tried other venues but have returned to the sale barn. As one farmer summarized,

> "Sale barns will always be necessary, and small producers need that connection. That's just something we do."

The need for convenience and trust influenced others as well, as they used familial relationships to sell or contract calves and stockers to relatives for feeding.

While convenience strongly influenced livestock marketing, pastureland use was mediated by what will contribute to a sustained livelihood in the light of current options. One informant described how his pasture has continued as such,

> "On Marion County pastures, it doesn't seem like there are a lot of things you can do. Either farm or pasture or build on it."

As this quote suggests, maintaining cattle and pastureland is dependent on the soils, topography, and proximate non-agricultural alternatives. Among agricultural options, pastures are justified with a cost-benefit comparison to row-crop land. "You can't plow those Gosport soils," [Gosport soils have little topsoil on shale] and "What else can we do? It's garbage ground!" were comments among many that weighed pasture against row-cropping. Other limitations such as inaccessibility, incompatibility to machinery size, or the need for terraces and drainage contributed to pasture use, as described in the following comments.

> "There is some land back there that a lot of people would crop. It's mixed with the whole field, but it's just as well in pasture. Of the 300 acres, a certain percentage would be waste if it didn't have cattle."
>
> "We are now in a position where I don't know what we would do with this ground if we didn't have the cattle. It's part of our operation that we need to maintain."
>
> "In the early 1970's we realized that it was a losing proposition to farm that kind of ground. A lot of it could potentially be cropped, but we have chosen to hay and pasture it. I just don't like farming hills."

A common solution to heterogeneous row-crop suitability, integrated crop-livestock field design, was described by another informant,

> "I believe in full utilization of the land relative to soil constraints. If it's not suitable for farming, let's pasture it; if it's suitable for both, we still have some waterways and headlands that we're going to harvest for the livestock."

Land use perspectives both on- and off-farm were strongly associated with livelihood strategies for full-time integrated operations. Surrounding land use change, and new neighbor complaints about odor, tractors, and chemicals affected them more than the changing appearance of the countryside, and they often considered them threats to their way of life. The informants assertively addressed these changes with plans to purchase surrounding farmland as it became available, and to provide free services such as snow plowing to adjacent owners and acreages in the interest of maintaining amicable relations. Such strategies prevented interruptions to their farming systems.

Assertiveness in the form of opportunism within a changing social landscape was a strategy several entertained. Some informants without long-term plans for their farm considered potential sales of their land, as one explained, "Development may be a potential for us as an investment strategy. This isn't a Century Farm so we don't need to protect it like some others around here." Other farms used new markets provided by changing demographics and land ownership. Many owners of new acreages maintain horses for which, "We have a great horse market to sell our extra hay to." To another, "Our new neighbors like our beef." Other new acreages still rent their land to farmers. As one observed, "Many people who work with farmers just want their ground in row crop, so I was surprised when I learned that many I've worked with are quick to say they want it in hay. They are really concerned about the way the farm looks when people drive by."

Values and desired futures

Acting opportunistically worked for different operations in different ways, but some adhered to values and family contexts that prevented it in certain situations. A family farm with a long agricultural heritage guarded their farm,

> "Everyone wants our land, but our family will sell nothing. It's so hard to get land, and we are really married to it. We're not the kind to sit and enjoy money from a land sale. This is everything, it is our life. It's so heartbreaking to watch farms get sold to investors around here."

This protectiveness about the future of the integrated full-time farms was not pervasive within the typology class. Only four of the 10 informants had confirmed the continuity of their farm with their children or family members, while four were certain that no immediate family members planned on continuing the farm operation as such. The rest were uncertain about the future of the farm, with one summarizing,

> "We really want to pass this land to the next generation, but we don't know about the status of our kids. We hope this land is used responsibly and for what it is best suited."

Despite the uncertainty about farming, informants with children emphasized passing on values they associated with agriculture. Seven of the 10 informants with children encouraged them to participate in 4H and FFA groups regardless of their future plans in farming, citing,

> "Being in 4H and FFA, helping around the farm, our kids have gotten really well-rounded. They can breed dogs, fix engines, and show cows, they've raised calves for pocket money – what great opportunities compared to some couch potatoes. We've made sure that they have always had opportunities."

Comments about diverse, farm-related skills, work ethic and independence were abundant among the full-time integrated typology informants, as were commitments to land conservation. One discussed the justification for pasture,

> "You don't want your soil leaving. You need a decent conservation plan, and part of that goes with the cows."

Some argue that the pragmatic land use criteria employed among the informants is what Glenna (1996:25) considers an "instrumental rationality" in which,

> "[The farmer] acts in a one-way relationship upon his land. He recognizes that the soil is susceptible to erosion, but this does not alter his overall goals for his land. He alters his land and his techniques in order to improve

> productivity and maximize efficiency while employing soil-saving techniques."

This strict economic motive was diluted by indicators of embeddedness as informants discussed how and why they manage pasture and cattle. The social capital and inherited linkages that several experienced through family were pivotal to their current cattle operation. Said one,

> "My father was a great livestock individual, and knew livestock well. My father-in-law by that same token was good at crops, and both were conservation leaders. I've been blessed to have two mentors of different backgrounds, and I've basically blended those."

Other informants used their social capital for entrepreneurship, and partially justified their operation with that capital. Regarding their decision to sell beef to friends and neighbors, one couple explained, "We don't make much of a return on it; we just figure they deserve to eat good beef."

Other informants associated cattle production with the lifestyle dimensions they consider important as they described,

> "We try to keep enough cows to take care of the land. And I've always preferred cattle, with the big hills and beautiful grass pastures. It's so neat. I could cow-calf forever."

Another described,

> "I look at it as a way of life. It's a good place to raise children, you're constantly involved with nature, and you're outside everyday. These are things that city people pay to see."

Cultural and ethnic studies of full-time agricultural operations have observed similar trends of decisions mediated by sociocultural attributes rather than strict profit maximization (Flora and Stitz, 1985; Salamon, 1985). Other studies have found that the path and success of entrepreneurs is derived from sociocultural relationships, and that this social capital is critical to decision making and persistence (Granovetter, 1985; Lauer, 2005; Portes and Sensenbrenner, 1993).

Integrating livelihood and values

The livelihood of the full-time integrated operators is dependent on the success of their crops and land-use strategies; their approach of matching soil and topographic characteristics to pastureland use reflects this. An agriculture professional explained, "The full-time operations… they're too busy to mess with alternative marketing and stuff like that. They're just trying to make money." This comment captures the emphasis on efficiencies and optimization of pasture use, and on the convenience and trust full-time operators seek in cattle marketing. However, underlying these decisions are also social relationships that provide additional opportunities, and also influence these choices.

Although a common response to a question about defining characteristics of cattlemen was "independence," all of the full-time integrated informants admitted that they begrudgingly participated in row-crop government programs, but as one stated, "It's not always the wisest thing to do, but we're stuck." Several also participated in the Environmental Quality Incentive Program (EQIP) for rotational grazing systems, and several stated that EQIP was instrumental to their design of sustainable, suitable grazing systems and expressed gratitude for the program and for the technical assistance provided by the administrator NRCS office.

A pool of literature argues for institutional recognition of local knowledge (Kloppenburg, 1991; Harrison et al., 1998; Ward and Munton, 1992), and multiple informants voiced their frustration about this void in government programs and extension education opportunities, feeling that much distributed information was not applicable to Marion County, Iowa, conditions due to topographic or climatic differences. Said one,

> "In northern Iowa they can do little square paddocks with everything laid out perfectly. Information about that is not very functional here because our topography varies so much."

Several extended this criticism to past government programs, expressing frustration that neighbors were rewarded for plowing and cropping steep land in preparation for the Conservation Reserve Program (CRP) while *they* maintained identical land in pasture with no reimbursement. Regarding other government programs and policies, some informants expressed frustration that the Iowa Department of Natural Resources has not worked more aggressively to curb the deer population as the abundant deer "...eat our crops *and* they wreck our electric fence. They are part of the reason a rotational paddock system isn't working in our operation."

The integrated cow-calf/corn-soybean full-time operation is strongly influenced by matching livelihood needs with their land use and cattle operations although informants were influenced by social relationships and values as they planned and executed their operations. The one member of this typology class who did not identify himself with "conventional" agricultural groups incorporated additional values but still made and executed plans founded on livelihood-oriented parameters.

Exclusive cow-calf operation, part-time income source

Livelihood system

Nine informants exclusively maintain cattle (any of a combination of cow-calf, calf to finish, stockers or feeders) or grass-based operations related to cattle as part-time income sources. Seven members maintain full-time off-farm employment from public service to private industry, while two are retired from former full-time non-farming jobs. Half of the respondents engage in their operation with their spouse and families, while half manage their operations independent of their spouse and alone or with only a grown child or hired labor. Roughly 25 percent of the informants stated that labor availability constrains their operations and that the land they currently own suits their needs. Twenty-five percent stated that land constrains their operations and that they would expand their cattle numbers with a larger land base given their current labor availability. Twenty-five percent suggested that both land and labor influence their cattle herd size, while the rest did not consider either to be constraining, partially because they desire a stable, small herd size that is not strongly influenced by changing cattle prices or market trends. The heterogeneity of constraints affecting the informants is consistent with work by Lawrence and Schuknecht (2005) who found labor availability a variable constraint to farm management and land as an occasional obstacle to profitable, optimum size operations.

Although several of the operations were not located on family homesteads, the decision to maintain operations was closely associated with heritage or identity. Some informants were continuing their family traditions, as apparent in the following comments,

> "With the cows, you're taking care of the soil. My dad's mother grew up there, so it's been in the family forever. We're going to keep that ground, so we might as well take care of it."

Another spoke of knowledge gained as a child,

> "I grew up on a farm, knew agriculture, and knew that pasture was what this farm needs. I get along well with a cow-calf operation."

Another was fulfilling a childhood dream,

> "Since I was a little boy, I wanted to be a ranger. I was born with it. But I came from a very poor farm family, and there was no way to get started. Eventually I got the opportunity to buy a really marginal farm that was all pasture, and expanded from there."

An informant without a direct agricultural background entered a lifestyle he desired for his family with the cow-calf operation,

> "I grew up near farms, liked working on them as a kid. This benefits our family. We all enjoy living out in the country, away from town. And we are able to raise our own food here, it's organic and it hasn't traveled far. And hopefully we'll soon be selling our beef and vegetables to others."

Very few of the part-time cow-calf operations generated substantial income on which the operator or the family depended, although it was a valued supplement to several. Members of the exclusively part-time class have significantly different identities in association with their operations, although all were associated with the countryside. Some members have a strong affiliation with conventional agricultural groups, with memberships in Farm Bureau and support for policy affecting grain farms,

> "People need to understand that when they're eating a hamburger or pork burger, that the agriculture around them is creating the food for a fourth of the United States. Not everyone relates to that."

Others identify themselves as "cattlemen" quite separate from grain farmers,

> "I think only in terms of pasture. I can't envision that ground would be considered crop suitable... but maybe someone who's a diehard grain farmer would think otherwise."

Said another,

> "I can understand why some people don't value things like graziers. Our neighbor continually grazes and has a major thistle problem. But he has so much other farmland that taking care of thistles is a low priority for him. Unless you're really committed to grazing, you don't have time to do that stuff."

Lawrence and Schuknecht (2005) found that only 63 percent of cow-calf operators with more than 100 head were members of Farm Bureau, confirming diverse identities among cow-calf operators in Iowa. Some informants toyed with calling themselves "hobby farmers" although one clarified, "With the time and money I spend for this, it's got to be more than a hobby!"

Other part-time exclusive informants called themselves "stewards" while one felt unrecognized and underserved, "When it comes to agencies and groups to work with, I'm a black hole."

These comments suggest that several of the informants associate their operation with more than finances, personal enjoyment or tradition, which resonates with findings of Hinrichs (1998:522) who observed that,

> "It can offer a way of creating or maintaining an identity as a rural resource producer. Recourse to such an identity is important, because, even as the place of production agriculture… declines in the regional economy, non-farm work becomes widespread, and farmers retire, the symbolic role and actual practices of rural resource producers remain compelling."

For these producers, managing a cow-calf operation provides a claim to the rural or country identity (Bell, 1992; Hinrichs, 1998).

Consistent with the varied background and identities of the informants, the size of the operations fluctuates substantially. All informants own the majority of the land used for their cow-calf or grass operations. As shown in Appendix C, the range of herd sizes is 8 to 200 head, with an average of 59 cows. The farm size ranges from 20-3,200 acres with an average of 499 acres, and managed pastures range from 20-1,200 acres with an average of 219 acres. Four informants operate rotational grazing systems under the USDA EQIP (Environmental Quality Incentive Program) although most others manage their pastures under type of some rotational system. Many of the informants own diverse land, with some fields dominated by high crop suitability coupled with nearby highly erodible fields. Some informants pasture the erodible land and rent the rest, while others manage all land as pasture.

Marketing cattle is an aspect of the part-time exclusive cattle livelihood strategy that many experiment with and enjoy. Six of the nine informants engage in some form of direct marketing, if through the sales of beef to neighbors, friends or clients, or through the sale of breeds and club calves. These informants associated their operations with challenges rewarded monetarily when done well, or with the satisfaction of providing good products. The thrill of marketing innovative ideas and breeds motivated some, "My philosophy is that if it's working, what can I do to make it better?"

> "The biggest reason we're in this business is because we enjoy the people and the satisfaction of raising cattle that other people want to buy for a premium. To be honest, from the sheer profitability standpoint, we cannot afford to have these cows and run the kind of operation we are if we didn't have off farm jobs."

Several commented that the social atmosphere at the sale barn and in marketing ventures contributed to their satisfaction in stockmanship, as shared in this sale barn story,

> "Everyone kept asking, me, where are your heifers? These people had just come to look! They eventually put them in the ring, and it was a phenomenal sight. They

> went in the ring, mingled, then all straightened out and stood and just looked at the people and just stood still. Every one of them. I topped the sale that day. I got more for my heifers that were unbred than some had gotten for their bred ones. It was just one of those days."

The marketing strategies among exclusive part-time informants were flexible and often guided by experimentation, as confirmed by an agricultural professional,

> "The part-time operators are looking for something different. It's not their life, it may be just as important to them [as full-time operators], but they're willing to gamble."

A sale barn was used by two informants occasionally and three informants intermittently, although two of these three sought opportunities to sell goats and sheep, which is not available in Marion County facilities.

A livelihood strategy not dependent on cattle-related income largely influenced the capacity of this typology class to use flexibility and experimentation in marketing. This flexibility tended to open land-use options available to the part-time exclusive operators as well, as they were not necessarily driven to optimize profit derived from their land. Nearly all of the part-time class members justified their choice for pasture use with the statement, "It *should* be in pasture." Several informants referred to what they considered past "misuse" of the land they now use as pasture, such as this operator,

> "I'm going to have this seeded down from now on. It shouldn't have been in row crops to start with."

In the process of purchasing land or re-entering a family farm with a new perspective, many of the part-time operators approach the land use in reaction to what they see as past mistakes.

Although the pasture and cattle management tactics were highly varied among the class members, all but one managed their pastures as "whole fields" in which the entire field is exclusively pasture (rather than being associated with nearby row-crops). This trend may be related to lack of other uses or labor limitations.

The part-time exclusive informants managed their farms with intention. Living in or protecting the countryside while engaging in a particular lifestyle was their goal, and changes to the countryside provoked concern among them. A loss of the countryside through farm sales, increased development, and increased land ownership among hunting and investment circles was leading to a loss of what many of the informants moved or stayed there for. Said one about surrounding development,

> "The demographics of my neighbors are changing and farms are selling out. We've been offered large sums to build on our land. But I can't sell. I think a lot of cattlemen have that attachment. I'd hate to lose that part of our landscape, when you drive down the road and see cattle grazing."

The countryside depopulation associated with row-crop expansion and confinement operations concerned another. Others expressed concern about competing interests for the land as it influenced the future of agriculture,

> "The demand from people who have money on the outside, like hunting or investment circles is stronger than from ag circles. That's a real challenge for us. Young people can't enter the cattle domain because land costs too much to rent."

Several considered the impact of inconsiderate or uninformed citizens more critical than the landscape change brought by them. Informants complained that new neighbors were often uninformed regarding their legal obligation to maintain fence, leaving the cattle operators with a burden to monitor the maintenance of their own and adjacent fencing. Others complained that hunters occasionally entered their property without permission, frequently leaving fence gates open or even damaging their property.

Part-time exclusive cow-calf operations seemed to lack capacity to act on their concerns. Apart from a decision to maintain their farms or to join organizations that advocate cattle interests, they appeared to respond passively to unfavorable land use changes around them.

Values and desired futures

Informants are motivated by the values embedded in the process of caring for cattle, as explained one,

> "It just gets in your blood. It's almost like an addiction. It's the satisfaction you get looking at those calves and knowing that the management decisions were good, and when a sale comes up in the fall, getting the satisfaction of a good sale."

Said another,

> "The reason I do it is because I enjoy working with cattle. Cattle to me are soothing. I love to fish, even if I don't catch anything. I can go out in a field and park in my pickup and look at my cattle I get the same relaxation as fishing."

Such comments suggest that cow-calving is embedded in a rural culture, and it serves needs that are separate from, although not necessarily at odd with, the matter of livelihood (Hinrichs, 1998). This embeddedness of cow-calving among part-time exclusive informants is a pervasive theme within the class. The role of the cow-calf operation is as an "end use" for eight informants who specifically value cattle as both a process and a product for the farming operation. Four informants associated the process of caring for and marketing cattle as driven by a desire to benefit their children or society at-large in non-economic ways, while four saw their livestock enterprise as fulfilling their personal desire for challenge, invention, and entrepreneurship.

Among those pursing family benefit, one informant explained,

> "We want to teach our girls at a young age about the things that need to know. With speech and showmanship contests, those are the opportunities we want to give our kids. And those little faces looking at me, that is by far the biggest reason why I do this. This operation has very little to do with monetary rewards."

Another informant relates the operation to the future as well,

> "Our kids have been checking the fence, doing chores, showing cows at fairs. They're really developing an interest. And also they are hunting turkeys and deer, and they really enjoy that too. It seems like they're really taking to the wildlife, the natural resources, the recreation, the cattle, and all of that. I hear my kids talking about wanting to live in the country, own the farm someday, and that's good."

Several mentioned a spiritual obligation towards stewardship of their land, with their pasture management critical to that.

> "I look at myself as being steward of that land, and as Christians, we also see it as a work of faith. We've been given the task of caring for this little speck of the earth, and we're trying to do as good a job as we can."

A cow-calf operation allows the expression of values that are limited by his occupation for another informant,

> "To me, there is something satisfying about making my own decision. I don't need to be second-guessed by a boss or customer. When it's your own, you take more pride in it."

These motivating values did not necessarily affect the future of the informant's farms. Only one of the nine informants had confirmed the continuity of their farm with their children or family members, while three were certain that no immediate family members planned on continuing the farm operation as such. The rest were uncertain about the future of the farm.

Despite the uncertainty about farming, four informants with children emphasized passing on the values associated with agriculture and encouraged their children to participate in 4H and FFA groups regardless of their future plans in farming, saying,

> "Cattle are a great opportunity for kids to learn ethical issues and life lessons. 4H encourages that even more. Kids growing up with that stuff grow up to be very successful adults."

It is notable that all of the informants who encouraged this participation were continuing or returning to their family background in agriculture.

Integrating livelihood and values

Livelihood and lifestyle dimensions motivate exclusive cow-calf, part-time income informants to maintain their operations. They are able to manage cattle, allocate pastureland and market their products with flexibility and innovation, attributes made possible by additional means of income but arguably also because of values that encourage animal husbandry and land stewardship. Most identify themselves as distinct from row-crop farmers, and make decisions for land-use that is sometimes in reaction to previous row-crop use. They also identify themselves as countryside inhabitants, and some expressed concern that current trends in row-crop or animal-confinement agriculture are degrading their quality of life in the countryside.

Four of the nine typology members participated in the Environmental Quality Incentive Program (EQIP) for rotational grazing systems and several stated that EQIP was instrumental to their design of sustainable, suitable grazing systems and expressed gratitude for the program and for the technical assistance provided by the administering NRCS office. Others suggested that the enrollment wait and bureaucratic tendencies of the program made it unfeasible, especially in light of changing cattle markets and trends. In addition, not all informants were aware of the diverse programs accessible to smaller operators. One informant was surprised to learn of programs that serve non-commodity operators such as EQIP. Several informants suggested that the fence law obligating property owners to maintain fence should be made more explicit in agency literature and policy.

Integrated cow-calf/corn-soybean operation part-time income source

Two informants of my purposive sample maintain integrated cattle (any of a combination of cow-calf, calf to finish, stockers or feeders) and grain operations as part-time income sources. Each of the interviewed members has spouses with off-farm jobs, although all family members (spouse, at-home children and occasional relatives) provide labor and management. As shown in Appendix D, the informants manage a mixture of rented and owned farmland and pastureland. The mean herd size among the informants is 80 cows. Managed farmland sizes average 633 acres, and managed pastures average 395 acres. Both manage their pastures in rotational systems although neither currently participate in EQIP contracts. Because of the small number of informants in this sample, generalizations cannot be reliably extracted about this typology class. Several trends are notable, however.

As suggested by the class title, many livelihood characteristics within this class seem to be a blend of the exclusive part-time and the integrated full-time typology classes. Each informant grew up on a farm, although each left and then returned to farming after becoming established in a professional field. One returned to the family farm homestead motivated to continue the family farm operation. He notes,

> "My dad hasn't been able to maintain the farm well. We just love the countryside, we enjoy farming, and we wanted to continue it."

Although they market their grains, they have emphasized the cow-calf component on their farm, allocating more time and interest to it compared to the smaller corn and soybean component. They explain the cow-calf operation,

> "For us, it's a family thing. We like to do it, and it fits our schedules well. Like last night, we got onto the 4-wheeler, and went through the pastures to check the cows. How many couples can go together, looking at cows, just enjoying the evening together? It's pretty neat."

For this informant, the cattle operation fits their livelihood because of compatible labor needs and an existing land base. Their identity and preference for the countryside as well as the values associated with raising cattle reinforced their desire to return to the farm and continue the original operation. The decision to maintain cropland for this operation was influenced by the existing allocation of land to row-crop as well as the pre-existing skills and machinery available to the farm family.

The other part-time integrated cow-calf and crop class informant purchased the farmland currently used for gain production and a small feeder operation, and rents substantial pastureland for the cow-calf component. They finish some cows on the grain, and direct market some beef. They explain their reasoning about the farm,

> "I bought the farm because that is how I wanted to raise my kids. Farming, and raising and showing cows have instilled some values that they will use for the rest of their lives. But also, farming is worth something to me. It's my relaxation, it's my hobby. Hobbies are things that lose money; I farm, that's my hobby."

Although the part-time integrated cow-calf and crop class informants entered their operations for slightly different reasons, both operations serve purposes related to family, identity and enjoyment, similar to the embeddedness observed among the part-time exclusive cow-calf operators but built on the integrated operation model that is attentive to efficiencies such as the full-time integrated operators.

Typology comparison

While there is substantial heterogeneity within each typology class, the integrated full-time operation informants were overwhelmingly guided by livelihood strategies in their cattle operation and associated land use. This emphasis on livelihood strategies among full-time integrated operators is consistent with work by Cashman (2002) who found that income reliance sculpted feasible management strategies among this group. The class also identified themselves uniformly as commodity farmers. Within the other typology classes, members had few unifying characteristics beyond their decision to maintain cattle.

This heterogeneity could bear consequences when one label, "commercial cow-calf operation," is used to develop programs, which is salient with perspectives articulated by Bourdieu and Wacquant (1992) and Glenna (1996) in which the logic of accumulation of capital and commodification of land is the dominant agricultural label. Glenna (1996:24) observed of two farmers who self-identify outside of this paradigm,

> "One claims he is about to be forced out of farming, and the other claims he has had to accept a lonely life in order to run his farm for aesthetic instead of economic goals. The failure to adopt rationality consistent with the dominant logic of the field has consequences."

These distinct identities among the exclusive part-time class could also affect political empowerment as suggested by Farming Systems Research (Flora and Francis, 2000).

All of the full-time and part-time integrated operators used and were aware of infrastructure such as the sale barn, institutions and policies such as USDA, NRCS and Iowa

State University extension to facilitate their work, although several had complaints about its design and implementation. The part-time exclusive cow-calf informants were less engaged in, and less aware of government programs, although several were grateful for opportunities to participate in programs such as EQIP. Cruise and Lyson (1991) and Schwarzweller and Davidson (1997) note that diverse structural components such as educational systems, market competition, and access to reliable sources of information significantly contribute to community productivity in dairy operations. The availability of a reliable, equitable marketing venue such as the sale barn may be sustaining the cow-calf operations in the region.

As described earlier, pasture systems among full-time integrated operators are generally "integrated fields" used for both row crop and cattle, and dependent on the season and the crop rotation. The part-time operators tended to use their fields exclusively for cattle and unrelated to row-crops. This difference suggests that they may be more willing and accessible candidates for long-term perennial vegetation projects and habitat development.

The future of the farms (whether integrated or exclusively cattle-based) was ambiguous among informants in all typology classes. Among all of the informants, 33 percent were confident that their operation would not continue as such when they retired, which is consistent with state-level findings by Lawrence and Schuknecht (2005) who determined that 42 percent of operations with more than 100 head would not be passed down to family. Only one of nine informants in the exclusive part-time class was confident of the continuation of the farm in the future, suggesting that the typology had a tendency to consider the operation as a lifestyle choice and as an identification of residence in the rural countryside (Hinrichs, 1998). This reiterates the perspective that the part-time exclusive farms suit current lifestyle needs.

Implications and Conclusions

Analyzing the potentially ambiguous cow-calf operations through the lens of income-relevance typology classes sheds light on substantial differences among operations, which resonates with recent farming systems research studies that advocate for recognition of diverse socioeconomic and biophysical influences on farming systems (Robotham and McArthur, 2001; Mishra et al., 1999). These differences may not be readily identifiable, although multiple studies suggest that proper labeling and understanding of operation types leads to more effective policy and institutional support (Carroll et al., 2003; Muth et al., 1996). The motivation to participate in, and otherwise maintain, labor- and knowledge-intense practices is embedded in complex socioeconomic and sociocultural systems (Hinrichs, 1998) and supported by both household and structural support mechanisms (Cruise and Lyson, 1991). It could be argued that many part-time exclusive cow-calf operator families are strongly motivated by a desire to maintain an agricultural heritage and image (Hinrichs, 1998), while integrated operations are more influenced by economically-driven instrumental rationale (Glenna, 1996). A better understanding of these diverse farming systems can contribute to the formulation of more effective agricultural policies (Dixon, 2000; Robotham and McArthur, 2001) such as the Conservation Security Program and EQIP, as well as a landscape continually carpeted in diverse grass-based agricultural systems.

Table 1. Farm size and distribution in 1997 and 2002 among Marion County, Iowa, farms.[z]

Farm size	1997	1997	2002	2002
	Total farms (1,059)	Percent of total farms	Total farms (1,051)	Percent of total farms
<10 Acres	45	4.25	34	3.24
10 to 49 Acres	187	17.66	258	24.55
50 to 179 Acres	403	38.05	385	36.63
180 to 499 Acres	242	22.85	212	20.17
500 to 999 Acres	127	11.99	101	9.61
1000+ Acres	55	5.19	61	5.80
Average Acres	280		263	

[z] Data acquired from the National Agricultural Statistics Service, 2002.

Table 2. Initial typology grid developed from original focus group.

Typology category	**Typology classes within each category**		
Cultural membership in cow-calf (CC) operations	Continued CC heritage	Returning to CC heritage	New to CC
Age	63+	31-62	30 and under
Income relevance	Exclusive CC part-time	Integrated CC/row-crop	Exclusive CC
Marketing strategy, types of engagement with like-interest organizations	Independent, old ways (follows marketing such as sale barn, inherited relationships and approaches without actively seeking new ones)	Cooperatives, use of organizations/ associations, retroactive fits for new demand	Entrepreneurial product/labeling

Table 3. Final modified typology developed from original focus group and adaptations from field observations.

Typology category	**Typology classes within each category**			
Cultural membership in cow-calf (CC) operations	Continued CC heritage	Returning to CC heritage		New to CC
Age	63+	31-62		30 under
Income relevance	Exclusive part-time	Exclusive full-time	Integrated CC/row-crop part-time	Integrated CC/row-crop full-time
Marketing strategy	Exclusively sale barn	Mixed strategy	Cooperatives, use of organizations/ associations, contracts, packer	Entrepreneur, direct sales of beef or breeding stock
Operation size*	Below average (1-30 cows, heifers or steer)	Average (38 +/- 8cows, heifers, heifers or steer)	Above average (45 -100 cows, heifers or steer)	Many (101 or more cows, heifers or steer)

*County average derived from USDA Agricultural Census, 2002, Table 11: Cattle and Calves – Inventory and Sales: 2002 and 1997, Marion County, Iowa.

Table 4. Question grid: themes of question development, with examples.

	Interaction internal to farm	Interaction external to farm
Farm level	Role of household in decisions Role of extended family in decisions	Effect of drought or flood on pasture upkeep Effect of increased grain prices on feeding regime
Community/ State/ Nation	Participation in government programs Organizations and other memberships	Effect of mad cow disease on marketing decisions Effect of new neighbor removing adjacent fence

Table 5. Four-fold analysis structure.

<table>
<tr><td rowspan="4">Income relevance</td><td rowspan="2"></td><td colspan="2">Operation type</td></tr>
<tr><td>Exclusively livestock</td><td>Integrated crop and livestock</td></tr>
<tr><td>Part-time</td><td>9</td><td>2</td></tr>
<tr><td>Full-time</td><td>0</td><td>10</td></tr>
</table>

Table 6. Typology class characteristics relative to livelihood systems and values.

		Typology class (number of informants in class)		
	Characteristics	**Exclusive Livestock Part-time (9)**	**Crop-Livestock Part-time (2)**	**Crop-Livestock Full-time (10)**
Livelihood system	**Farm description**	Fields owned, exclusively intended as pasture.	Fields rented and owned, mixture of exclusively intended as pasture and integrated with crop fields	Fields owned, integrated with row crop fields.
	Cultural membership/ heritage	Mixture of new, returning and continuing operators with heterogeneous identification.	Returning to farming, with heterogeneous identification.	Dominantly continuing farming, with identification as commodity farmers.
	Marketing strategy	Some cow-calf at sale barn, mostly direct sales of beef or breeds and contracts.	Mixture of strategies with cow-calves and stockers.	Dominantly cow-calves using sale barn and contracts with relatives. Some stocker/feeder operations.
Values & desired futures	Values	Participation in enjoyable/ wholesome activity. Benefits children, opportunity for entrepreneurship and challenge.	Participation in enjoyable/ wholesome activity. Benefits children.	Soil conservation, land stewardship.
	Future	Few with definite plans	Some with definite plans	Half have family that will continue operation; half unknown or definitely unlikely.

Appendix A. Interview Protocol

1. Descriptive questions

What's the purpose of your herd? Income-wise, hobby-wise. . .

Farm – layout, breeds, life stage, crops, grasses, acreage

Farm location – how much is high or low corn suitability rating (CSR)?

History

Family. Self-identity as "heritage, new idea?'

Organizations engaged in

Publications commonly read or subscribed to

Relevance to income. "Some people say they're hobby farmers, others consider cattle farming their main income. Others are retired full-timers. Where does this fit for you?"

2. Structural questions

Why cow-calf (CC) and cattle (vs. other livestock, corn-soybean farming, recreation). If you had a slogan for your farm, what would it be?

<u>Relationships</u>
-Family contribution to management
-Family relationships in cattle purchases
-Neighbor-relations, demographic changes
-New relationships, changing relationships. Like sprayers on crop ground, or . . .
-Peer groups. How do your friends and foes influence how you do things?

<u>Agency use/policy</u>
-What agencies do you use?
-Organizations? Relation within those. Desire to be part of the organization; need for political clout?
-How have agencies helped you? Hindered you?
-How did you respond to previous programs like when there was a push for early spring calving with marketing in November/December?
-What would be beneficial policies at the local level?

Extension
-Has it, or could it contribute with finances, technical information, social organization?

Marketing
-Typical outlets used
-Influence of consumer preferences and demands
-Participation in "alternative" and "specialty" niches, "why not?"
-Use of "traditional" marketing and slaughter facilities
-Where do your market ideas come from?
-Perspective on future relative to changes in hog and poultry markets

International trends
Cattle ID systems
Disease issues (BSE, mad cow)

3. Contrast questions

Do you like the system you're in? Is this something you want to continue. . .into retirement?

What are limiting factors for you? Land quantity?
Watering systems, fencing . . . ?

How would you prefer it be?

Desired qualities in cattle – breed-wise, health-wise, color. .
Usual outcome in cattle – what's acceptable to take to market? What won't you take to market?

Use of systems. Some have said that they'd like to be using a more intensive system or use new approaches… are you in the same boat? Why don't you?

Reaction to the "get big or get out" idea

How does your CC contribute to you, the area, the county, region, state?

What is Marion County's overall role in the cattle industry?

Concerns about small farms, diversified farms, countryside
Optimisms about…

How would things change to make it smoother, better?

How does/did your cattle operation work in the upbringing of children?
Have you seen your neighbors quit CC, and why did they?

<u>Land values and selling</u>

-Perspective on hunters and land bought by non-residents
-Will future generations be inheriting this land, this system? What do you hope for them?

[If not trained as a farmer] How does your profession affect your operation, affect the cattle industry? Are there others like you?

What is a cattleman to you? What characteristics do cattlemen share?

Appendix B. Full-time Integrated Cow-Calf/Row-Crop Operation Informants.

Informant ID	Cultural membership	Age	Cattle operation size*	Pasture acreage (acres)	Total managed land (acres)
A	Continued	63+	Above average (100)	300	2,000
C	Continued	63+	Above average (100)	?	1,000
E	Continued	31-62	Above average (120).	?	880
H	Continued	31-62	Above average (300). Feeders.	?	1,000
I	Continued	31-62	Average (38)	?	200
J	New	31-62	Above average (60). 10 feeders.	200	?
L	Continued	31-62	Above average (70)	300	4,500
M	Continued	31-62	Above average (65)	500	1,050
N	Continued	31-62	above average (53)	140	2,000
T	Continued	31-62	Above average (50). 25 feeders.	?	370

*County average derived from USDA Agricultural Census, 2002, Table 11: Cattle and Calves – Inventory and Sales: 2002 and 1997, Marion County, Iowa.

Appendix C. Part-time Exclusive Cow-Calf Operation Informants.

Informant ID	**Cultural membership**	**Age**	**Cattle operation size***	**Pasture acreage (acres)**	**Total managed land (acres)**
B	New	31-62	Above average (90). 60 cows, 60 calves/breeds, 30 feeders.	66	280
D	Continued	31-62	Above average (70)	200	200
F	New	31-62	Below average (8). Steers.	40	62
G	New	63+	Above average (200)	1,200	3,200
K	Returning	63+	Average (35)	90	200
O	Continued	31-62	Below average (25)	80	80
P	New	31-62	Below average (10). Steers.	20	20
S	Returning	<31	Above average (75).	225	400
V	Continued	31-62	Below average (20)	50	50

*County average derived from USDA Agricultural Census, 2002, Table 11: Cattle and Calves – Inventory and Sales: 2002 and 1997, Marion County, Iowa.

Appendix D. Part-time Integrated Cow-Calf/Row-Crop Operation Informants.

Informant ID	**Cultural membership**	**Age**	**Cattle operation size**	**Pasture acreage (acres)**	**Total managed land (acres)**
Q	Continued	31-62	Above average (80)	315	540
R	Continued	31-62	Above average (80)	475	725

*County average derived from USDA Agricultural Census, 2002, Table 11: Cattle and Calves – Inventory and Sales: 2002 and 1997, Marion County, Iowa.

Chapter Four. Evaluation of Organic Management Strategies for Native Species Pasture Establishment

A paper to be submitted to *Crop Science*

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INTRODUCTION

A prevailing theme in a study conducted of cow-calf operators in southern Iowa when asked why pastureland works in their operation was a reference to the "marginality" of their pastureland. This response summarizes a combination of land characteristics including steep slope, infertility, limited topsoil, inaccessibility due to surrounding timber or riparian systems, and previous abuse or lack of use. Numerous studies have determined that good grazing management can transform poor grazing land into productive pasture (Elmore, 1992; Turner, 1974) particularly when site suitability is addressed.

Matching site conditions with appropriate management can be a challenge in resource-poor regions such as many pastures in the focus of this study, Marion County, Iowa. Site characteristics, including gentle (1 to 9%) to steep slopes (9% or greater) on soil with limited available phosphorous and organic matter, limit row crop potential. After breaking the native tallgrass sod or removing savannah vegetation, early settlers often seeded these lands to species such as Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundicacea* Schreb.) for use as pasture and forage (Scholl et al., 1955).

Extant individuals of warm-season species native to the original vegetation on such sites have frequently been observed on cool-season species pastures, however. Rosburg (1990) inventoried ten pastures with similar soil and topographic conditions near the study site and enumerated seven native warm-season grasses and eleven native forbs at variable abundances among seeded cool-season species, consistent with earlier work identifying various frequencies of native grasses, forbs and legumes on similar pastures (Pammel et al., 1901; Pammel and King, 1926).

Native perennial warm-season grasses (characterized by C_4 photosynthesis) have been found to be drought tolerant and highly productive during the summer season (Jung et al., 1978; Hall et al., 1982; Krueger and Curtis, 1979). A Nebraska grazing study showed that rotating animals from cool-season to warm-season and back to cool-season paddocks resulted in higher average gain than leaving animals on cool-season grasses during the entire period (Conard and Clanton 1963). Similar experiments in other locations generated complementary results (Samson and Moser, 1982; Wedin and Fruehling, 1977).

The use of warm-season species in pastures as “prairie paddocks” on marginal sites may match the farmer’s needs for summer forage under low input, limited site biophysical characteristics, and constraints such as limited access, small available area, and a desire to protect natural resources. The implementation and facilitation of native prairie species in pasture may serve landscape conservation functions as well. Between 80 and 85% of Iowa was originally covered by tallgrass prairie (Smith, 1998), and today less than 0.2% of the former prairie ecosystem remains in a few state preserves and numerous, mostly undocumented and unprotected fragments (Smith, 1992). Tallgrass prairies are known to support high plant species richness and diversity of vegetative and animal populations (Frisina and Mariani, 1995; West, 1993).

In light of the fragmentation and rarity of tallgrass prairie systems, some advocate that every remnant habitat within the agricultural matrix be recognized (Jackson, 1999). Conservation theory predicts that species within native habitat islands will lose genetic diversity due to small population sizes and the difficulties of re-colonizing distant remnants once a species has been extirpated (Primack, 1993). With pasture occupying more than 10% of Iowa land and more than 14% of Marion County land (using pastureland of all types; USDA-NASS, 2002), pasture, cow-calf systems and prairie paddocks can contribute to native habitat diversity.

Prevailing literature regarding warm season species establishment in cool-season pasture suggests management strategies that result in rapid existing species elimination. Through tillage methods, pasture is mechanically cultivated and seeded with the desired species to facilitate establishment before existing species regrow (Cox and McCarty, 1958; Wilson and Tilman, 1993). Through chemical methods, either a non-selective herbicide such as glyphosate is sprayed on germinating or newly emerging vegetation to provide a clean seedbed (Wilson and Gerry, 1995; Malik and Waddington 1990), or selective herbicides such as 2,4-D or atrazine are applied to strategically eliminate broadleaf species (Anderson, 1994). Desired species are subsequently seeded to decreased neighboring vegetation and competition.

While both approaches rapidly prepare pastures for desired species establishment, each also has drawbacks. The use of tillage methods on the slopes of marginal pastureland often contributes to soil loss and compromised soil quality as well as the potential loss of desired native species. When non-selective herbicides are used on existing pastureland with intermittent remnant native species, desirable species such as legumes or palatable forbs may be eliminated or reduced (Bragg and Sutherland, 1989; Rosburg and Glenn-Lewin, 1992; Seguin et al., 2001); native species richness decreased (Bragg and Sutherland, 1989; Gillen et al., 1987; Tomkins and Grant, 1977); community equitability decreased (Seguin et al., 2001), and residual herbicide carried over for months after application, resulting in compromised establishment of some seeded species (Bragg and Sutherland, 1989). Use of herbicides also limits marketing options. For operators interested in raising and/or marketing their livestock as certified organic, all land used for forage production must be free from prohibited substances such as synthetic herbicides for at least three years immediately prior to certification (USDA-AMS, 2005). Manipulating and suppressing species through ecological strategies is an option commonly employed in organic management systems. In numerous community studies, suppression of dominant vegetation resulted in temporarily unsaturated communities with opportunities for immigration and germination of other species (Cornell and Lawton, 1992; Howe, 1999; Huston, 1994). This study tested ecological suppression techniques in order to establish native species in an existing pasture.

Establishment and suppression dynamics

The developmental stages of germinating and seedling warm-season grasses and native forbs are significantly influenced by a broad set of environmental factors. Individual species generally require certain levels of soil moisture and soil temperature (Ambrose and Wilson, 2003; Briggs and Knapp, 2001; Potvin, 1993; Sala et al., 1988) and generally react negatively to the presence of litter (Bargelson, 1990; Damhoureyeh and Hartnett, 1997;

Ehrenreich, 1959; Knapp, 1984; Tix and Charvat, 2005). Seedling growth stages also interact with light penetration (Suding and Goldberg, 1999; Olff et al., 1994; Tilman, 1993) and competition from existing vegetation (Bragg and Sutherland, 1989; Foster, 1999; Foster and Gross, 1997; Potvin, 1993; Suding and Goldberg, 1999; Tix and Charvat, 2005).

Rosburg (1990) determined that burning pastures in late March significantly decreased the relative frequency of tall fescue, consistent with other work (Probasco and Bjugstae, 1977). Towne and Owensby (1984) found that Kentucky bluegrass was essentially eliminated by burning at any developmental stage out of dormancy. Defoliation through cutting or grazing has been shown to affect the vigor of cool-season species when applied at particular growth stages (Eastin et al., 1964; Johnson, 1989; Reynolds and Smith, 1962; Willson and Stubbendieck, 2000). Warm-season species are susceptible to depleted carbohydrate reserves due to untimely or repeated defoliation (White, 1973; Willson and Stubbendieck, 2000), and, in general, forbs and many native legumes have an elevated apical meristem after growth begins and are thus susceptible to injury by defoliation as well (Ehrenreich and Aikman, 1963).

Many studies have suggested that events occurring during seed dispersal, germination, and seedling establishment determine the fate of individual plants (Foster and Gross, 1997; Grubb, 1977; Harper, 1977), and that the environment and neighbors immediately surrounding a seedling are of critical importance in determining the composition of plant communities (Fowler, 1988; Foster, 1999). Facilitating the conditions most amenable to native species germination and emergence is likely to facilitate successful establishment.

Kemp and Williams (1980) suggested that because introduced cool-season grasses grow faster and begin growth earlier than native warm-season species, these species possibly exploit resources and prevent warm-season species establishment on shared sites. In situations marked by such site pre-emption, dominants may remain competitively superior under either competitive tolerance or suppression (MacDougall and Turkington, 2004). This theory suggests that changing competitive conditions through methods such as burning, tilling, mowing or grazing shifts competitive interactions (Kleijin, 2003; MacDougall and Turkington, 2004).

In an experiment in which the competitive dominance was shifted by management practices in favor of warm-season grass establishment over smooth brome (*Bromus inermis* Leyss.), Willson and Stubbendieck (2000) determined that, at a low tiller density, the competitive effect of suppression by native grasses was not strong enough for complete suppression of smooth brome. Increasing tiller density of warm-season species was correlated with increased inhibition of smooth brome tillering, however, which is consistent with other studies (Hertz, 1962; Willson and Stubbendieck, 2000).

On-farm research has been used to develop recommendations that are representative of regional dynamics with location specificity (Tripp, 1991). This approach incorporates aspects affecting whole farm management such as land and labor availability, cost of practice, effect on adjacent fields and on neighbors, and farming system objectives (Shaner et al., 1981). Our hypothesis was that, through on-farm research, a native prairie pasture system could be developed, matching site-specificity with the economic, social and cultural objectives of the farm family.

Study Objectives

This study intended to exploit ecologically based, organic management practices to suppress undesired existing vegetation while optimizing conditions for native species establishment. We specifically compared mowing, controlled grazing and no treatment in the establishment of a diverse native, warm-season species paddock in an on-farm research trial on marginal existing pasture in Marion County, Iowa. Management packages that were considered feasible for working farms and commonly used in pasture management were tested, including prescribed burns and spot removal of invasive species. The effect of these practices on the establishment success of big bluestem *(Andropogon gerardii* Vitman.), little bluestem (*Andropogon scoparius* Michx.), indiangrass (*Sorghastrum nutans* (L.) Nash ex Small), Illinois bundleflower (*Desmanthus illinoensis* Michx.), purple prairie clover (*Dalea purpurea* Vent.), round-headed bush clover (*Lespedeza capitata* Michx.), showy tick trefoil (*Desmodium canadense* (L) DC), and Maximillian sunflower (*Helianthus maximiliani* Schrad.) was monitored for three seasons. The effect of these practices on the existing pasture community was evaluated to determine if particular strategies more effectively foster the seeded species growth relative to existing species suppression.

MATERIALS AND METHODS

Experimental Sites

The experiment was conducted from 2003 to 2005 on two sites (designated as "north" and "south") located on a farm in southern Marion County, Iowa. The farm is located in USDA hardiness zone 5a (U.S. National Arboretum, 1990); 41°10' lat., 93°00' long. (Fig. 1).

The area is characterized by the Gosport-Pershing-Gara soil association with gentle to steep slopes, well-drained to somewhat poorly drained soils that formed in residuum from shale, glacial till, and loess on uplands (Russell and Lockridge, 1980). The dominant soils at experimental sites are silty loam Clinton (alfisol) and Gosport (inceptisol) (Russell and Lockridge, 1980). The north experimental site has a 40° northeast aspect with a 12% mean slope. The south experimental site has a 71° southeast aspect with a 13% mean slope.

The experimental sites were on a fallow pasture dominated by tall fescue (*Festuca arudinacea* Schreb.) and other introduced pasture grasses and broadleaf species. The farm family had no records or recollections of the site being plowed or row cropped, although portions of the land are severely eroded, suggesting previous soil disturbance. The farm family observed infrequent native grasses, composites and legumes on each site before the experiment began. The sites are surrounded by deciduous forest and located near a first-order stream.

Site preparation

A prescribed burn was applied to the entire experimental area on 24 April 2003, when the majority of the dominant fescue was in the mid- to late-elongation stages (Willson and Stubbendieck, 1997). All existing vegetation in the experimental sites and surrounding area (a perimeter of 10 m) was homogeneously burned under a ring firing technique (Pauly, 1997).

Soil samples were taken from each experimental unit on 30 April 2003, and on 24–25 May 2005, following standard soil sampling procedures (ISU Extension, 2003). Soils were analyzed for phosphorous (Bray-1), potassium (Mehlich-3), calcium (Mehlich-3), pH (1:1), and organic matter at the Soil Testing Laboratory at Iowa State University (Ames, IA). VolcanaPhos™ (Midwestern Bio-Ag, Blue Mounds, WI), a phosphorous source that can be used in certified organic production, and Ca CO_3 were applied with a fertilizer spreader at a rate of 336.3 kg ha^{-1} and 2241.7 kg ha^{-1} ECC, respectively, on 18 June 2003, to both experimental sites, based on soil analysis results and farmer preference.

Soil electrical conductivity (EC), used to measure the electrical conductivity of bulk soil, which is primarily a function of soil salinity, cation saturation percentage, water content, and bulk density (Corwin and Lesch, 2003), was determined in order to characterize any spatial variation in EC that could be correlated with site productivity (Johnson et al., 2001; Kitchen et al., 1999; Kitchen et al., 2003). Electrical conductivity measurements were taken in four sub-quadrats (0.04 m^2) in each topographic position of each treatment strip with the EM-38™ (Geonics Limited, Mississauga, ON, Canada) in the north experimental site on 2 October 2004, and 24 May 2005, and on 8 October 2004, and 25 May 2005, in the south site. Mean EC values per topographic position in each treatment strip were calculated.

Experimental seeding

The design of the two experimental sites was identical in treatments and blocking (Fig. 2), but due to variability in site characteristics and farmer-managed practices, each site was analyzed separately. Each site covered an area of 46 x 160 m and was seeded with southern Iowa local-ecotype, native seed mixture acquired from Osenbaugh Seed Company (Chariton, IA) composed of big bluestem, little bluestem, indiangrass, Illinois bundleflower, purple prairie clover, round headed bush clover, showy tick trefoil, and Maximillian sunflower (Table 1). The mixture composition (Tables 2a and 2b) were selected on the basis of farmer preference, functional group diversity (Tilman et al., 1996; Tilman et al., 1997), documented mid- to late-summer palatability, life cycle traits, documented historic presence in south-central Iowa, and seed price. Seeding volume per species and in total was designed to reflect guidelines by NRCS (1997).

Seeding occurred on 15 May 2003, with a 2.4-m Truax™ no-till drill. The no-till drill created a 0.64-cm deep furrow in the sod, releasing the calibrated seed content, and partially covering each furrow. A designated area (2.73 x 46 m each) at six topographic positions along the slope of the experimental sites was excluded from seeding to permit sampling of existing vegetation for pre-existence of native species in the seed mixture.

Experimental design

The experimental sites were arranged in a complete block design of two blocks measuring 23 x 160 m (Fig. 2). Each block consisted of three treatments. Five plots, in a contiguous column from the base to the apex of the slope, were superimposed on the treatments in order to assign five topographic positions in each block (Fig. 2). Because these positions were not identical across both sites, the information collected from these areas was not statistically analyzed, but was evaluated to determine trends along the slope of the site. Management treatments consisted of mowing, grazing, and no management (control). Plots receiving the mowing treatment or no management were 7 x 32 m and plots receiving the grazing treatment were 9 x 32 m to allow for an adequate area for cattle movement and turning. Each plot included a 2.74 x 7 or 9 m (relative to treatment received) control non-seeded strip that was not seeded but received the treatment. Each non-seeded strip was separately sampled for the presence of extant native species that were included in the experimental seed mix.

Management practices within treatments

Researcher-managed trials in on-farm research attempt to simulate farmers' conditions to the greatest extent possible. Experimental treatments need to reflect a realistic management package that corresponds with a farmer's priorities and concerns (Shaner et al., 1981). In this experiment, the farm family was concerned about control of invasive species and the prevention of thorny species establishment which could deter grazing. For this reason, each treatment was uniformly inspected and managed for multiflora rose (*Rosa multiflora* Thunb.), honey locust (*Gleditsia triacanthos* L.), and musk and bull thistles (*Carduus nutans* L. and *Cirsium vulgare* [Savi] Ten.). Within each treatment, these target plants were cut off with a lopper at 5 cm above the soil surface throughout the experimental years.

Mowing management

In order to reflect realistic on-farm mowing management, the mowing treatment was designed and implemented with guidance from the Natural Resources Conservation Service (NRCS, 1997; NRCS-Iowa, 1998). A combination of tractor-pulled and self-propelled rotary mowers was used to apply each mowing treatment. The date and frequency of mowing was determined on an observational basis and was guided by NRCS literature. Mowing occurred when vegetation exceeded 18 cm in 2003 and 30 cm in 2004. In 2005, the sites were mowed at an 8 cm height only at the beginning of the growing season (Table 3). The mowed cuttings were left on the plots.

Grazing management

The grazing treatment was designed to balance realistic on-farm cattle management decisions with a specific management tactic. Flash grazing, typically a short-term, one-time grazing event at a high stocking density that forces improved distribution of grazing animals within a pasture (Schacht et al., 1996), was used in this treatment. This system of grazing was used in order to reduce animal selectivity, resulting in low defoliation heights and homogeneous grazing (Schacht et al., 1996).

The grazing treatment reflected on-farm management decisions, as determined by the farmer. The grazing management decisions were predicated by water availability for the cattle and by time availability relative to other farm tasks. When the experimental sites had substantial vegetation and the creek provided substantial water, the family transported the cattle to the experiment.

High-tensile, PVC-wire with pigtail posts was used to construct an electric fence perimeter of the grazing treatment area. Polywire gates could be opened or closed to regulate cattle entry. Polywire lanes adjacent to the gates were constructed to provide assess to a nearby creek, which served as the water source. The fence was removed each winter to be re-established in the spring.

As shown in Table 4, grazing intensity varied among the experimental sites and years. The low precipitation in 2003 and late 2004 resulted in a lack of water availability in the creek and, therefore, prohibited substantial grazing in the south experimental site. The grazing treatment was removed from the south experimental site in 2005 due to farm labor constraints.

No management

After burning on 24 April 2003, the no management treatment (control) remained unmanaged during the first two years of the experiment (2003–2004). On 1 May 2005, a prescribed burn following a ring firing technique (Pauly, 1997) was executed to control unwanted species, according to the farmer's specifications.

Data Collection

The dates and types of measurements taken, including the presence or absence of a particular species and leaf area index can be found in Tables 5, 6, and 7.

Presence-absence and community inventory

In order to determine the presence or absence of a particular species, a 1-m^2 frequency grid (Vogel and Masters, 2001) was randomly placed in five locations (correlated with topographic positions down the slope) within each treatment. Samples were taken within five 0.04-m^2 sub-quadrats per quadrat placement. Vegetative height was recorded for each quadrat. The presence or absence (denoted as a 1 or 0 respectively) for each identifiable seeded species was recorded for each 0.04-m^2 sub-quadrat. In 2003, the only identifiable species observed for presence or absence criteria were native grasses, Illinois bundleflower, and purple prairie clover. In 2004 and 2005, all seeded species were observed for presence or absence. For the north experimental site, in 2003, I made 5 observations (sampled 5 sub-quadrats) within a 1-quadrat sample for each of the 5 topographic positions within each treatment (total of 25 observations). In 2004, 2 quadrat samples yielded 10 observations for each of the 5 topographic positions within each treatment (total of 100 observations), and in 2005, 4 quadrat samples yielded 20 observations for each of the 5 topographic positions within each treatment (total of 200 observations). For the south experimental site, in 2003, 1 quadrat sample yielded 5 observations. In 2004, 2 quadrat samples yielded 10 observations, and in 2005, 3 quadrat samples yielded 15 observations. The presence of each seeded species was analyzed as a percentage of total observations.

All species present in each of the 5 samples per quadrat were recorded in the July 2005 sampling period yielding 20 inventories per topographic position in the north experimental site and 15 inventories per topographic position in the south site. Species were identified using identification procedures developed by Stubbbenbieck et al. (1995), Christiansen and Müller (1999) and Barnes et al. (1995), and were verified using taxonomic keys in Steyermark (1963) and Rydberg (1965). The frequency of each identified species per sample was recorded.

Biomass assessments

For both experimental sites, in August of each year of the study (2003 to 2005), a 25 x 25 cm (0.1-m^2) quadrat was randomly placed on each topographic position and the height of the total existing vegetation was measured. All living and dead vegetation was cut within the quadrat at ground level. Data was recorded from 1 quadrat per topographic position per treatment in 2003 and 2004, and 4 quadrats per topographic position per treatment were acquired in 2005. Biomass samples were dried for 72 hours at 67°C and weighed. The mean dry weight was recorded for each sample.

Non-seeded topographic position measurements

For each non-seeded area, the presence or absence of seeded native species was measured within one randomly placed 1-m^2 quadrat per topographic position per treatment area. Five 0.04-m^2 sub-quadrat samples were observed for each seeded species. Each experimental site was surveyed in August 2003 and in August 2004. The percentage of the presence of each seeded species per each experimental unit was recorded.

Radiation measurements

Solar radiation penetration through the vegetative canopy was measured with the LAI-2000 Plant Canopy Analyzer (LI-COR, Inc., Lincoln, NE). By using DIFN (diffuse non-interceptance), values between 0 and 1 were assigned, based on the probability of diffuse radiation from the upper hemisphere penetrating the canopy to a particular location (LI-COR, Inc., 1992). Four replications per topographic position were taken on days when the sun was obscured by cloud cover with a 90° view cap. This DIFN measurement was averaged by LAI-2000 software and recorded per topographic position.

Weather Conditions

Monthly mean precipitation and monthly mean temperatures from the Knoxville, Iowa, NWS COOP Network climate station was acquired from Iowa Environmental Mesonet (2005). The Knoxville station was the closest location to the experimental site.

Data Analysis

All field data were analyzed using analysis of variance with mixed models (Littell et al., 1996). Differences among treatments were obtained through Least Square Means and statistically separated using Tukey's studentized range (HSD) means comparison test at $p \leq 0.05$ significance level. An analysis of covariance was applied to the specific soil characteristics (Bray P, K, pH, Ca, O.M., and EC) against the species frequency variables to examine any variability in the experimental units that could not be controlled by the design structure (Littell et al., 1996). Results were statistically separated using Fisher's Protected LSD at $p \leq 0.05$.

RESULTS AND DISCUSSION

North Site

The establishment of seeded native species into existing pasture was successfully completed in the grazing and mowing treatments on the north site, but results varied based on species and year. Background presence of native species prior to the experiment was not significant, as the frequency of finding existing native species was low in non-seeded control strips in 2003 and 2004 (Table 8). Native grasses (specifically big bluestem and indiangrass) were present in less than 5% of samples in control strips, and other species were similarly absent or sparse across all treatments and topographic positions. This presence was considered during interpretation of the results, but did not impact the evaluation of management techniques.

The frequency of seeded native species declined in the grazing and control treatments from 2003 to 2005, with only a small but non-significant increase in the mowing treatment (Fig. 3). By the end of the third year of the experiment, native species were observed in 65% of samples from the mowing treatment and ≈50% from the control and grazing treatments. The overall frequency of seeded legume species also decreased from 2003 to 2005 (Fig. 4), and by August 2005, native legumes were present in 22% of control treatment samples, 10% of mowing treatment samples, and 7% of grazing treatment samples. The seeded native grasses, however, increased from 2003 and 2005 in the grazed and mowed plots (Fig. 5), and by August 2005, native grasses were present in 61% of mowing treatment samples, 46% of grazing treatment samples and 36 % of control treatment samples.

Treatment Effects

In order to examine the specific effect of the three treatments on native plant establishment and growth, individual responses by treatment are discussed below. Frequency of species observance within quadrat samples and overall relative abundance were evaluated for each species.

Control treatment

In the control treatment, seeded native species declined over the three years of the experiment, tending to occur at the lowest frequency compared to the other treatments in 2004 and in August 2005 (Figs. 6, 7, 8). Native species in the control treatment were significantly lower than the grazing treatment in July 2004 (Fig. 7). No apparent trends in abundance of native species relative to the total pasture community were observed among the three treatments (Fig. 9).

Native legume species tended to appear the most frequently in the control treatment. The frequency of legume species was significantly higher in the control compared with the other treatments in June 2003 and July 2005, with no significant differences on other sampling dates (Figs. 10, 11, 12). Native legume species relative abundance was significantly greater ($p \leq 0.05$) in the control treatment compared with the mowing and grazing treatments by the end of the third year (Fig.13).

The control treatment appeared to contain the lowest frequency of seeded native grasses among treatments across the years, with the exception of the June 2003 sampling period, where grasses tended to be greater in the control (Figs. 14, 15, 16). Grasses in the control treatment were significantly lower than all treatments in July 2004, and significantly lower than the mowing treatment in August 2005 (Figs. 15 and 16). There was also a trend ($P \leq 0.10$) towards lower native grasses in the control compared to the mowing treatments in August 2004 (Fig. 16). The control treatment also tended to have the lowest relative abundance of native grasses in the pasture community among all treatments, with a trend ($P \leq 0.12$) towards lower populations than the mowing treatment (Fig. 17).

Specific legume and forb species varied in their response to treatments, with Illinois bundleflower (Fig. 18) and purple prairie clover (Fig. 19) decreasing from 2003 to 2005. There was a trend, however, towards increasing populations of bush clover (Fig. 20), tick trefoil (Fig. 21), and Maximillian sunflower (Fig. 22) across the years in the control treatment.

Community structure

In the pasture community structure census (i.e., site inventory of native and introduced species), the highest ratio of native legume species to all introduced agricultural species occurred in the control treatment (Table 9), along with the highest ratio of native legume species to introduced agricultural legume species (Table 9). The relative abundance of introduced agricultural grasses in the control treatment was significantly lower than all treatments (Table 9).

The control treatment tended to have the lowest relative abundance of total (native and introduced agricultural) legume species compared to the other treatments (Table 9), which was notably lower ($P \leq 0.08$) than the mowing treatment. This result contrasts with the relative abundance of *native* legume species to the total community, which was significantly greater than all other treatments. The control treatment had significantly higher species richness than the mowing treatment, with 29 species compared to 22.6 species per quadrat sample in the mowed plots (Table 10). There was also a trend toward greater species richness compared to the grazing treatment ($P \leq 0.06$) (Table 10).

Stand structure

The control treatment consistently had the lowest DIFN, or most complete canopy preventing light penetration, which was significantly lower than all treatments in 2004 (Table 10). Overall vegetative biomass in the control treatment tended to be greater than mowed and grazed plots in 2004 and 2005, but because of variability across plots, significant differences among treatments were not observed (Table 10).

Control treatment discussion

The highest absolute abundance and relative abundance of legume species in the control treatment compared to the other treatments corresponded with low light penetration (low DIFN), greater community richness, and low relative abundance of introduced agricultural grasses in the north experiment. Some studies on legume establishment contrast with these results while others support our observations. Tix and Charvat (2005) determined that forb populations, including bush clover, increased in tallgrass prairie communities following litter removal such as burning or raking. However, some studies (Fowler, 1986; Lauenroth and Dodd, 1979; Towne and Knapp, 1996) found that water availability may be an important factor limiting legume populations; below average precipitation during the fist year of the experiment may relate to low legume survival (see Weather Effects below). Other studies (Fowler, 1986; Suding and Goldberg, 1999; Wilson et al., 2004) suggest that vegetation and litter ameliorate moisture stress, outweighing light availability for successful establishment of seedlings under stressful abiotic conditions.

The community richness observed in control plots was consistent with some studies but contrasted with others. Foster and Gross (1997) and Tilman (1993) determined that the decreased light penetration caused by litter increased mortality and decreased species richness. However, Wilsey and Polley (2003) found that litter removal had no effect on diversity but that light availability did influence seedling emergence.

Grazing treatment

In the grazing treatment, seeded native species declined over the three years of the experiment (Fig. 3), tending to vary substantially among the months and years of the experiment (Figs. 6, 7, 8). Native species populations in the grazing treatment were significantly higher than the control only in July 2004 (Fig. 7). Although there appeared to be less native species in the grazing treatment, relative abundance of native species was statistically equivalent among the three treatments (Fig. 9).

The frequency of native legume species tended to be more similar between the mowing and grazing treatments than the control plots throughout the experiment (Figs. 10, 11, 12). The grazing treatment tended to have the lowest relative abundance of native legume species among all treatments–significantly lower than the control treatment (Fig. 13).

Native grasses in the grazing treatment were routinely present at lower frequencies than in the mowing treatment in 2004 and 2005. Only in July 2004, however, were more native grasses observed in the grazed and mowed plots compared to the control (Figs. 14, 15, 16). There were no differences among treatments in grass relative abundance (Fig. 17).

Specific legume and forb species varied in their response to treatments, with Illinois bundleflower (Fig. 18) and purple prairie clover (Fig. 19) initially at the highest frequency among treatments in the grazing treatment in the first year, but declining to negligible levels by the third year. Bush clover was consistently present at lower numbers in the grazing treatment compared to other treatments (Fig. 20). Similar populations of tick trefoil (Fig. 20) and Maximillian sunflower (Fig. 21) were found in the grazed and mowed plots throughout the years of the experiment.

Community structure

In the pasture community structure census, there was a trend towards lower ratios of seeded native legume species to all introduced agricultural species in the grazing treatment

(Table 9). This ratio was significantly lower than the control, but not the mowing treatment. There was also a trend towards a lower ratio of native legume species to introduced legume species in the grazing treatment, which was significantly lower than the control but not the mowing treatment (Table 9).

Relative abundance of the introduced agricultural grasses was significantly higher than all treatments in the grazing treatment (Table 9). The grazing treatment had an intermediate relative abundance of total (native and introduced agricultural) legume species compared to other treatments, but this ratio was not significantly different from the control or mowing treatments (Table 9). The grazing treatment also had an intermediate species richness compared to other treatments, which was not significantly different from the other treatments (Table 10).

Stand structure

The grazing treatment had the highest DIFN, representing the most open canopy among treatments, in 2004 and in 2005, and was significantly higher than other treatments in 2005 (Table 10). Overall vegetative biomass in the grazing treatment tended to be intermediate among the treatments, but because of high variability among plots, significant differences among treatments were not observed (Table 10).

Grazing treatment discussion

Although not tested in this experiment, the lowest absolute and relative abundance of legume species in the grazing treatment may have been correlated with selective grazing of legumes by cattle. Numerous studies have demonstrated cattle's preferential grazing of legumes (Harmoney et al., 1998) and palatable native forbs and legumes (Berg, 1990; Hickman and Hartnett, 2002), although the effect of grazing varied by grazing intensity. Berg (1990) found that grazing was negligible on purple prairie clover populations but significantly lowered Illinois bundleflower populations in Oklahoma.

Community richness in the grazing treatment was at an intermediate level compared to the other treatments, similar to some studies on the effect of grazing on community composition. Damhoureyeh and Hartnett (1997) observed a competitive release of subdominant species caused by grazing of dominant species, leading to heterogeneous patches associated with fewer dominant species, increased light penetration and warmer soil temperatures. Hartnett et al. (1996) showed greater microsite diversity as a result of preferential cattle grazing behaviors.

Mowing treatment

In the mowing treatment, seeded native species were stable compared to a declining population in the other treatments (Fig. 3). Seeded native grasses in the mowing treatment remained at high levels in the mowed plots, unlike the native legume species (Figs. 4, 5). There was a trend towards a higher frequency of native species within mowed plots compared to other treatments over three years, with significantly greater native species found in the mowed and grazed plots in July 2004 compared to the control (Figs. 6, 7, 8). Although there appeared to be a greater relative abundance of native species in the mowing treatment, no significant differences in relative abundance of native species were observed among the three treatments (Fig. 9).

The frequency of seeded legume species in the mowing treatment was similar to the grazing treatment–significantly lower than the control in June 2003 and in July 2005 (Figs. 10, 11, 12). There was a trend ($P \leq 0.09$) towards a lower frequency of seeded legume species in the mowing treatment compared to the grazing treatment in August 2003 (Fig. 10). The mowing treatment had an intermediate relative abundance of native legume species, significantly lower than the control treatment (Fig. 13).

Grasses tended to appear most frequently in the mowing treatment in the final sampling periods of the experiment (Figs. 14, 15, 16). The frequency of native grass species was significantly greater in the mowing and grazing treatments compared to the control treatment in July 2004 (Fig. 15) and in August 2005 (Fig. 16). The mowing treatment tended to have the highest relative abundance of native grasses in the pasture community among all treatments, with a trend ($P \leq 0.12$) towards higher populations than the control treatment (Fig. 17).

Specific legume and forb species populations varied over time, with Illinois bundleflower (Fig. 18) and purple prairie clover (Fig. 19) decreasing from 2003 to 2005 in the mowing treatment. Bush clover frequency was intermediate between the control and grazing treatment, and tended to increase from 2004 to 2005 (Fig. 20). Tick trefoil (Fig. 21) and Maximillian sunflower (Fig. 22) populations were similar in the grazing and mowing treatments with a slight increase from 2004 to 2005.

Community structure

In the pasture community structure census, the mowing treatment had an intermediate ratio of seeded native legume species to introduced agricultural species, which was significantly lower than the control but not the grazing treatment (Table 9). There was a trend ($P \leq 0.08$) toward a higher relative abundance of total (native and introduced agricultural) legume species in the mowing treatment compared to the control (Table 9). This result contrasts with the relative abundance of *native* legume species in the community, which was significantly lower than the control treatment (Fig. 13). The relative abundance of introduced agricultural grasses was significantly greater than the control, but significantly lower than the grazing treatment (Table 9). The mowing treatment had significantly lower species richness than the control treatment, with 22.6 species per quadrat compared to 29 species per quadrat. While there was a trend towards lower species richness in the mowing treatment, differences with the grazing treatment were not significant (Table 10).

Stand structure

The mowing treatment had the highest DIFN, representing the most open canopy among treatments in 2003, with an intermediate DIFN in 2004 and 2005 (Table 10). Overall vegetative biomass in the mowing treatment tended to be lower than grazing and control treatments across years, but because of high variability across treatment plots, significant differences among treatments were not observed (Table 10).

Mowing treatment discussion

The mowing and grazing treatments generally had the highest absolute and relative abundance of native grasses compared to the control treatment. This result appeared to correspond with the lower canopy cover (high DIFN) and lower community richness. Numerous studies have correlated successful grass seedling establishment to low litter and lack of neighbor presence (Bargelson, 1990; Foster and Gross, 1997; Potvin, 1993) and light penetration to greater germination (Olff et al., 1994) or emerging seedlings (Gibson, 1989).

Although studies have correlated the light penetration facilitated by mowing to increased community richness (Collins et al., 1998), these results suggest that the non-selective elimination of biomass through mowing may have pushed the system towards lower community richness. In addition, mowing may have been connected with the trend towards lower absolute and relative abundance of *native* legume species. Mowing at or below 24 cm, the height of the seeded native legumes' apical meristems, may have been detrimental to these species when applied during particular life stages, including the pre-bud and early reproductive stages. The creeping stolons and prostrate morphology of several introduced agricultural legumes, alternatively, may have persisted under mowing conditions and may have contributed to the high total legume relative abundance in the mowing treatment (MacAdam and Nelson, 2003), although this study did not specifically test this hypothesis.

Species Responses

The response of native legumes and forbs to the three treatments varied by species and time of year (site inventory in Appendix A). Each species planted in the experiment is evaluated below.

Illinois bundleflower

As shown by Figure 18, this species was initially abundant in all treatments in 2003, appearing in 43% of sampling units in the grazing treatment; 37% in the control treatment;

and 32% in the mowing treatment. However, by 2005, populations had declined to 2% in all treatments.

Purple prairie clover

As shown in Figure 19, this legume was initially abundant in all treatments in 2003, appearing in 39% of sampling units in the grazing treatment; 34% in the control treatment; and 28% in the mowing treatment. However, this native clover rapidly declined to very low abundance in all treatments by 2005.

Bush clover

Bush clover populations were too sparse to be reliably sampled in 2003. Greater numbers were observed by 2005, when bush clover appeared in 8% of sampling units in the control treatment; 3% in the mowing treatment; and 1% in the grazing treatment (Fig. 20).

Tick trefoil

Tick trefoil was also too sparse to be reliably sampled in 2003, but increased in abundance by 2005, with greatest numbers in the control treatment (13% of all samples) and in 4% of both grazing and mowing treatment samples (Fig. 21).

Maximillian sunflower

Like bush clover and tick trefoil, Maximillian sunflower populations could not be reliably sampled in 2003. By 2005, 10% of the control treatment; 1% of the grazing and 2% of the mowing treatments' sampling units contained Maximillian sunflower plants (Fig. 22).

Forb species establishment discussion

Jackson (1999) and Berg (1990) each noted a substantial decline in seeded Illinois bundleflower populations in their studies that they attributed to selective grazing of the legume species. Beran et al. (2000) attributed the failure of Illinois bundleflower to establish to competition from weed species. Berg (1990), conversely, noted an increase in purple prairie clover stands in his study. Other studies have demonstrated the exploitative effects of living neighbors in the survivorship of native grasses (Foster and Gross, 1997) and broadleaf species (Reader and Best, 1989). This trend may have been relevant in the decline of Illinois bundleflower and purple prairie clover in our experiment. Wilsey and Polley (2003) also noted substantial emergence of seeded grasses and forbs but very low survivorship throughout the season in their study.

The increased abundances of bush clover, tick trefoil, and Maximillian sunflower from 2003 to 2005 may have been related to delayed germination until the second season. Maximillian sunflower undergoes germination after successive cold-dry and warm-moist stratification (Steffen, 1997) and has been observed to establish several years after seeding (Berg, 1990). Tick trefoil generally germinates after seed scarification (Steffen, 1997). Bush clover germinates best after a combination of cold-dry stratification and acidic scarification (Steffen, 1997). Bush clover may have increased populations due to competitive abilities with grasses related to an erect stem (Brewer, 1947).

Site Characteristic Effects

Soil analysis determined very low P content, averaging 2.9 ppm, and low K content, averaging 107 ppm (Sawyer et al., 2002). Soil analysis determined low organic matter (OM), averaging 3.7%, which is characteristic of the dominant soil types (Russell and Lockridge, 1980). Overall low fertility may have been correlated with treatment effects on native plant establishment and growth. Studies have demonstrated that grazing affects soil chemical properties (Dormaar et al., 1997), but no significant differences were observed in soil properties in the grazing treatment compared to mowing or the control.

Although no significant covariance among site characteristics and native species responses was observed (data not presented), some trends are worth noting, such as electrical conductivity (EC) and native species abundance. In eastern Colorado, the highest EC values were characteristic of eroded surfaces and lower crop yields (Johnson et al., 2001), and in southeastern Iowa, Guretzky et al. (2003) found the distribution of legume species was associated with gradients of slope and EC, with legume species most abundant in soil with intermediate EC values. The EC of soils in the north site declined consistently down slope within treatments, but the native legume populations within treatments or by clumped treatments did not show a response to declining EC.

Weather Effects

Variations in precipitation and temperature during the growing seasons of the experiment may have contributed to native species responses (Table 11). During the first year of the experiment, above average precipitation occurred in June, followed by precipitation substantially below the 1951–2005 mean precipitation in July and August.

During the months of May, July and August 2004, precipitation was above the 1951–2005 mean level. The temperatures throughout the years were generally average.

Numerous studies have determined that soil moisture is critical to successful species emergence (Ambrose et al., 2003; Wilsey and Polley, 2003). Following experimental seeding in May and June 2003, the region received above average precipitation, which may have corresponded with greater observed species frequencies. Precipitation in July and August 2003, however, was substantially lower than average, a situation which may have caused significant stress and mortality among the newly emerged species, and which may have favored individuals in microsites which conserved moisture through shade or litter (Fowler, 1986; Suding and Goldberg, 1999; Olff et al., 1994; Wilson et al., 2004). Briggs and Knapp (1995) and Peters (2000) also found a relationship between successful prairie seeding efforts and precipitation in their studies.

South Site

The south site complemented the trends identified in the north site although the control and mowing treatments displayed larger contrasts in the north site. By the end of the third year of the experiment, native species were observed in 49% of samples from the mowing treatment and 29% from the control treatment (Fig. 23). The overall frequency of seeded legume species decreased from 2003 to 2005 (Fig. 24), and by August 2005, native legumes were present in 37% of control treatment samples and 12% of mowing treatment samples. By August 2005, native grasses were present in 41% of mowing treatment samples and 16 % of control treatment samples (Fig. 25).

Treatment Effects

Pre-experiment levels of native species at the south site were low (Table 12). Thus, treatment effects were explicit to the seeded native species.

Control treatment

Similar trends to the north site were also observed in the south site (Figs. 26, 27, 28) although no significant differences were noted among treatments. No apparent trends in relative abundance of native species were observed between the two treatments (Fig. 29).

In the south site, seeded native legume frequency was not significantly different in the control treatment from other treatments over all experimental years, and no treatment was consistently higher than any other over all years (Figs. 30, 31, 32). Native legume species relative abundance was not significantly different between the treatments (Fig. 33).

Native grass trends were similar to the north site in the south site. Of the three sampling periods in the three years of the experiment (2003, 2004, and 2005), significant differences between treatments were only found in July 2004, when the native grasses in the control treatment were significantly lower than the mowing treatment in July 2004 (Fig. 34, 35, 36). Native grass species relative abundance was not significantly different between the treatments (Fig. 37).

The south site displayed identical trends to the north site regarding the overall decrease of native seeded forbs and legumes (Figs. 38, 39, 40, 41, 42), with the exception of Illinois bundleflower, which was present at similar frequencies each year in the control treatment (Fig. 38).

Community structure

Explicit trends were not distinct in the south site, with no ratios displaying significant differences between treatments although the ratio of seeded native legumes to introduced agricultural legumes was notable ($P \leq 0.07$) (Table 12). The control treatment species richness was not significantly different than the mowing treatment with 27.3 species per quadrat compared to 25.6 species per quadrat (Table 13).

Stand structure

The south site showed similar trends to the north site, with lower light penetration in the control treatment compared to the mowing treatment ($p \leq 0.06$) in 2005. There was also significantly greater biomass in the control treatment in 2004 compared to the other treatments, and a trend toward higher overall vegetative biomass in the control treatment over all experimental years (Table 13).

Mowing treatment

Similar trends were noted in the south site compared to the north site (Figs. 26, 27, 28), as the grass frequencies remained stable throughout the experiment and there were no significant differences between treatments. No apparent trends in relative abundance of native species were observed between the two treatments (Fig. 29).

In the south experiment, seeded native legume frequency was not significantly different in the mowing treatment from other treatments over all experimental years, and no treatment was consistently higher than any other over all years (Figs. 30, 31, 32). There was a trend towards a higher frequency of native legumes in the mowing treatments, however.

Native legume species relative abundance was not significantly different between treatments (Fig. 33).

Native grass trends were similar in the south site to the north site. Native grasses in the mowing treatment were significantly higher than the control treatment in July 2004 and notably higher than the control treatment in August 2005 ($p \leq 0.07$) (Figs. 34, 35, 36). Native grass species relative abundance was not significantly different between the treatments (Fig. 37).

In the south site mowing treatment, specific legume and forb species trends were similar to the north site. Illinois bundleflower and purple prairie clover each declined over the years (Figs 38, 39) while bush clover, tick trefoil and maximillian sunflower all increased from 2004 to 2005 (Figs. 40, 41, 42). Bush clover was more frequent and increased more from 2004 to 2005 in the south site mowing treatment compared to the north site, but similar to the south site control treatment.

Community structure

Community trends were less distinct in the south site compared to the north site in the mowing treatment, with no significant differences between treatments in ratios of legumes and grasses, and displaying trends similar to the control (Table 14).

Stand structure

The south site showed similar trends to the north site, in that the control treatment in 2003 excluded light penetration (significantly lower DIFN compared to the grazing and mowing treatments) (Table 14). There was a trend of higher light penetration in the mowing treatment ($p \leq 0.06$) in 2005 compared to the control. Overall vegetative biomass was lower than the control treatment, with a significant difference in 2005 (Table 13).

Species Responses

The response of native legumes and forbs to the three treatments varied by species and time of year (site inventory in Appendix B). Each species planted in the experiment is evaluated below.

Illinois bundleflower

In the south site, the Illinois bundleflower initial populations were similar among all treatments, but by the last year, populations declined in the mowing treatment while maintaining initial population levels of roughly 33% in the control treatment (Fig. 38). This persistence contrasts to the north site.

Purple prairie clover

As shown by Fig. 39, purple prairie clover was initially abundant among all treatments in the south experiment, but declined in a manner similar to the north site by 2005.

Bush clover

Bush clover populations were too sparse to be reliably sampled in 2003. Greater numbers were observed by 2005, when bush clover appeared in roughly 5% of the control treatment samples and 4% in the mowing treatment (Fig. 40) in trends similar to the north site.

Tick trefoil

Tick trefoil was also too sparse to be reliably sampled in 2003, but increased in abundance by 2005, with equal frequency of roughly 5% in the south site treatments. Tick trefoil was observed less frequently compared to the north site.

Maximillian sunflower

Like bush clover and tick trefoil, Maximillian sunflower populations could not be reliably sampled in 2003. By 2005, roughly 7% of experimental units in control and grazing treatments contained sunflower plants (Fig. 41).

Site Characteristic Effects

Soil analysis determined very low P content, averaging 3.1 ppm, and optimum K content averaging 157 ppm (Sawyer et al., 2002). Soil analysis determined low organic matter (OM), averaging 4.8%, which is characteristic of the dominant soil types (Russell and Lockridge, 1980). Overall low fertility may have been correlated with treatment effects on native plant establishment and growth. Studies have demonstrated that grazing affects soil chemical properties (Dormaar et al., 1997), but no significant differences were observed in soil properties in the grazing treatment compared to mowing or the control.

Integration of Effects

Establishment of native species without herbicides

Previous research has suggested that successful establishment of native species requires sowing in a competition-free, clean seedbed as established through herbicides or tillage (Anderson, 1994; Bragg and Sutherland, 1989; Wilson and Gerry, 1995; Wilson et al., 2004). Results presented here, however, suggest that establishment of native species, sown into existing mixed pasture stands, can be achieved through management techniques, including grazing and mowing.

Management throughout the experiment was selected in the interest of suppressing existing cool-season dominant grasses to allow the warm-season species to survive. Numerous studies suggest that burning smooth brome or fescue during their pre-elongation stages stresses their carbohydrate storage and subsequently suppresses their vigor (Wedin and Fruehling, 1977; Willson, 2000; Willson and Stubbendieck, 1997). Others suggest that mowing or vegetation removal resembles the effects of fire (Davison and Kindscher, 1999). Diboll (1986) and Old (1969) showed a significant decrease in Kentucky bluegrass with mowing, while Johnson (1989) also showed decreases in tall fescue with strategic mowing.

With relative abundance of native grasses and total native species statistically equivalent among treatments, we can deduce that all treatments affected the pasture community similarly in relation to native grass and total native species establishment. The legume species relative abundance, however, was significantly different between treatments, with the control treatment exhibiting higher legume relative abundance compared to all treatments.

The burn conducted in the third year exclusively in the control treatment may have been associated with the increased native legume populations in the control treatment, which is supported by studies of Tix and Charvat (2005) and Towne and Knapp (1996). The relative abundance of the introduced agricultural grasses, however, also differed among treatments, with the control treatment having the lowest relative abundance of introduced agricultural grasses and the grazing treatment the highest. While fire has been reported to decrease grass vigor, overall grass frequency remains unaffected. Briggs and Knapp (2001) showed that forbs are constrained by their interactions with grasses. This hypothesis suggests that the control treatments, as evidenced by their high species richness, provided more opportunities for diverse species to establish at the expense of the dominant introduced agricultural grasses. This trend was unique to the north experiment, as the south experiment exhibited none of these trends.

Weather impacts had a definite effect on native species establishment and growth. The north experiment lies with a northeast aspect and the south experiment with a southeast aspect. North-facing aspects are much less subject to direct solar radiation and the consequences of evaporation and heat compared to south-facing aspects. These factors could have contributed to differences between the sites and results that may have occurred without the initial drought.

Competitive abilities of species

Interspecific competition among diverse community members can be classified as preemptive or overgrowth competition (Morin, 2002). The establishing native grass and forb seedlings experienced strong overgrowth competition from existing vegetation that may have reduced photosynthetic capabilities in native species. Through erect growth and undamaged physiological processes, a large portion of the seedling native grasses acquired adequate resources to grow and shift the neighboring overgrowth competition. Successful establishment was particularly evident in the mowing treatment, in which the neighboring overgrowth was homogenously lowered during periods in the native grass lifecycle in which native grasses rapidly outgrew the pressure exerted from neighboring species. In the grazing treatment, neighboring, as well as the native, grasses were grazed below the apical meristems, with the consequence of slow regrowth between both classes and the loss of the opportunity to outgrow the neighbors. The native species may have eventually died due to the preemptive competition for radiation and soil resources continuously exerted by the existing neighbors.

The native legumes also experienced preemptive and overgrowth competition, with morphological and physiological features preventing any opportunity to overcome this competition. All exhibited determinate growth in which stem growth ceases upon shoot apices developing into inflorescences. This trait prevents strong persistence under defoliation (Mitchell and Nelson, 2003). In addition, as upright perennial forbs, the shoot apex is located at the top of plant, which is also detrimental. When the shoot apex is removed, that plant must regrow from axillary buds at the base of the stems, at significant energetic cost to the plant (Mitchell and Nelson, 2003). In the mowing and grazing treatments, the legumes consistently experienced defoliation and the costs of regrowth. In the control treatment, the overgrowth and preemptive competition of the surrounding vegetation may have been less prohibitive to survivorship than the stresses of the vegetative removal treatments. The stress was great enough, however, to prevent high native legume or grass species abundance within the control treatment.

Reconstruction versus replacement

These results suggest that in a low-productivity, partially stressed and frequently managed pasture community, existing dominants can be adequately suppressed to allow establishment of new species. The management practices used, and these new species, however, did not lead to higher community species richness, which is a phenomenon noted extensively among established tallgrass prairies which are occasionally managed with these tactics (Collins et al., 1998; Davison and Kindscher, 1999; Hartnett et al., 1996; Howe, 1999). The management practices and new species mimic and perpetuate competitive characteristics of the previous dominating functional group. In this context, heterogeneous grazing or a continued lack of management that permits species with diverse growing heights, meristems and lifecycles to be sustained in niches, sustains richness.

Epilogue

Existing literature has generally taken one of three views of native species dynamics: (i) as components of natural native species communities exhibiting reactions and interactions with neighbors, disturbances, and biophysical events; (ii) as extant individuals within hostile environments sustained by niches or disturbances; or (iii) as seeded species establishing in sterile environments under substantial experimental control. This experiment may contribute to a new view for native species research: the understanding of species and community dynamics under management tactics that are feasible for farmers in working agricultural landscapes.

Innumerable pasture acres throughout Iowa are currently used in agricultural systems on land that could arguably be multifunctional regarding benefits for livestock production, resource conservation, biodiversity and native ecosystem preservation. Such pasture systems may also be strong candidates for native species due to soil and site characteristics as well as a potential lack of past plowing. The managers of this land may prefer to abstain from the use of plowing or pesticides as they enter the organic market, protect remnant species, or practice environmental stewardship.

The collaborators in this participatory on-farm research experiment operate a system and manage land that fits all of these characteristics, and they aren't alone, as they describe, "Farmers with the land ethic are hidden... but they're growing." The collaborative family is pursing ecologically-based grazing systems that will eventually permit entry into the organically-raised, grass-finished beef market. They explained their motivations, "Our first priority is to keep our farm wild. Our second priority is to get an ecological profit." These motivations have led them to protect wildlife habitat, open spaces, and water quality while nurturing plant diversity. As they said, "We like to see a pasture with 40-plus species, because many plants take different minerals, grow at diverse times of the year. We want to graze year-round, and native warm season grasses and forbs are part of that mix."

The land used for the experiment had seasonally-limited water availability and difficult access, factors that have led to under-use but tremendous diversity potential. Despite these limitations (or perhaps due to them) the experiment demonstrated that native species can be successfully established in a way that fits the economic parameters of their agricultural system by providing diverse forage during scarce points in the calendar, under organic agriculture protocols by using strategies that gradually replace but do not destroy an existing plant community.

Table 1. Native seed mix and seeding rate of certified southern Iowa local-ecotype varieties.

Common name	Scientific name	Seed/ha	Percent of seed mix
Total Grasses		567,562	72.61
Big bluestem	*Andropogon gerardii Vitman.*	238,995	30.58
Little bluestem	*Andropogon scoparius* Michx.	89,613	11.46
Indiangrass	*Sorghastrum nutans* (L.) Nash ex Small	238,954	30.57
Forbs		214,099	27.39
Legumes		180,643	23.11
Illinois bundleflower	*Desmanthus illinoensis* Michx.	66,906	8.56
Purple prairie clover	*Dalea purpurea* Vent.	100,360	12.84
Round headed bush clover	*Lespedeza capitata* Michx.	6,688	0.86
Showy tick trefoil	*Desmodium canadense* (L) DC.	6,689	0.86
Composites		33,455	4.28
Maximillian sunflower	*Helianthus maximiliani* Schrad.	33,455	4.28
Total		781,661	

Table 2a. Seeded native grass species characteristics.

Common name	Scientific name	Soils	Vegetative stage initiation	Maturation stages	Plant form	Harvest period	Yield
Big bluestem	*Andropogon gerardii Vitman.*	Wide range of soils, including poorly drained[1]	Mid-May to Early June[1]	Flowers August - September[2]. Produces 70% of growth between June 15 - Aug 31[1]	Bunchgrass[3]	Graze at 10-12". Cut for hay at boot stage.[1] Begin at 15-20" and end at 10-12".[4] Apical meristems at 6-8"[3]	3-4 tons/acre common, 6 tons/acre possible[3]
Indiangrass	*Sorghastrum nutans* (L.) Nash ex	Fair tolerance to poor drainage,[1] best on deep, well-drained soils but will tolerate clay soil.[2]	Mid-June[1,4]	Flowers August-September[2]. Produces 70% of growth between July 1 and Aug 31, 2-3 weeks later than big bluestem[1].	Bunchgrass. Reproduces from short rhizomes in large clumps.[2,3]	Graze at 10-12". Cut for hay at early boot stage.[1] Begin at 12-16" and end at 6-10".[4] Apical meristems at 5-8".[3]	4-6 tons/acre[3]
Little bluestem	*Andropogon scoparius* Michx.	Mesic, dry mesic, dry.[2] Does well on droughty sites.[3]	Mid-June[1,4]	Flowers August-September[2]	Bunchgrass[2]	Apical meristems at 4-6"[3]	1-2 tons/acre[3]

[1] Kallenbach and Bishop-Hurley (2002).
[2] Shirley (1994).
[3] NRCS-Missouri 1998).
[4] May and Sole (2000).

Table 2b. Seeded native forb species characteristics.

Common name	Scientific name	Optimum radiation	Optimum soil	Flowering period	Plant form	Forage attributes
Bush clover	*Lespedeza capitata* Michx.	Full or partial sun[1]	Sandy, well-drained, loamy soil[1]	Blooms August - September[1,2]	Legume. 30-48" height with deep taproots.[1]	Very palatable, high protein forage. Grows vigorously with tall grass.[3]
Illinois bundleflower	*Desmanthus illinoensis* Michx.	Full sun[1]	Wide range from moist depress-sions to well drained loam to sandy alluvium.[1]	Blooms July-August[1,2]	Legume. 3-4' height[1]	High in protein, similar to domestic legumes[3]
Maximilian sunflower	*Helianthus maximiliani* Schrad.	Full sun[1]	Mesic soil[1]	Blooms July – October[2]	2-5' height[1]	Palatable , nutritious, readily eaten[3]
Purple prairie clover	*Dalea purpurea* Vent.	Full sun[1]	Mesic to sandy soil[1]	Blooms July – Sept.[2]	Legume. 2' height[1]	High protein content[3]
Showy tick trefoil	*Desmodium canadense* (L) DC.	Full to partial sun[1]	Wide soil range; does well in clay and loam as well as moist sand. Wet mesic, mesic, dry mesic[1]	Blooms July – August[1]	Legume. 1-4' Height with branched taproots[1]	Palatable[3]

[1] Shirley (1994)
[2] Robison et al. (1995).
[3] Philips Petroleum Company (1959).

Table 3. Mowing dates and heights–2003 to 2005.

Date	Site	Original height (cm)	Mowed height (cm)
6/18/2003	N	25.4-30.5	10.2
	S	25.4-30.5	10.2
7/10/2003	N	30.5-50.8	10.2
	S	35.6	10.2
5/29/2004	N	35.6-60.9	15.2
	S	25.4-30.5	15.2
6/30/2004	N	38.1-50.8	15.2
	S	40.6-55.9	15.2
5/23/2005	N	33.0-50.8	7.62
	S	25.4-50.8	7.62

Table 4. Grazing dates and management information for the north and south experimental sites in Marion County, Iowa, during the 2003, 2004, and 2005 grazing seasons.

Date	Site[z]	Original height (cm)[y]	Length of grazing (hr)[x]	No. head grazing
6/16 – 6/17/2003	N block A	25.4-30.5	12 night hours	24
6/17/2003	N block B	25.4-30.5	12 night hours	24
-	S	-	-	-
7/10/2003	N block A	25.4-76.2	12 night hours	24
7/11/2003	N block B	25.4-76.2	12 night hours	24
7/3 – 7/4/03	S block A and B	15.2-50.8 (A) 20.3-88.9 (B)	24 night hours	24
6/4 – 6/16/04	N blocks A and B	60.9-76.2 (A) 63.5-88.9 (B)	120 night hours	5
6/22 – 6/25/2004	S blocks A and B	55.9-127 (A) 55.9-101.6 (B)	96 hours[w]	5
7/20 – 7/30/2004	N blocks A and B	35.6-40.6 (A) 35.6-152.4 (B)	120 night hours	5
6/16 – 6/20/2005	N blocks A and B	15.2-91.4 (A) 15.2-76.2 (B)	96 hours[w]	10
-	S	-	-	-

[z] N = north site; S = south site; A and B = blocks A and B on each site.
[y] Immediate post-grazing plant heights were not measured, as they were highly variable and heterogeneous within and among blocks and topographic positions.
[x] "Night" indicates the time between 9 pm - 9 am.
[w] Block choice was not restricted and cows could enter either grazing treatment unit at any time (during the day or night).

Table 5. Sampling dates and measurements for experimental sites in Marion County, Iowa, during the 2003 experimental season.

Site	Date	Type of measurement	Description
North	6/29 and 7/7	P/A[z]	5 to 15 0.04-m^2 samples
North	7/17	P/A and DIFN[y]	5-0.04-m^2 samples (P/A) and 4 measurements (DIFN)
North	7/31	P/A and DIFN	5-0.04-m^2 samples (P/A) and 4 measurements (DIFN)
North	8/26	Biomass and P/A	1-0.1-m^2 sample (biomass) and 2-0.04m^2 (P/A)
South	7/17	P/A and DIFN	5-0.04-m^2 samples (PA) and 4 measurements (DIFN)
South	7/31	P/A and DIFN	5-0.04-m^2 samples (P/A) and 4 measurements (DIFN)
South	8/26	Biomass and P/A	1-0.1-m^2 sample (biomass) and 2-0.04-m^2 samples (P/A)

[z] P/A: Presence/absence of particular species.
[y] DIFN: Diffuse non-interceptance measurement of light penetration to ground.

Table 6. Sampling dates and measurements for experimental sites in Marion County, Iowa, during the 2004 experimental season.

Site	2004	Type of measurement	Description
North	6/19	P/A[z]	10-0.04-m^2 samples
North	7/17	P/A	10-0.04-m^2 samples
North	7/12	P/A	10-0.04-m^2 samples
North	8/19	Biomass and P/A	1-0.1-m^2 sample (biomass) and 10-0.04-m^2 sample (P/A)
South	6/26	P/A and DIFN[y]	10-0.04-m^2 samples (P/A) and 4 measurements (DIFN)
South	7/16	P/A and DIFN	10-0.04-m^2 samples (P/A) and 4 measurements (DIFN)
South	8/29	Biomass and P/A	1-0.1-m^2 sample (biomass) and 10-0.04-m^2 sample (P/A)

[z] P/A: Presence/absence of particular species.

[y] DIFN: Diffuse non-interceptance measurement of light penetration to ground.

Table 7. Sampling dates and measurements for experimental sites in Marion County, Iowa, during the 2005 experimental season.

Site	2005	Type of measurement	Description
North	6/29 to 7-11	P/A[z] & Community Inventory	20-0.04-m^2 samples
North	7/13	P/A & Community Inventory	5-0.04-m^2 samples/ non-seeded strip
North	8/12 to 8/15	P/A & DIFN[y]	20-0.04-m^2 samples (P/A) and 4 measurements (DIFN)
North	8/22	Biomass	4-0.1-m_2 samples
South	7/15 to 7-18	P/A & Community Inventory	15-0.04-m^2 samples
South	7/18	P/A & Community Inventory	5-0.04-m^2 samples/ non-seeded strip
South	8/12 to 8/15	P/A & DIFN	15-0.04-m^2 samples (P/A) and 4 measurements (DIFN)
South	8/23	Biomass	4-0.1-m^2 samples

[z] P/A: Presence/absence of particular species.

[y] DIFN: Diffuse non-interceptance measurement of light penetration to ground.

Table 8. Native species presence in non-seeded north site control strips – 2003 and 2004.

Species (%)[z]					
Grass	Illinois bundleflower	Purple prairie clover	Bush clover	Tick trefoil	Maximillian sunflower
4.29	0.00	1.43	0.00	4.29	0.00

[z] Percentage of number of times species was found in quadrat samples over two sampling periods.

Table 9. North site community components in third year after seeding.

Treatment	Introduced grass relative abundance[z]	Ratio of native legumes to introduced species[y]	Ratio of native legumes to introduced legumes[x]	Relative abundance of total legumes[w]
Control	0.19c[v]	0.09b	0.34a	0.30
Grazing	0.24a	0.02a	0.05b	0.36
Mowing	0.22b	0.03a	0.09b	0.38
P-value	0.0026	0.0104	0.0027	NS

[z] Introduced grasses defined as tall fescue, smooth brome, Kentucky bluegrass, and orchardgrass.

[y] Introduced species defined as tall fescue, smooth brome, Kentucky bluegrass, orchardgrass, white clover, red clover, birdsfoot trefoil, and alfalfa.

[x] Introduced legumes defined as white clover, red clover, birdsfoot trefoil, and alfalfa.

[w] Total legumes defined as Illinois bundleflower, purple prairie clover, bush clover, tick trefoil, white clover, red clover, birdsfoot trefoil, and alfalfa.

[v] Means within each column not followed by the same letter are significantly different according to Tukey's difference of the least square means.

[NS] Not significant at $P > 0.05$; P value stated otherwise.

Table 10. North site vegetative cover characteristics.

	2003		2004		2005		
Treatment	DIFN[z]	Biomass ($g\ m^{-2}$)	DIFN[z]	Biomass ($g\ m^{-2}$)	DIFN[z]	Biomass ($g\ m^{-2}$)	Richness[y]
Control	0.18a[x]	208.7	0.09a	406.4	0.14a	406.9	29.0a
Grazing	0.25a	291.2	0.43b	243.7	0.27b	312.8	24.4ab
Mowing	0.46b	128.9	0.34b	289.9	0.20a	302.5	22.6b
P-Value	00.0418	NS	0.0213	NS	0.0138	NS	0.0331

[z] Diffuse non-interceptance measures the radiation penetration to ground with higher values indicating greater light penetration.
Biomass as g/m^2 dry weight.
[y] Mean species richness per 0.04-m^2 quadrat sample.
[x] Means within each column not followed by the same letter are significantly different according to Tukey's difference of the least square means.
[NS] Not significant at P>0.05; *P* value stated otherwise.

Table 11. Monthly mean temperature (°C) and precipitation (cm) totals in Knoxville, Iowa (Iowa Environmental Mesonet, 2005).

	May		June		July		August	
	Temp (°C)	Precipitation (cm)	Temp (°C)	Precipitation (cm)	Temp (°C)	Precipitation (cm)	Temp (°C)	Precipitation (cm)
2003	15.56	10.49	20.56	16.36	23.33	4.01	24.44	2.44
2004	17.22	22.89	20.00	6.78	22.22	15.27	20.00	19.30
2005	15.00	6.58	23.33	13.41	24.44	8.26	23.33	3.94
1951 to 2005 Mean	16.67	10.77	22.22	11.33	24.44	10.52	23.33	10.11

Table 12. Native species presence in non-seeded south site control strips – 2003 and 2004.

Species (%)[z]					
Grass	Illinois bundleflower	Purple prairie clover	Bush clover	Tick trefoil	Maximillian sunflower
4.29	0.00	1.43	1.43	1.43	2.86

[z] Percent specifies number of times species was found in quadrat samples over two sampling periods.

Table 13. South site vegetative cover characteristics.

	2003		2004		2005		
Treatment	DIFN[z]	Biomass (g m^{-2})	DIFN[z]	Biomass (g m^{-2})	DIFN[z]	Biomass (g m^{-2})	Richness[y]
Control	0.24c[x]	232.2	-	436.3a	0.07	360.9	27.3
Grazing	0.46b	217.51	-	360.7b	-	-	-
Mowing	0.66a	144.5	-	266.4b	0.18	249.1	25.6
P-Value	0.004	NS		0.025	NS	NS	NS

[z] Diffuse non-interceptance measures the radiation penetration to ground with higher values indicating greater light penetration.
[y] Mean species richness per 0.04-m^2 quadrat sample.
[x] Means within each column not followed by the same letter are significantly different according to Tukey's difference of the least square means.
[NS] Not significant at P>0.05; *P* value stated otherwise.

Table 14. South site community components in third year after seeding.

Treatment	Introduced grass relative abundance[z]	Ratio of seeded legumes to introduced species[y]	Ratio of seeded legumes to introduced legumes[x]	Relative abundance of total legumes[w]
Control	0.15[v]	0.08	0.39	0.07
Mowing	0.14	0.07	0.22	0.10
P-value	NS	NS	NS	NS

[z] Introduced grasses defined as tall fescue, smooth brome, Kentucky bluegrass, and orchardgrass.
[y] Introduced species defined as tall fescue, smooth brome, Kentucky bluegrass, orchardgrass, white clover, red clover, birdsfoot trefoil, and alfalfa.
[x] Introduced legumes defined as white clover, red clover, birdsfoot trefoil, and alfalfa.
[w] Total legumes defined as Illinois bundleflower, purple prairie clover, bush clover, tick trefoil, white clover, red clover, birdsfoot trefoil, and alfalfa.
[v] Means within each column not followed by the same letter are significantly different according to Tukey's difference of the least square means.
[NS] Not significant at P>0.05; *P* value stated otherwise.

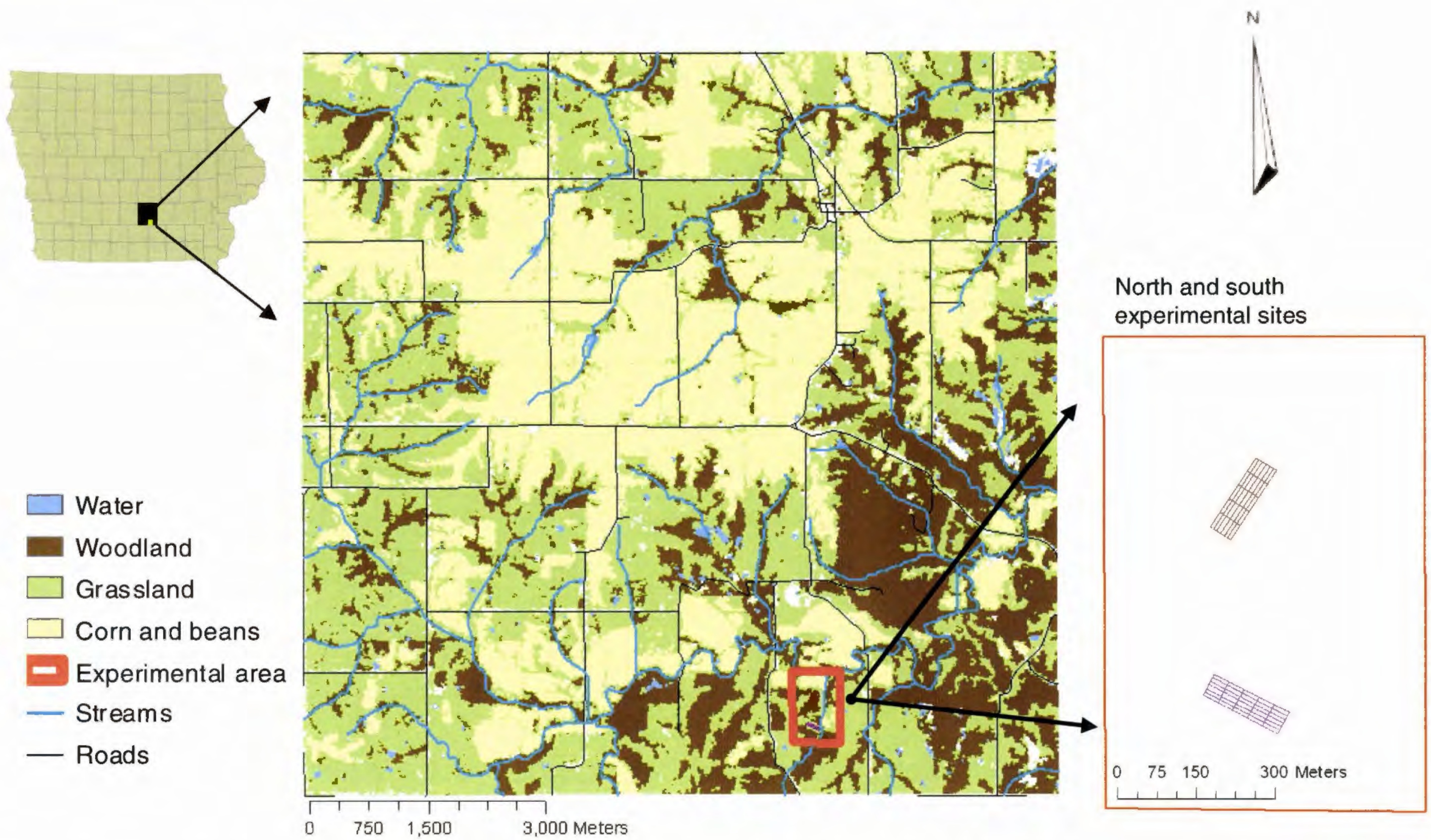

Figure 1. Experiment location and landscape characteristics. The experimental area is located in Indiana township of Marion County, Iowa at R18W-T74N at NAD 1983 UTM Zone 15N with Transverse Mercator Projection. Land use classification is derived from satellite imagery collected in May 2002 and May 2003. Data in raster format in $15m^2$ cell size resolution. Data acquired from the Iowa DNR GIS library at http://www.igsb.uiowa.edu/./nrgislibx/. Map created by Karie Wiltshire in ArcMap 9 in October, 2005.

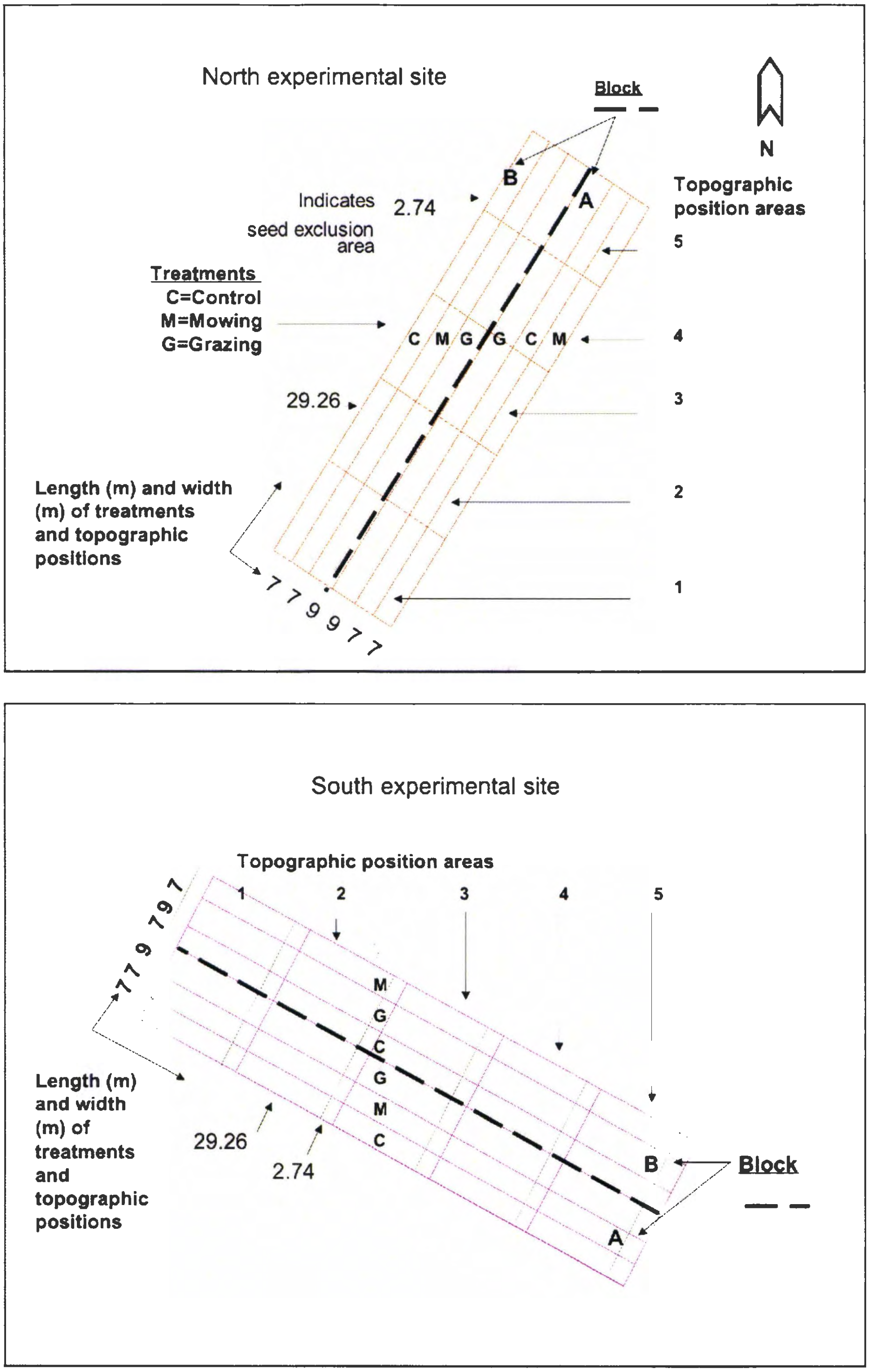

Figure 2. Experimental site design.

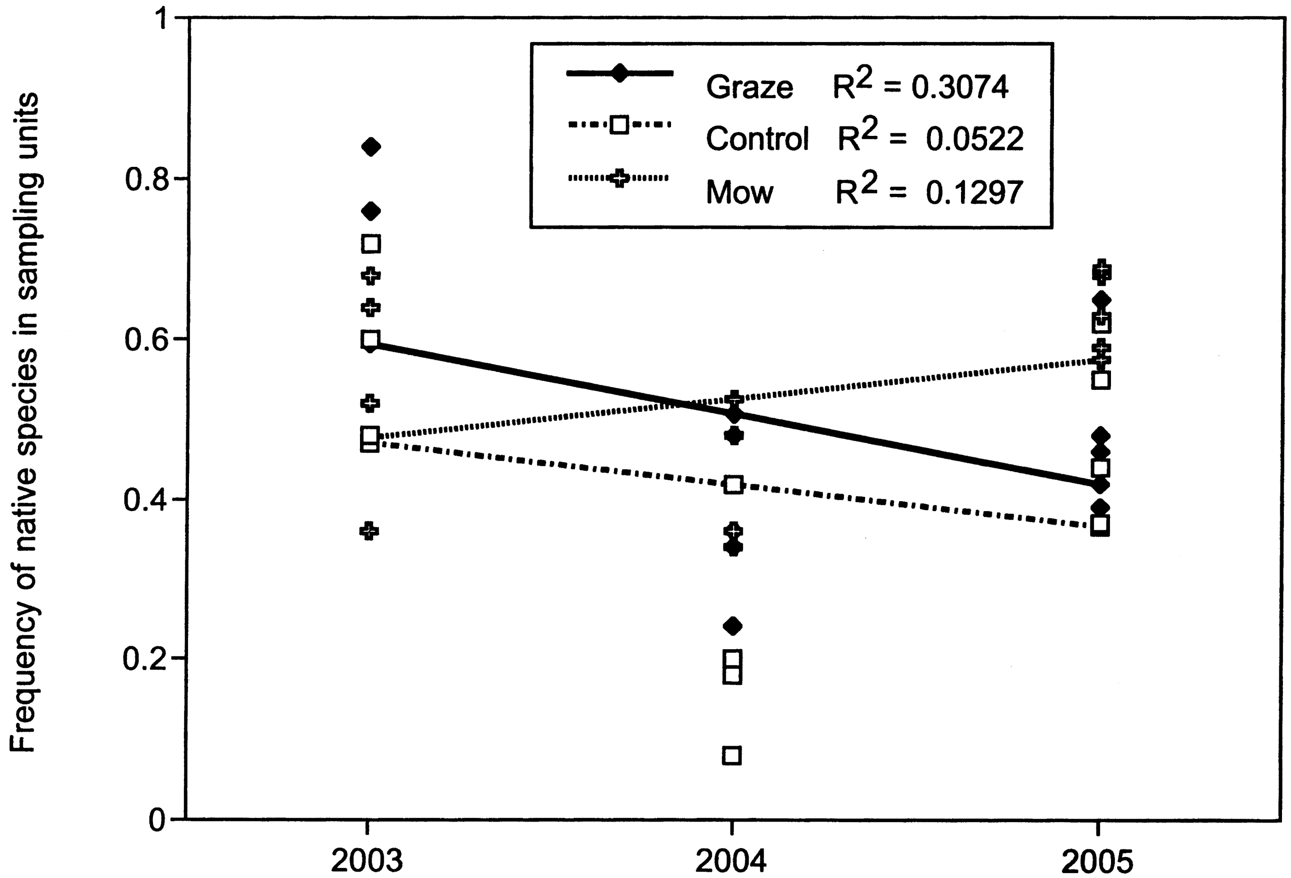

Figure 3. North site native species presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 200 samples per two sampling periods.

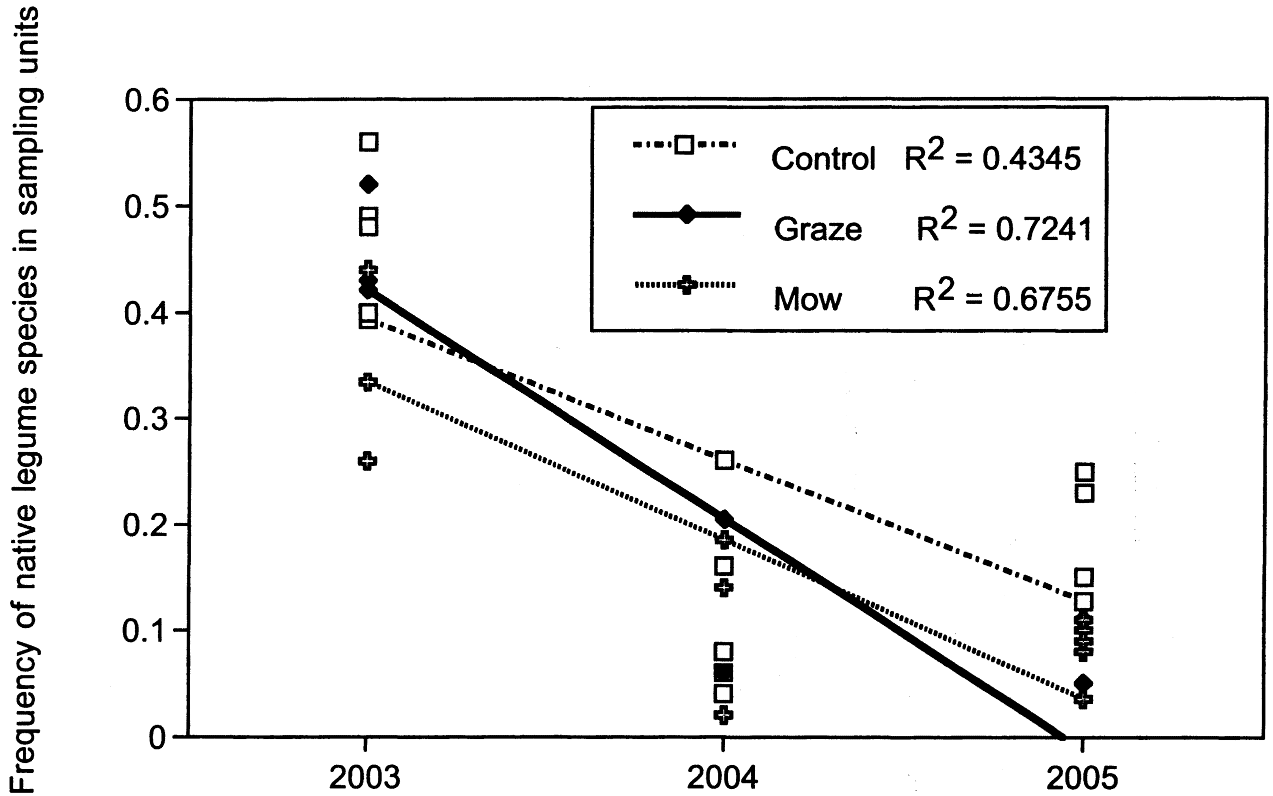

Figure 4. North site native legume presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 200 samples per two sampling periods.

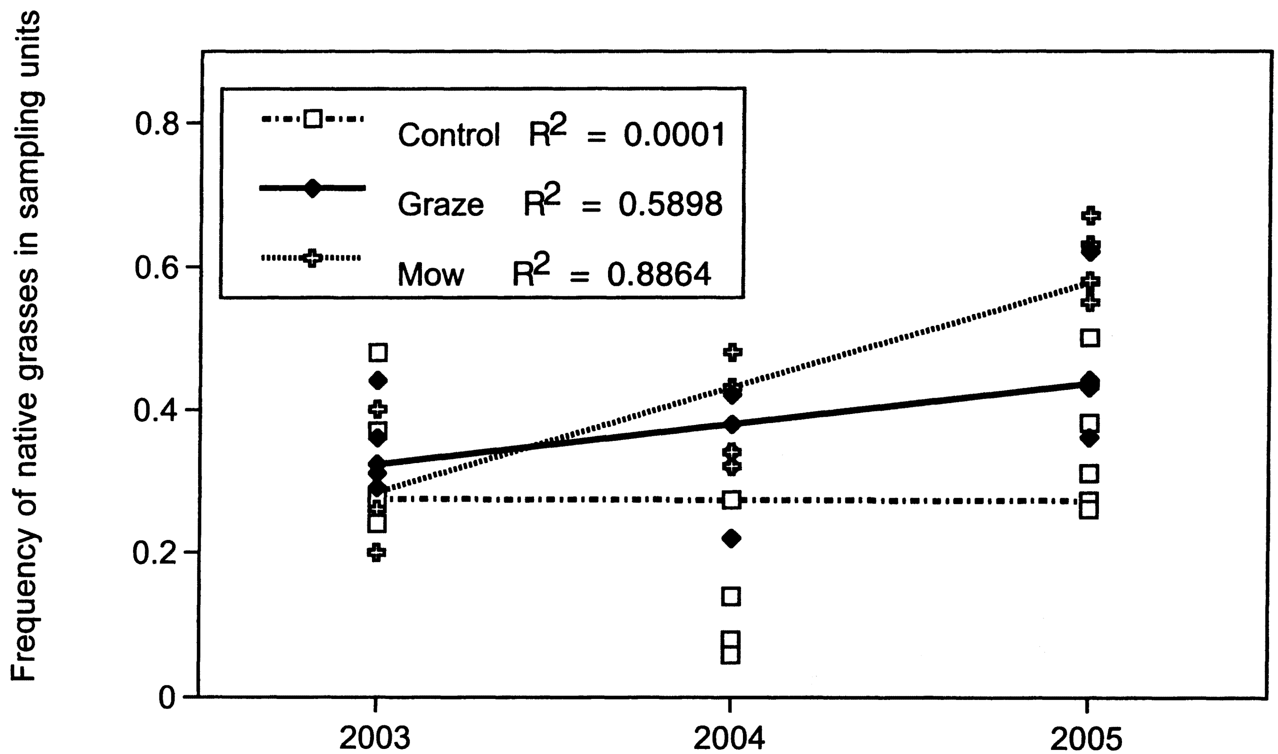

Figure 5. North site native grass species presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 200 samples per two sampling periods.

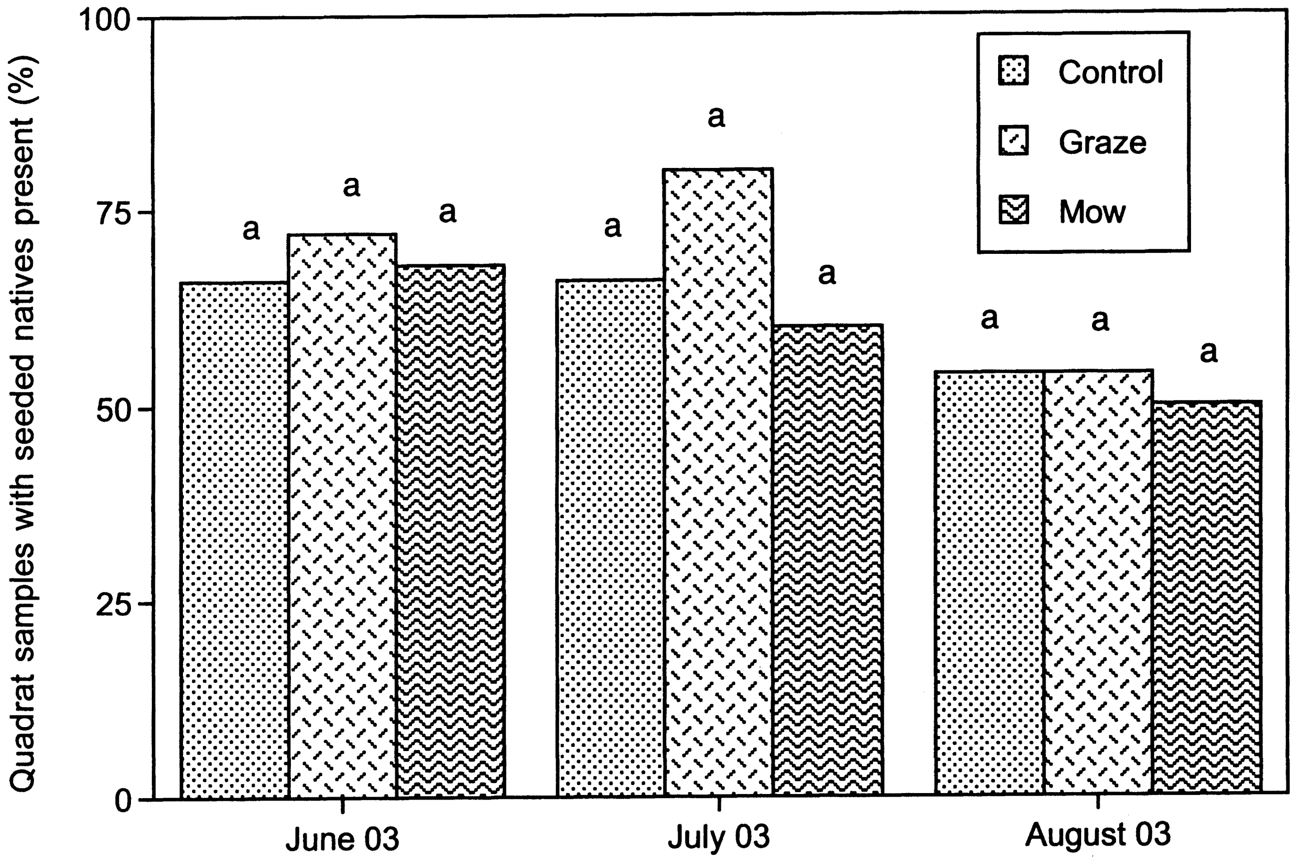

Figure 6. North site seeded native species presence in initial year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

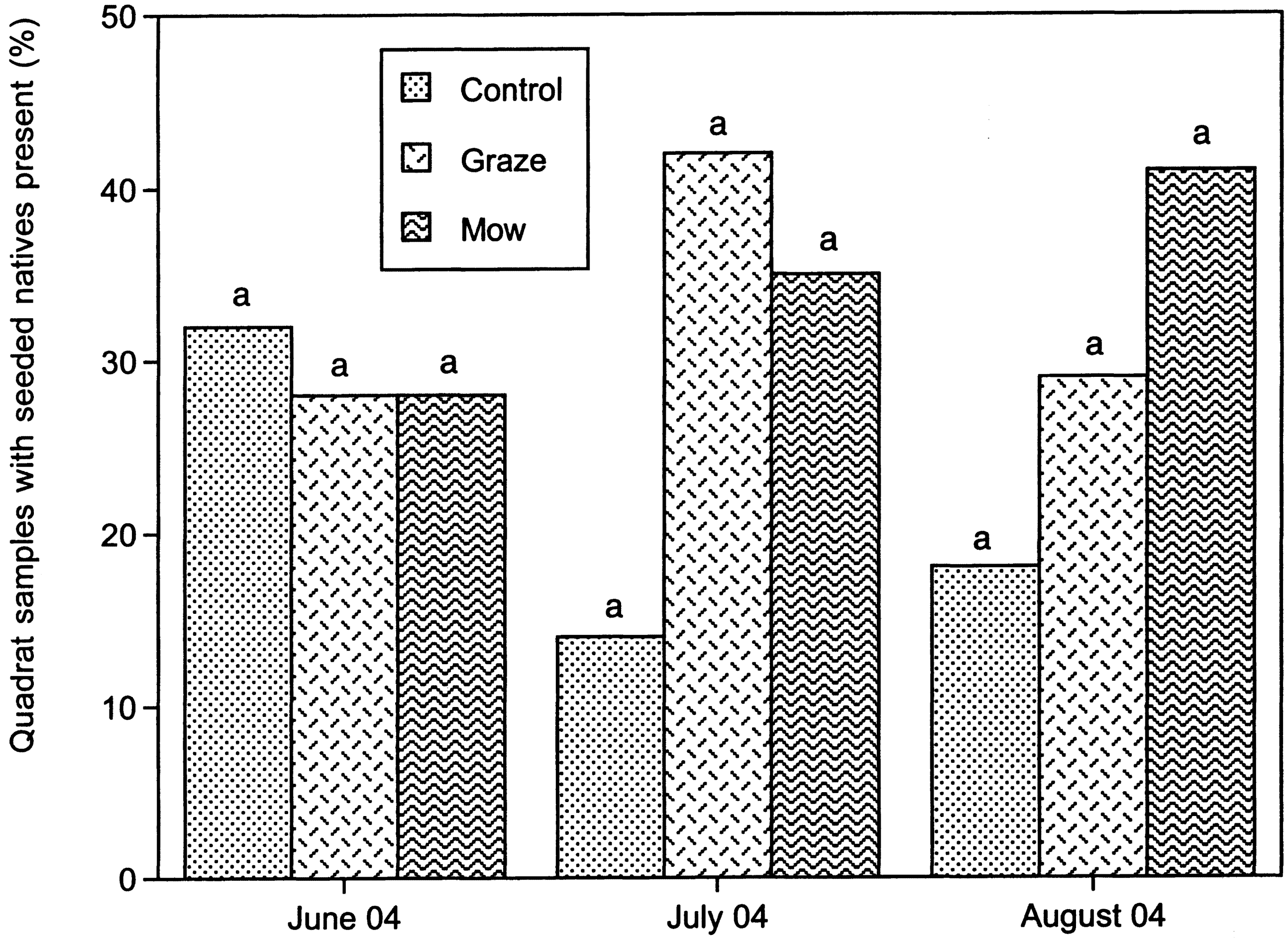

Figure 7. North site seeded native species presence in second year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

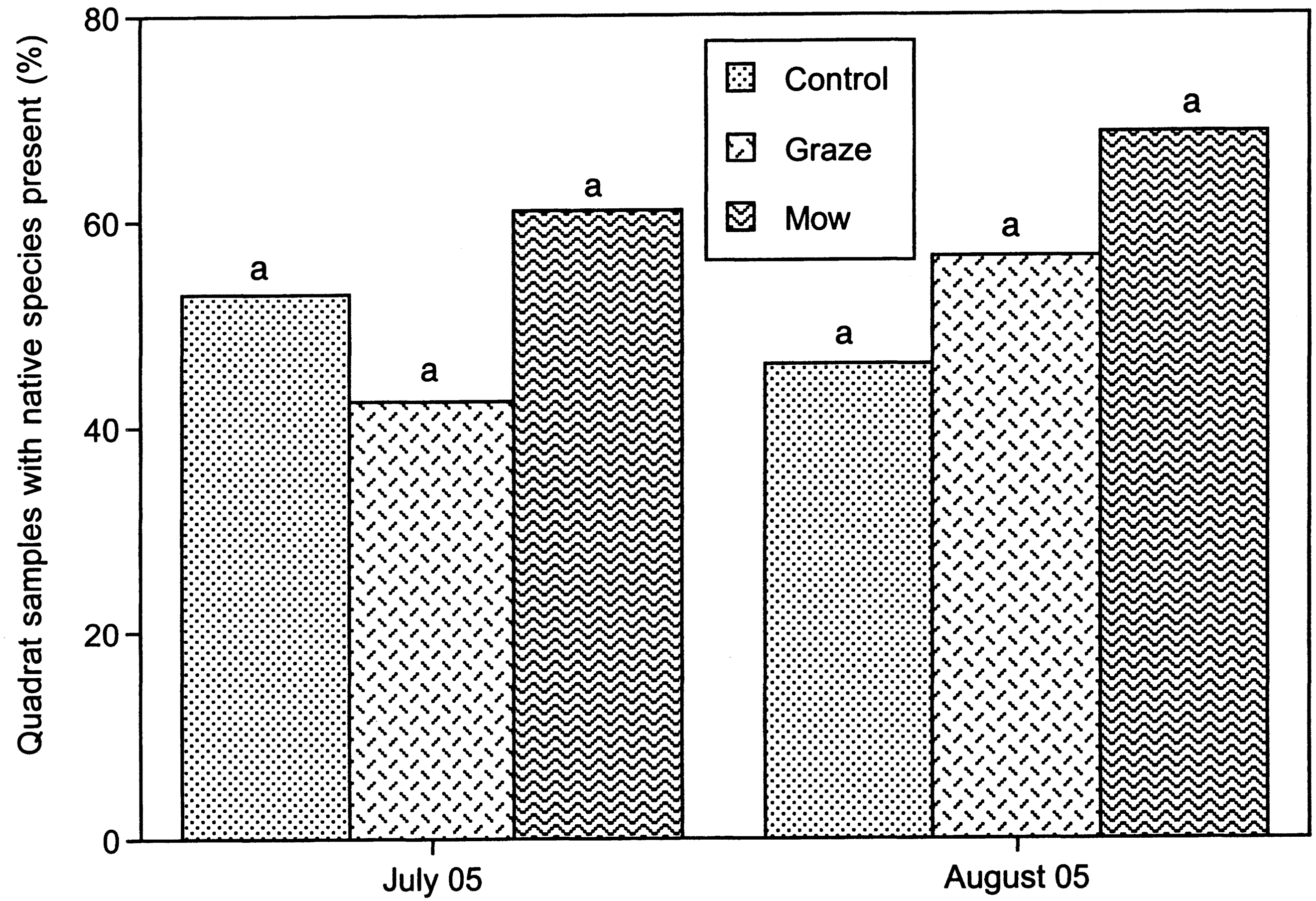

Figure 8. North site seeded native species presence in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

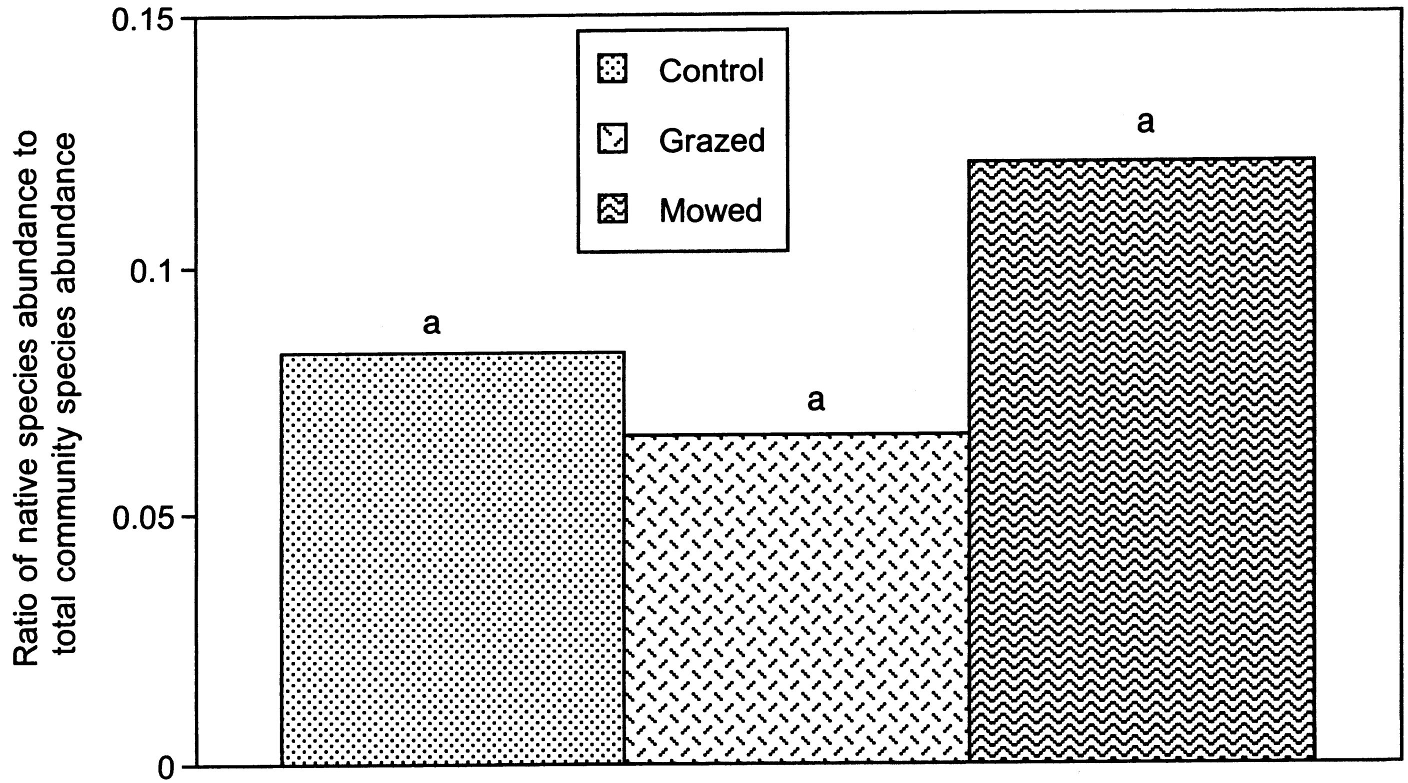

Figure 9. Native species relative abundance in pasture community in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

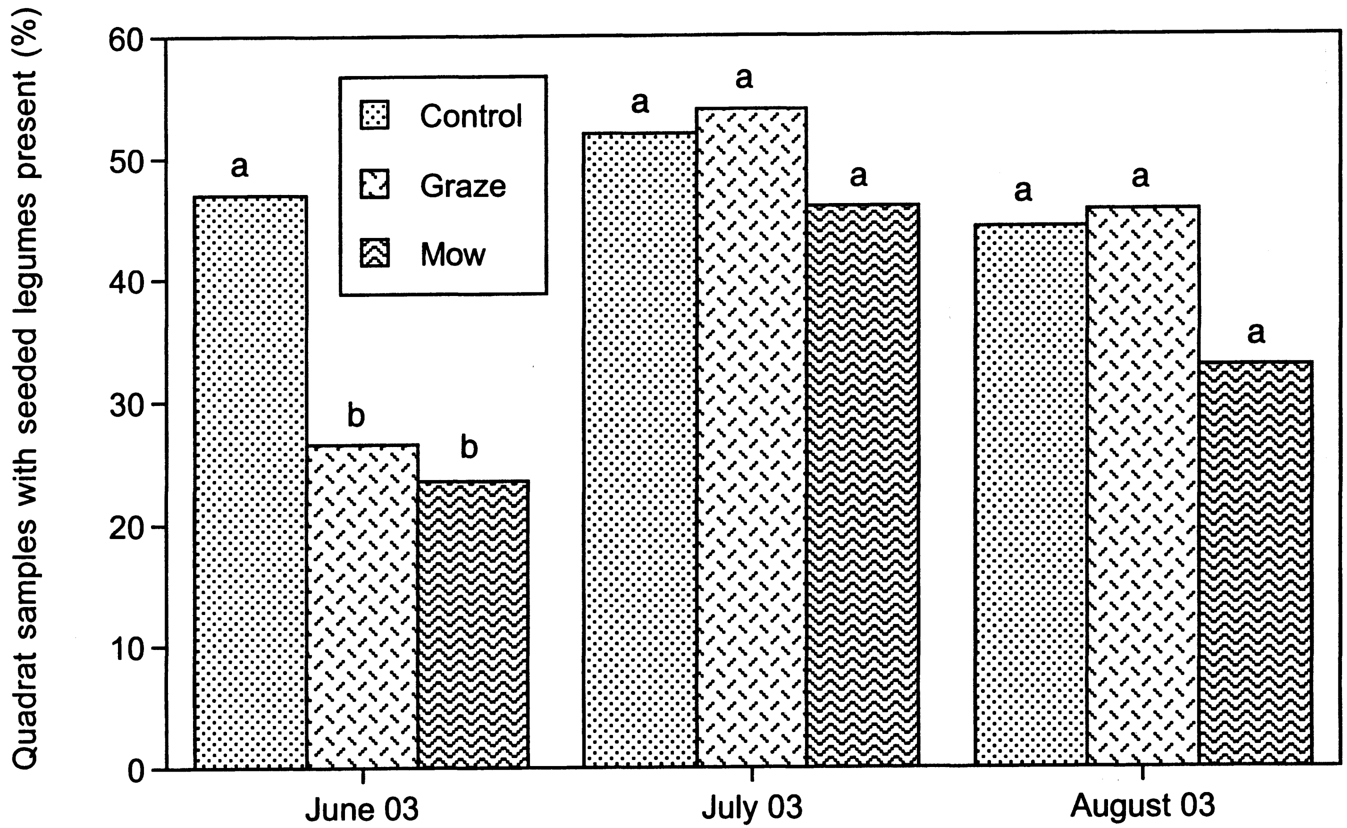

Figure 10. North site native legume species presence in the first year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

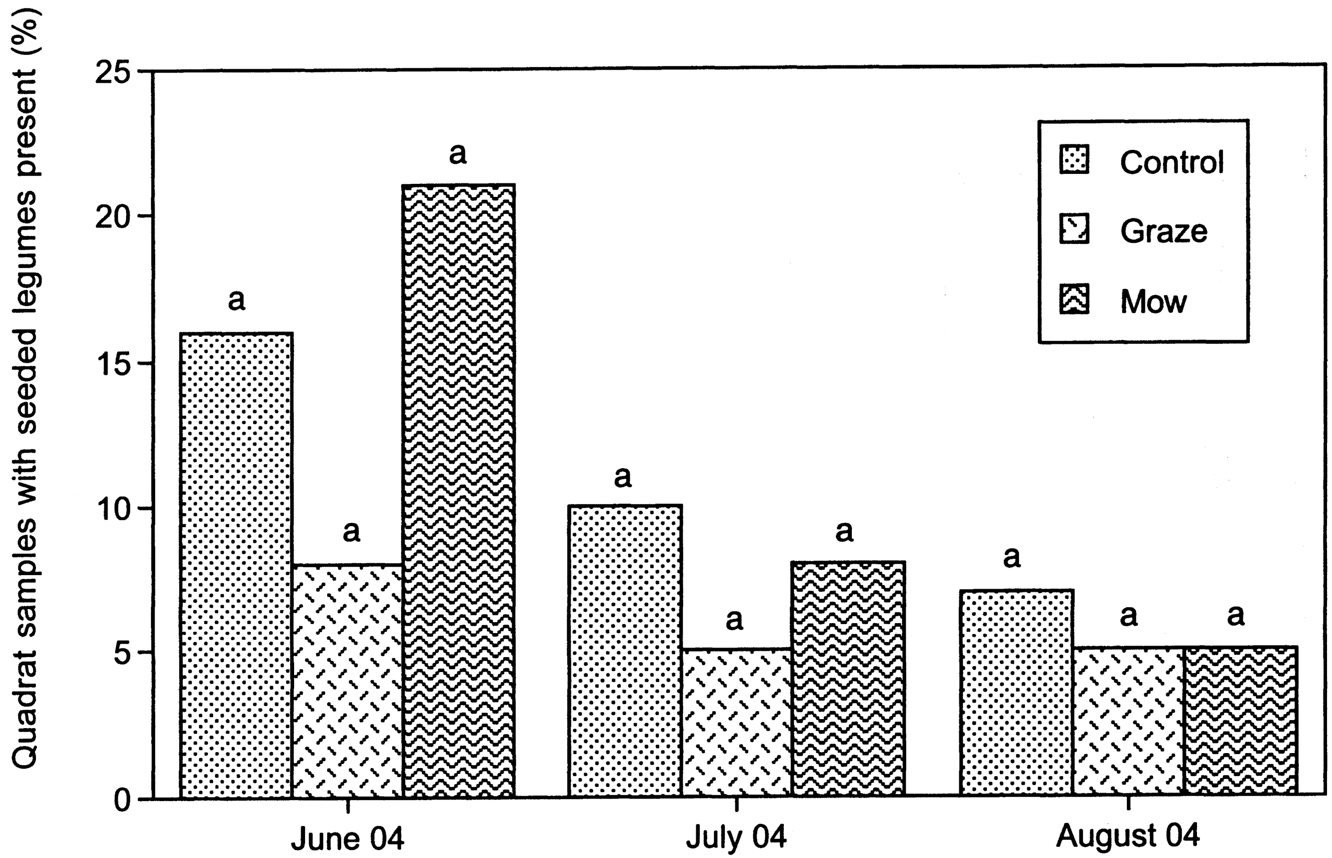

Figure 11. North site native legume species presence in the second year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

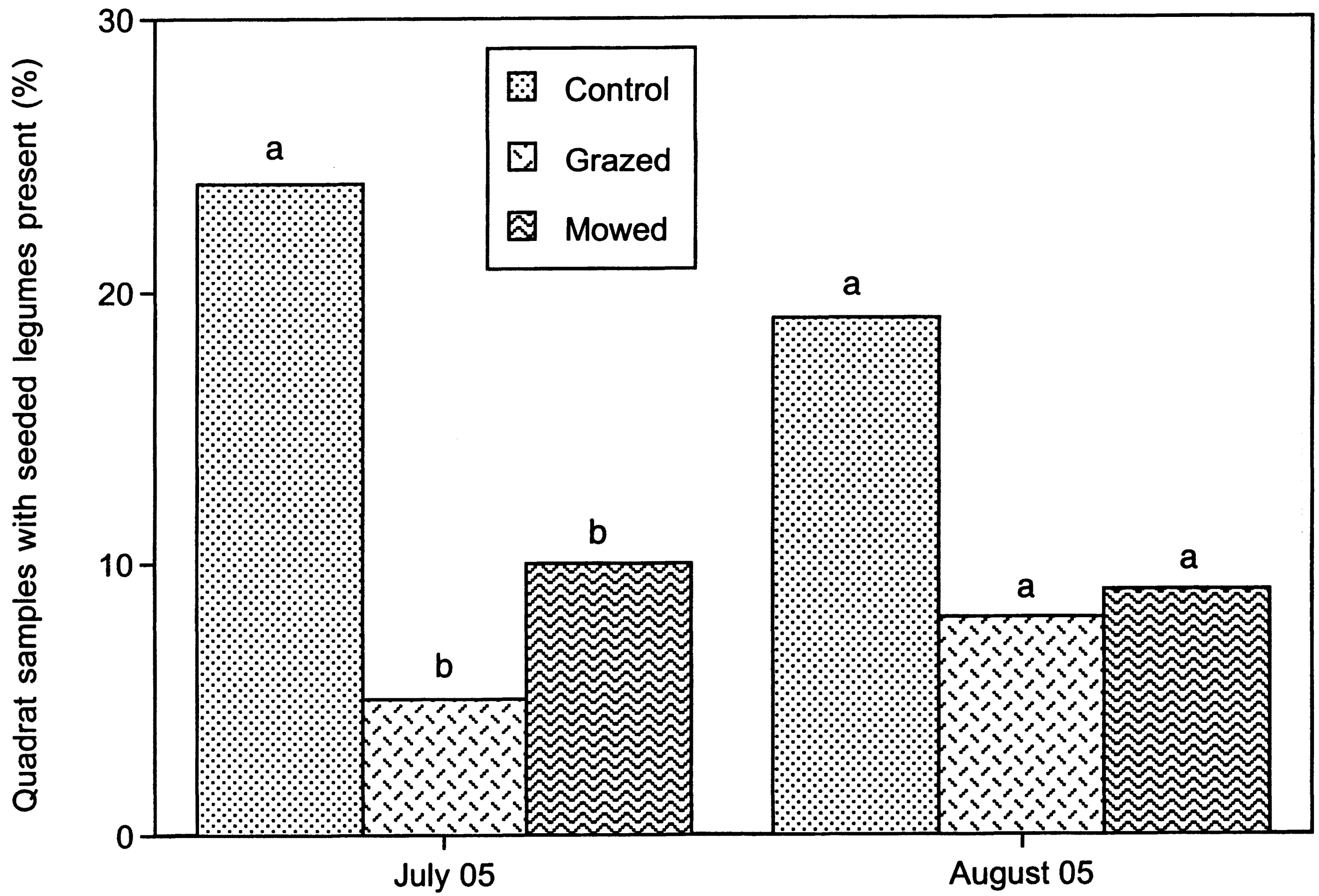

Figure 12. North site native legume species presence in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

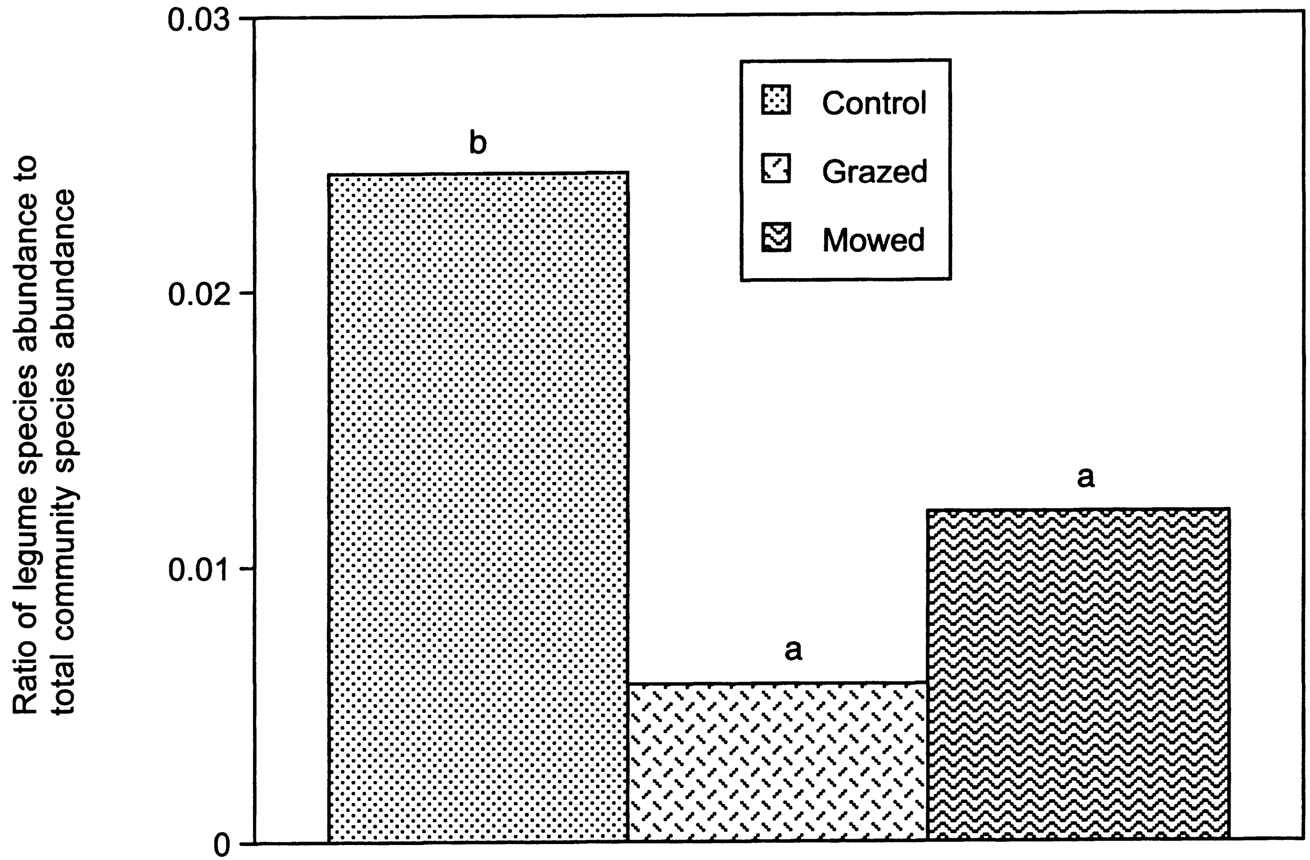

Figure 13. Native legume relative abundance in pasture community in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

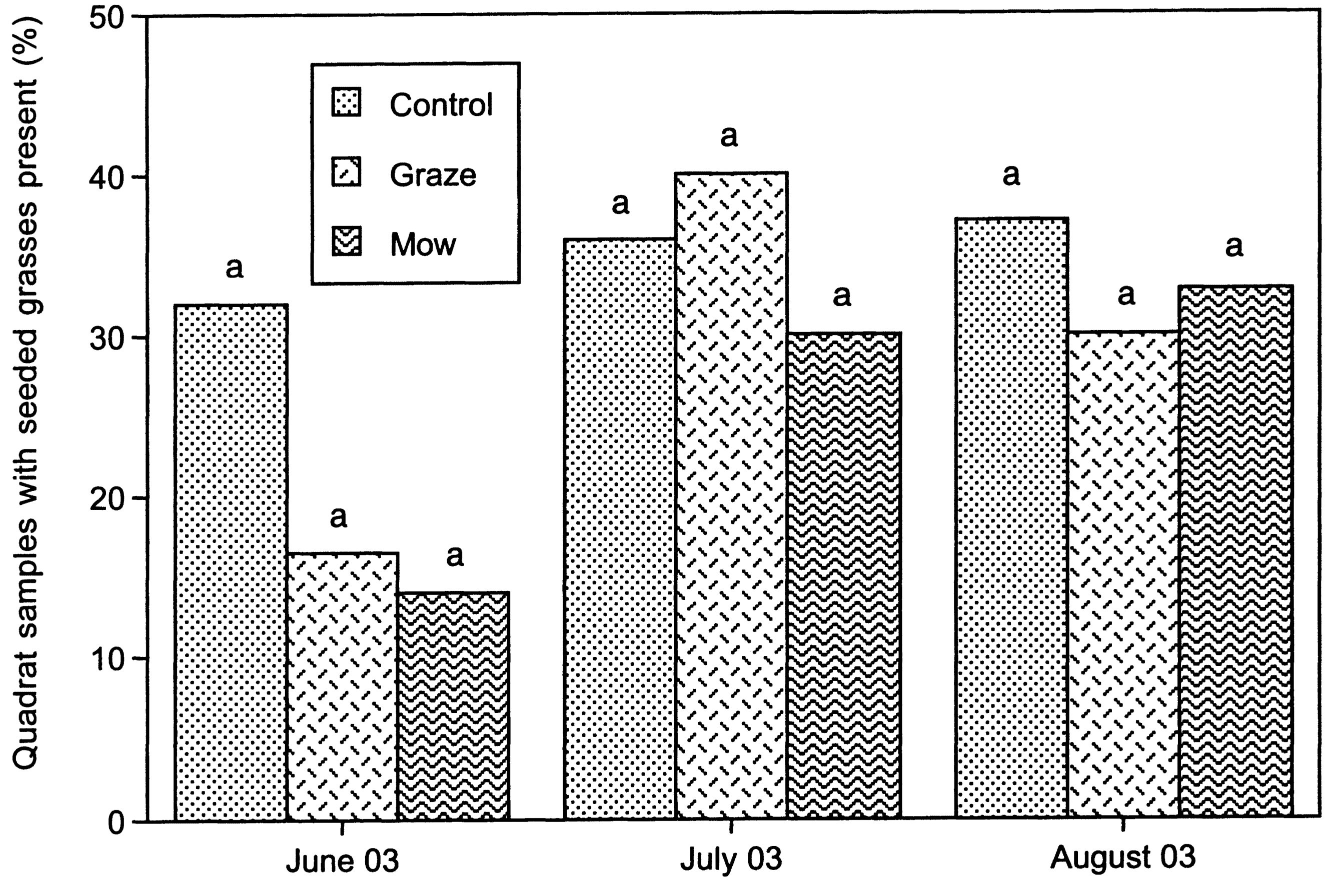

Figure 14. North site native grass species presence in the first year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

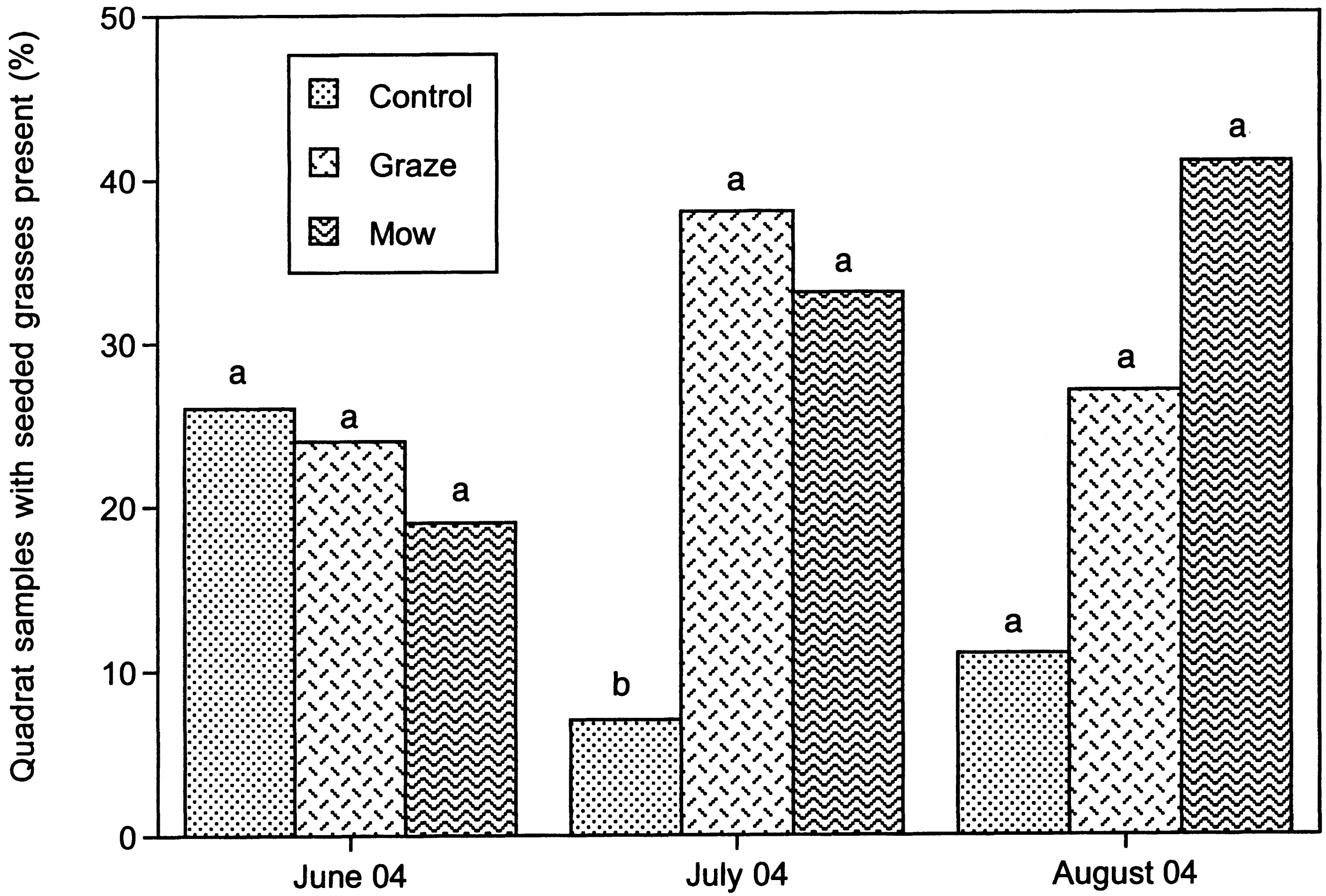

Figure 15. North site native grass species presence in the second year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

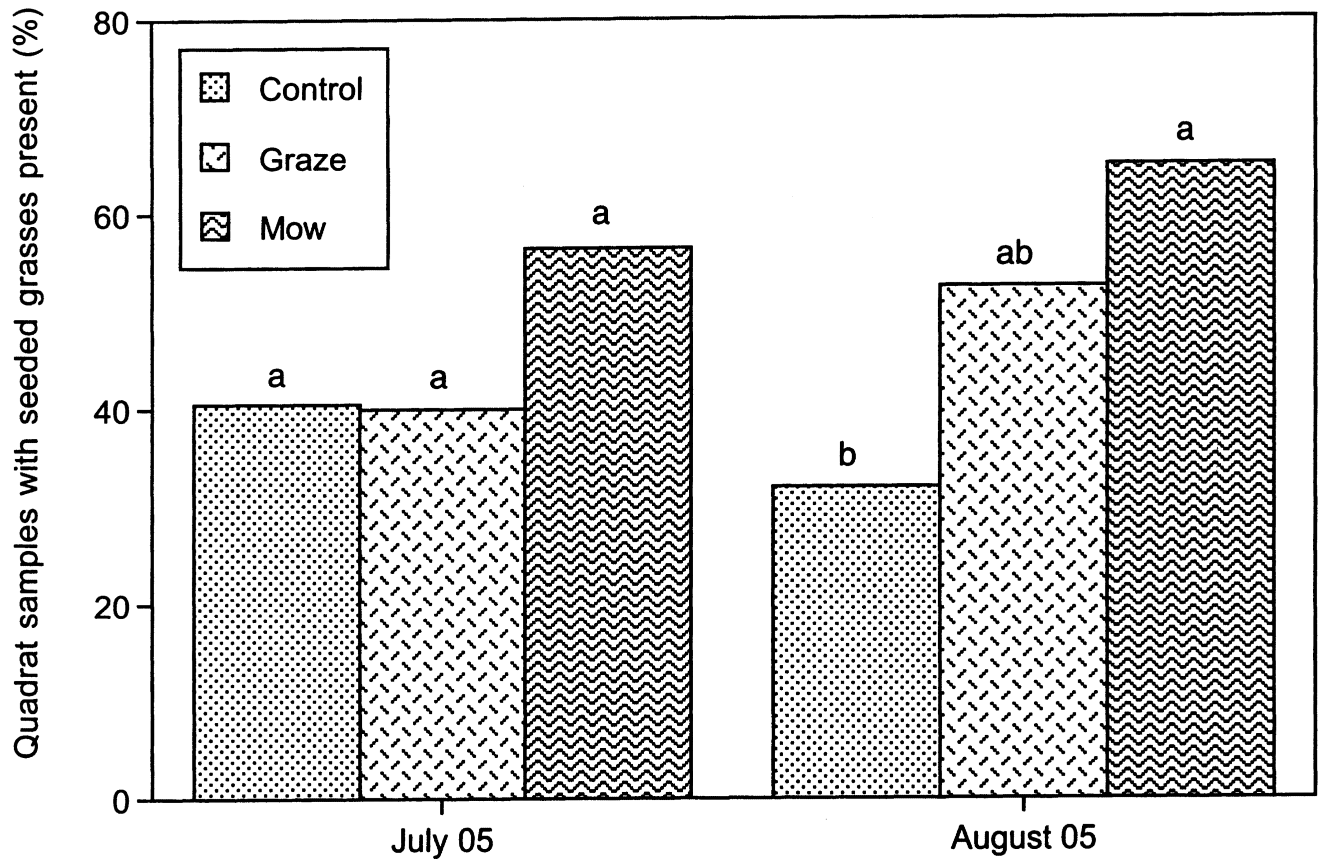

Figure 16. North site native grass species presence in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

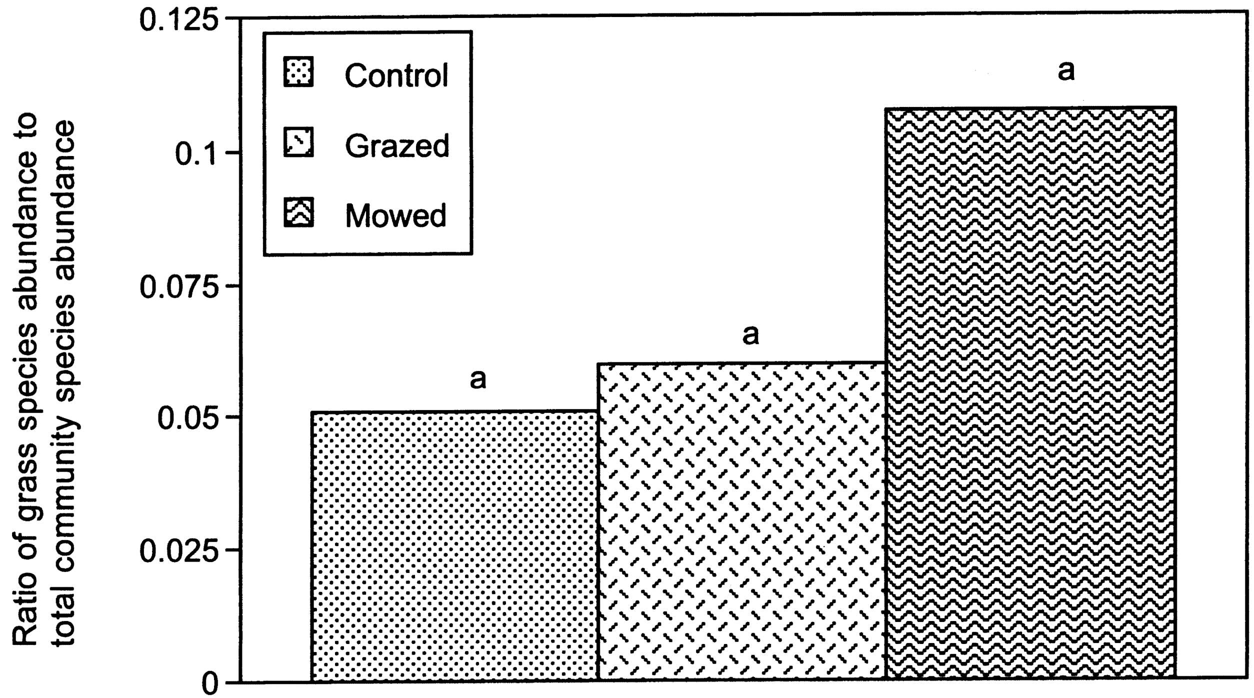

Figure 17. Native grass relative abundance in pasture community in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

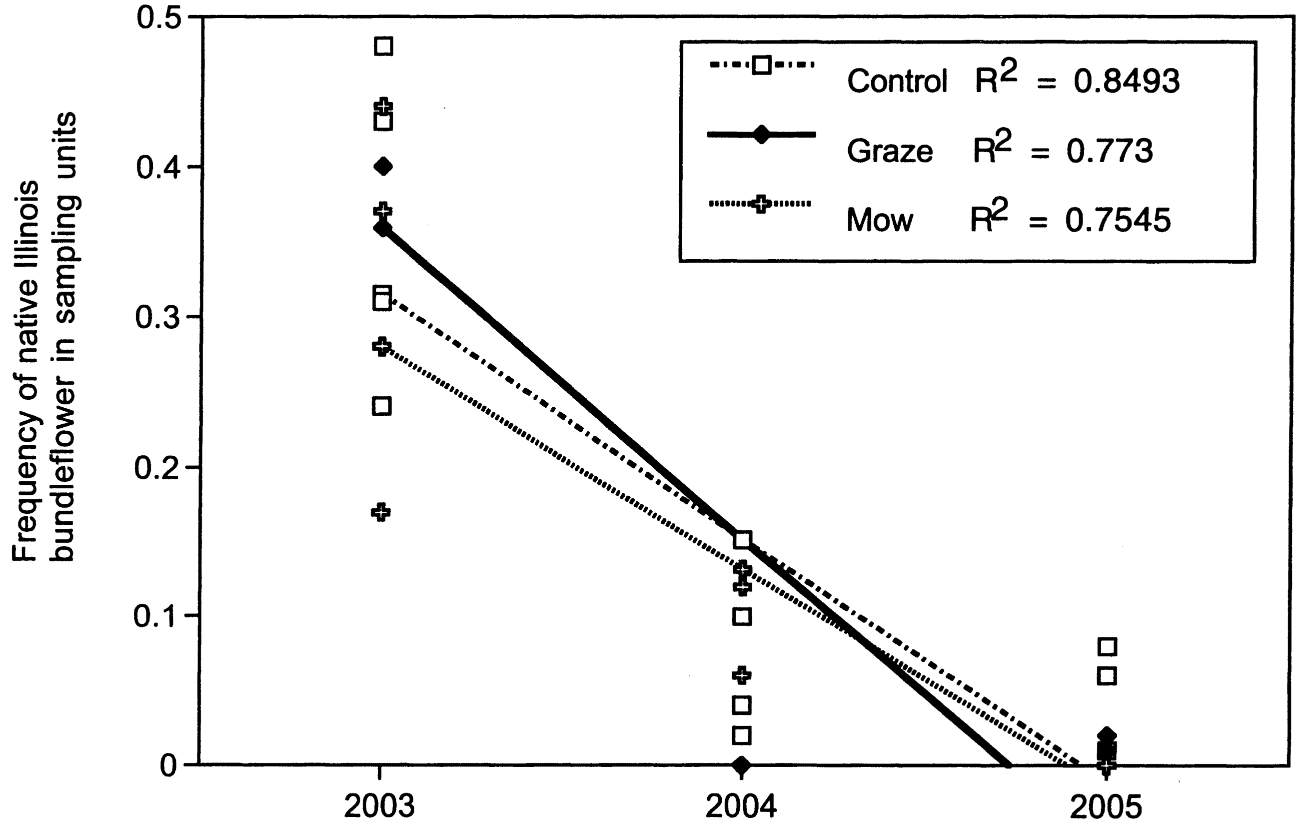

Figure 18. North site Illinois bundleflower presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 200 samples per two sampling periods.

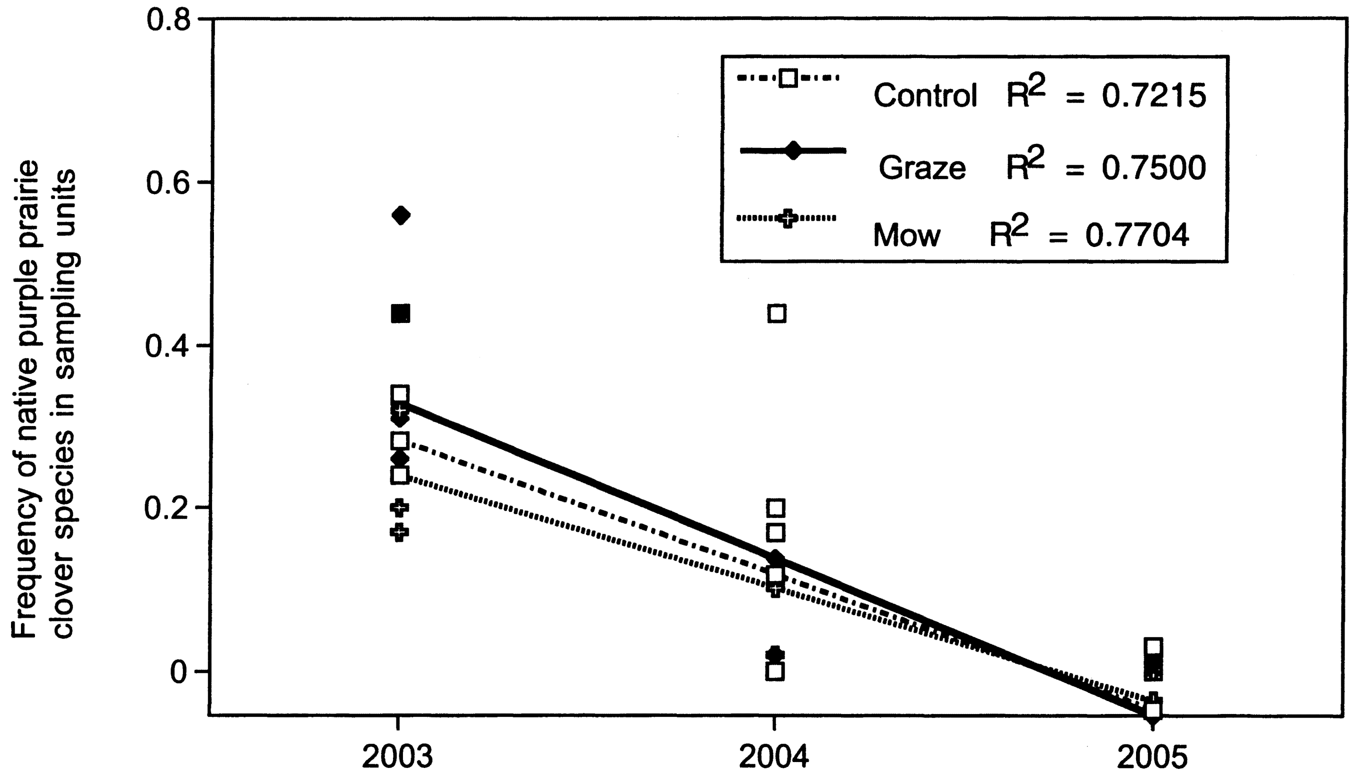

Figure 19. North site purple prairie clover presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 200 samples per two sampling periods.

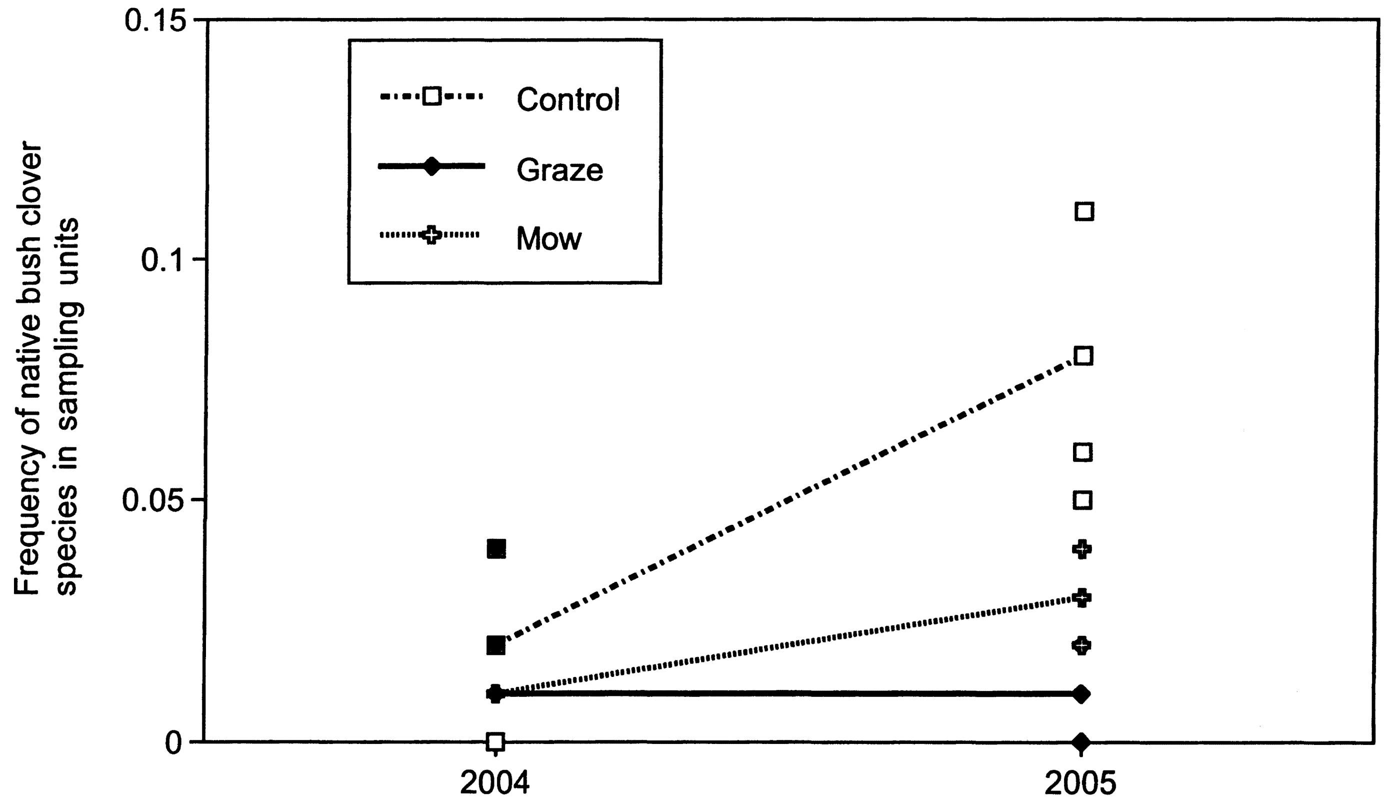

Figure 20. North site bush clover presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 200 samples per two sampling periods.

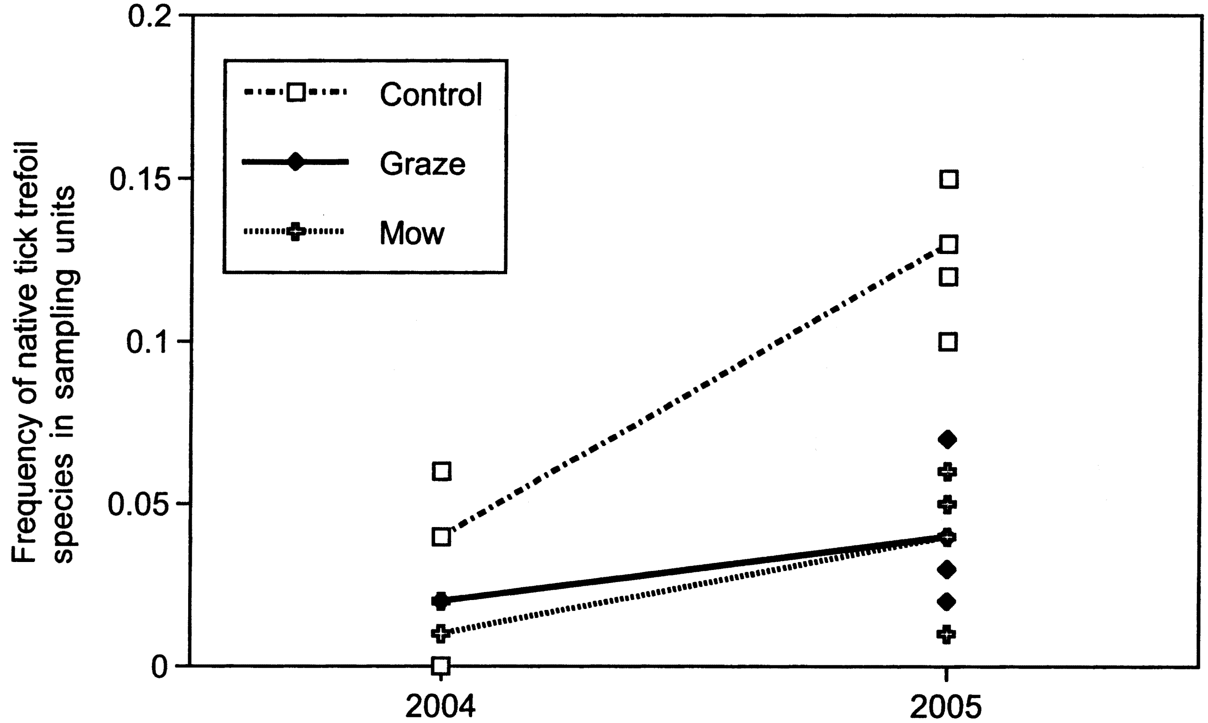

Figure 21. North site tick trefoil presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 200 samples per two sampling periods.

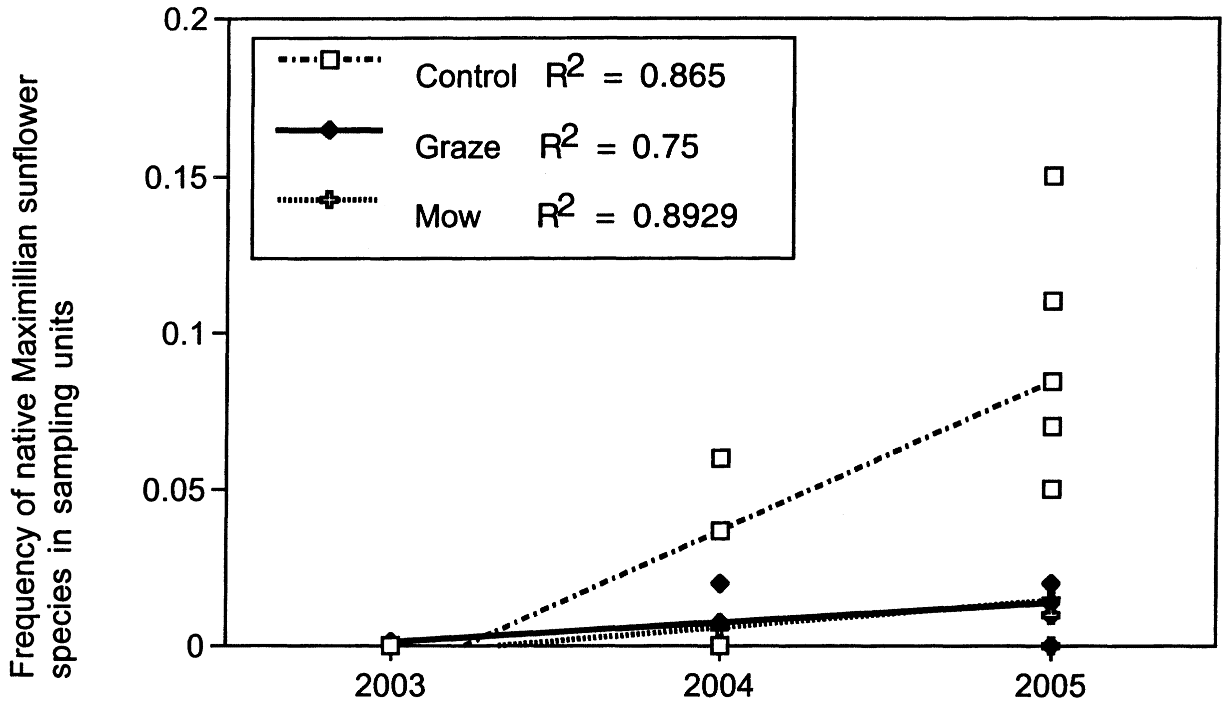

Figure 22. North site Maximillian sunflower presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 200 samples per two sampling periods.

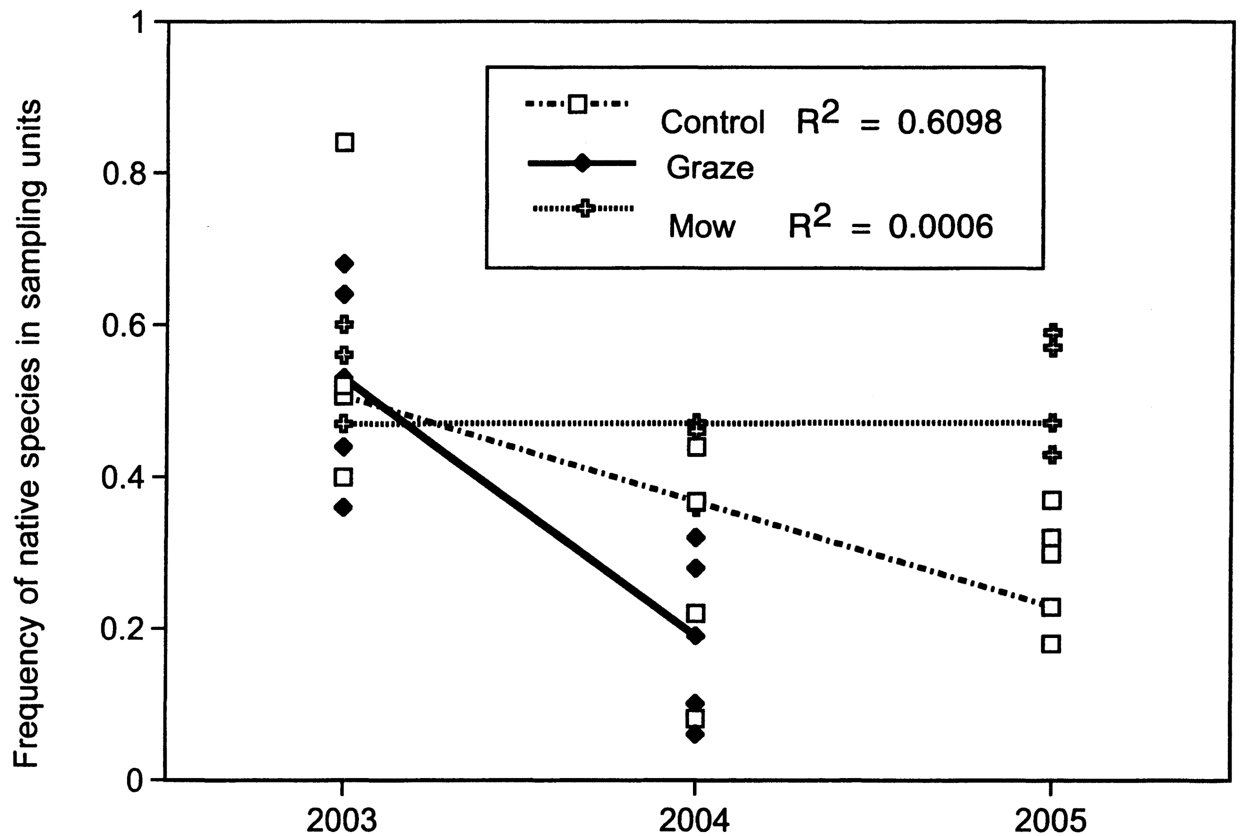

Figure 23. South site native species presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 150 samples per two sampling periods.

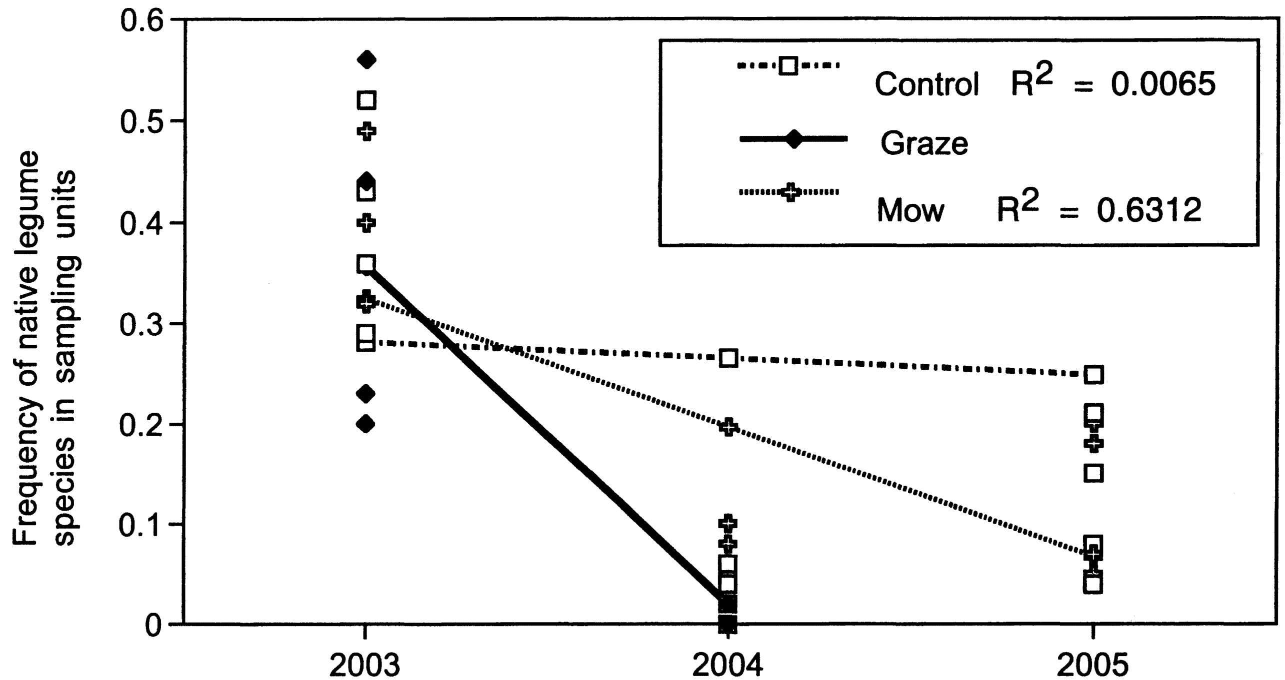

Figure 24. South site legume presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 150 samples per two sampling periods.

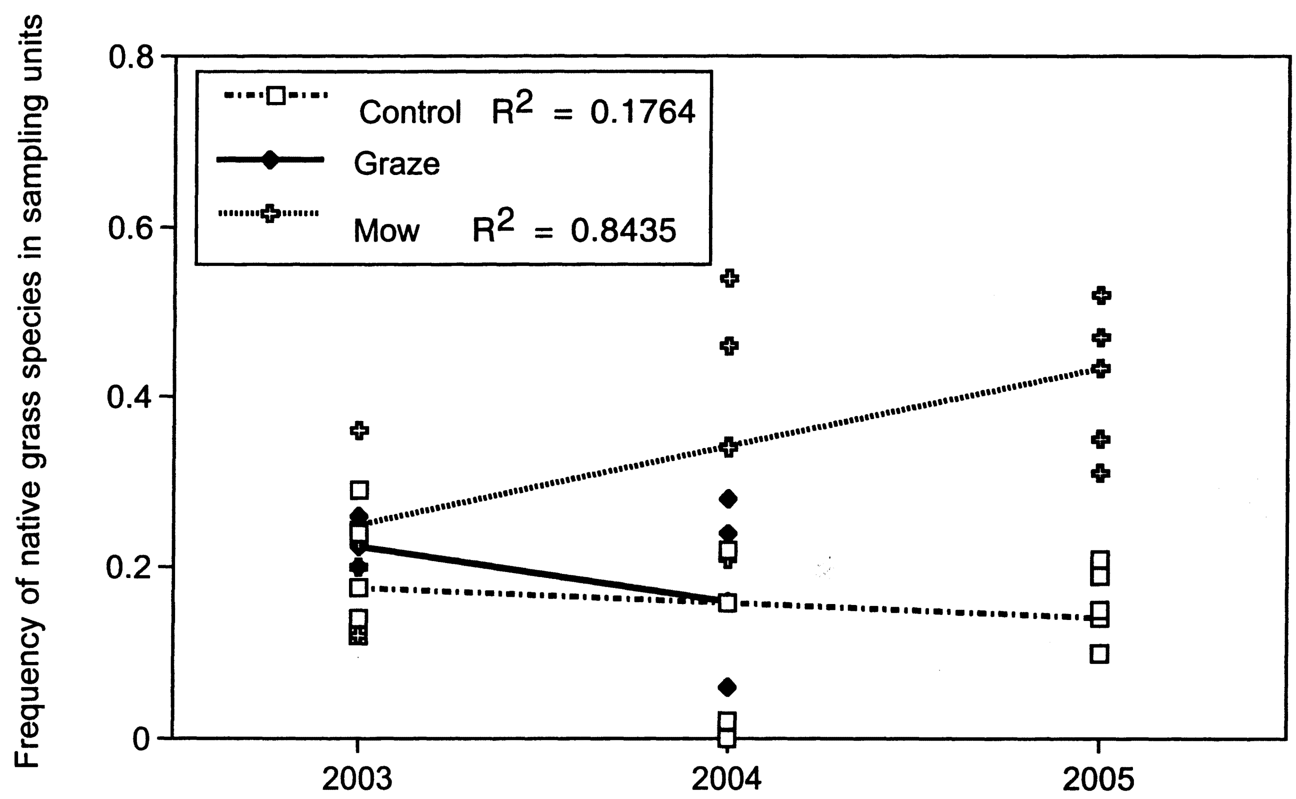

Figure 25. South site grass species presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 150 samples per two sampling periods.

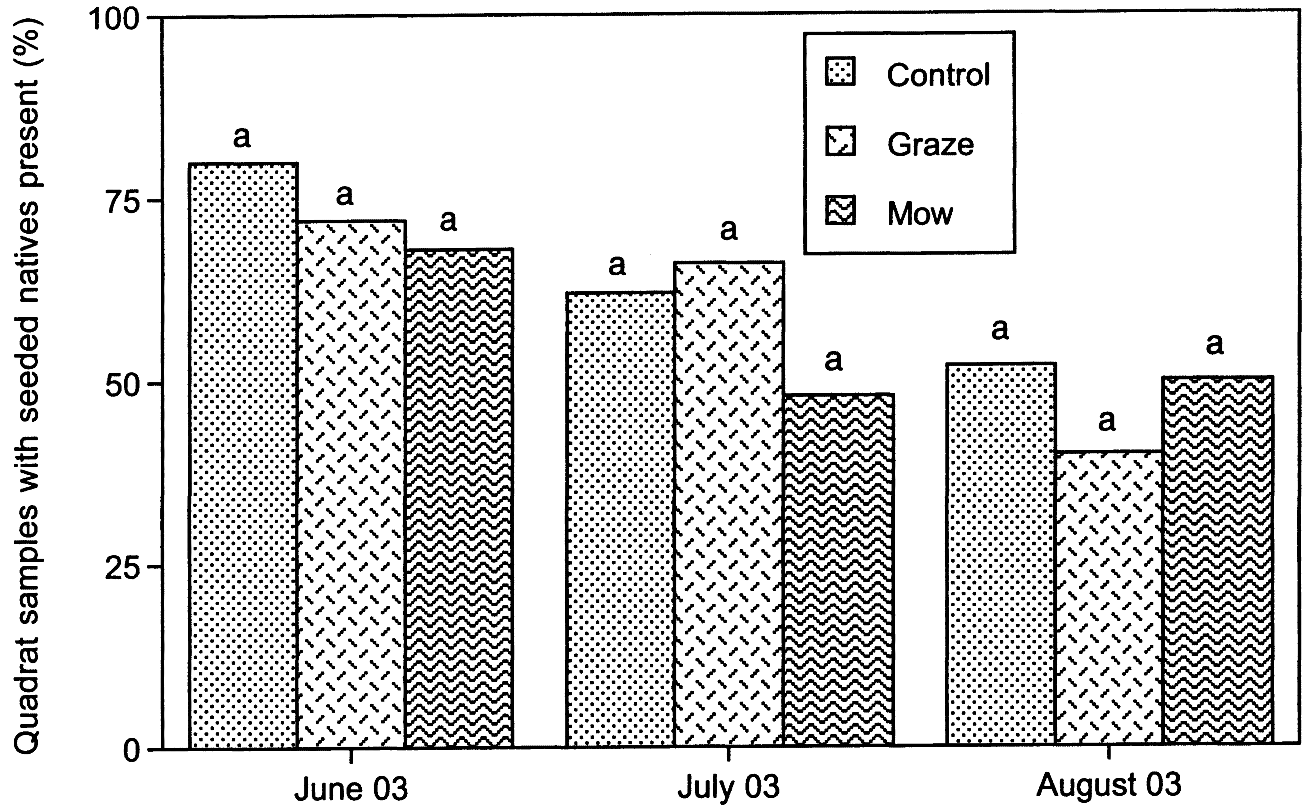

Figure 26. South site seeded native species presence in initial year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

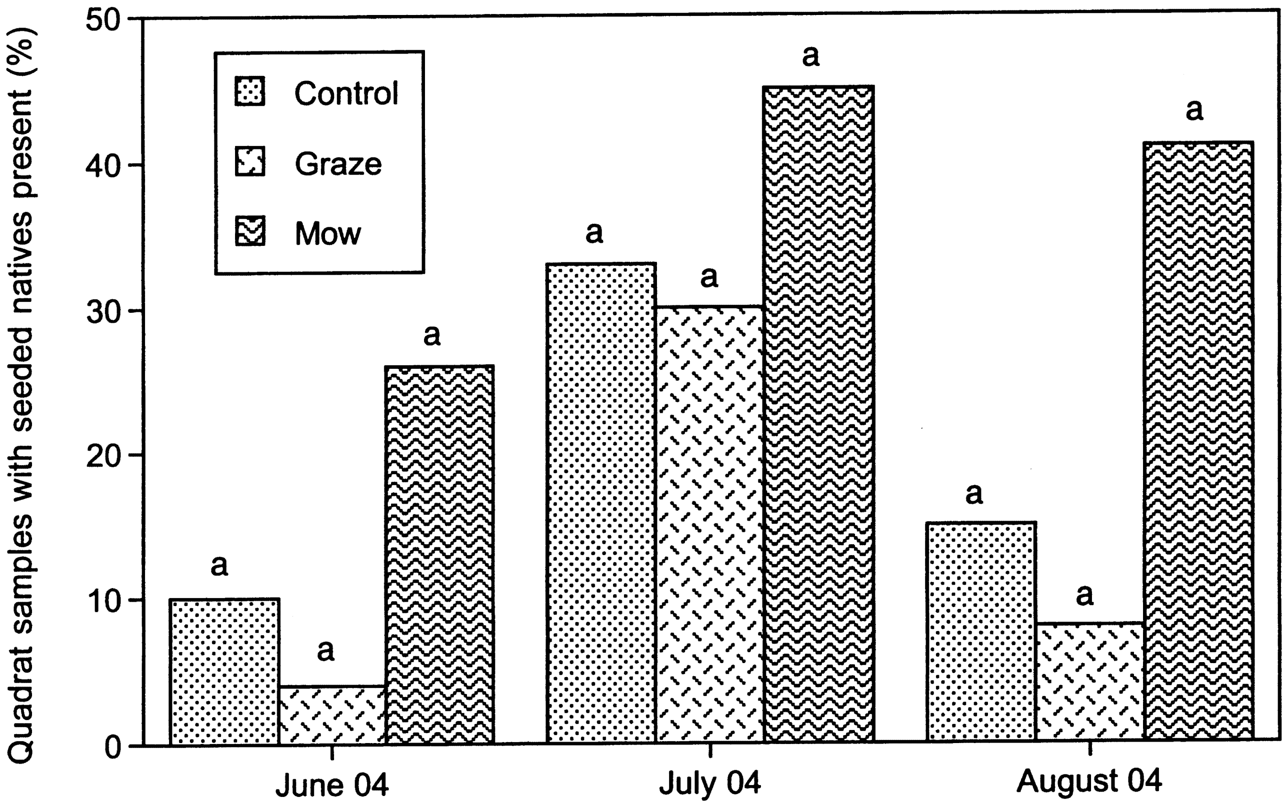

Figure 27. South site seeded native species presence in second year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

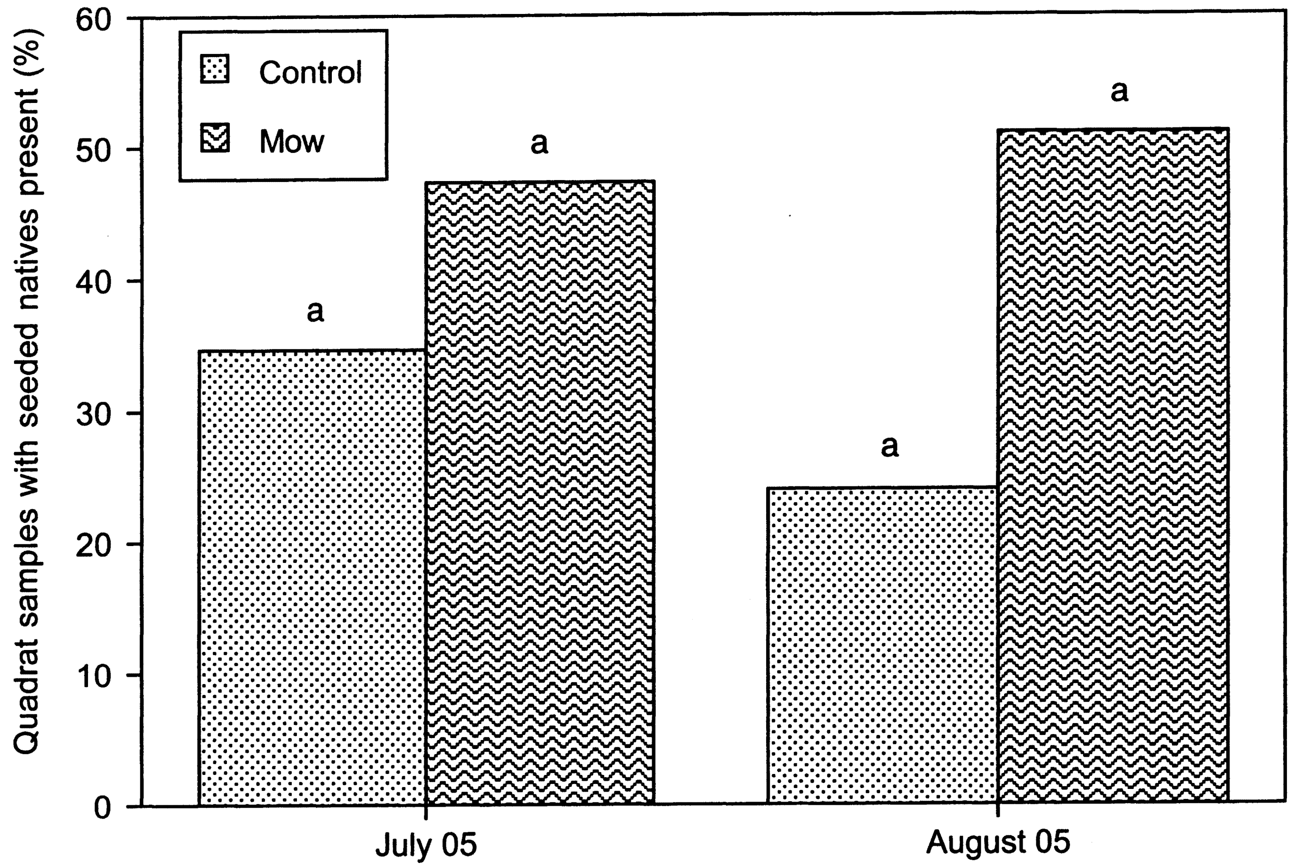

Figure 28. South site seeded native species presence in the third year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

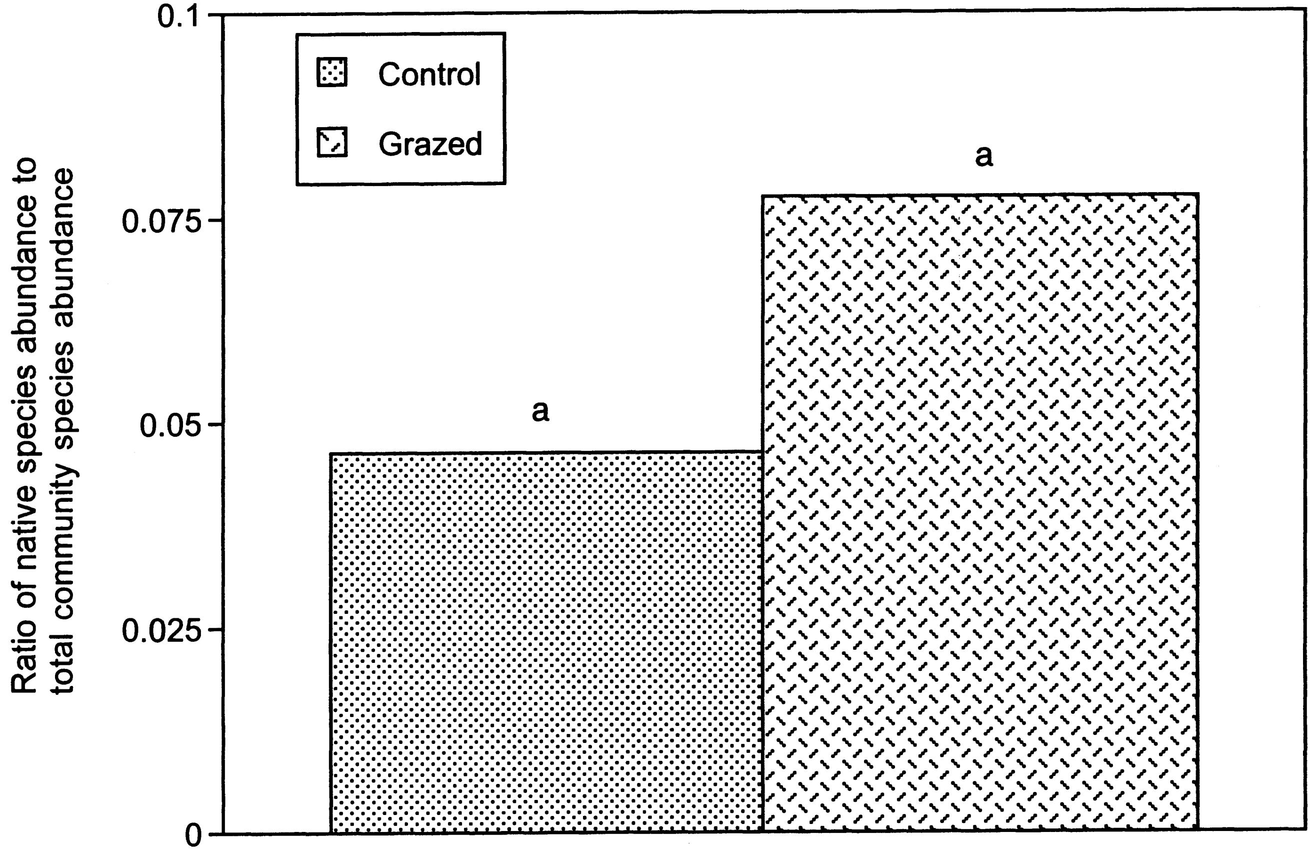

Figure 29. South site native species relative abundance in pasture community in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

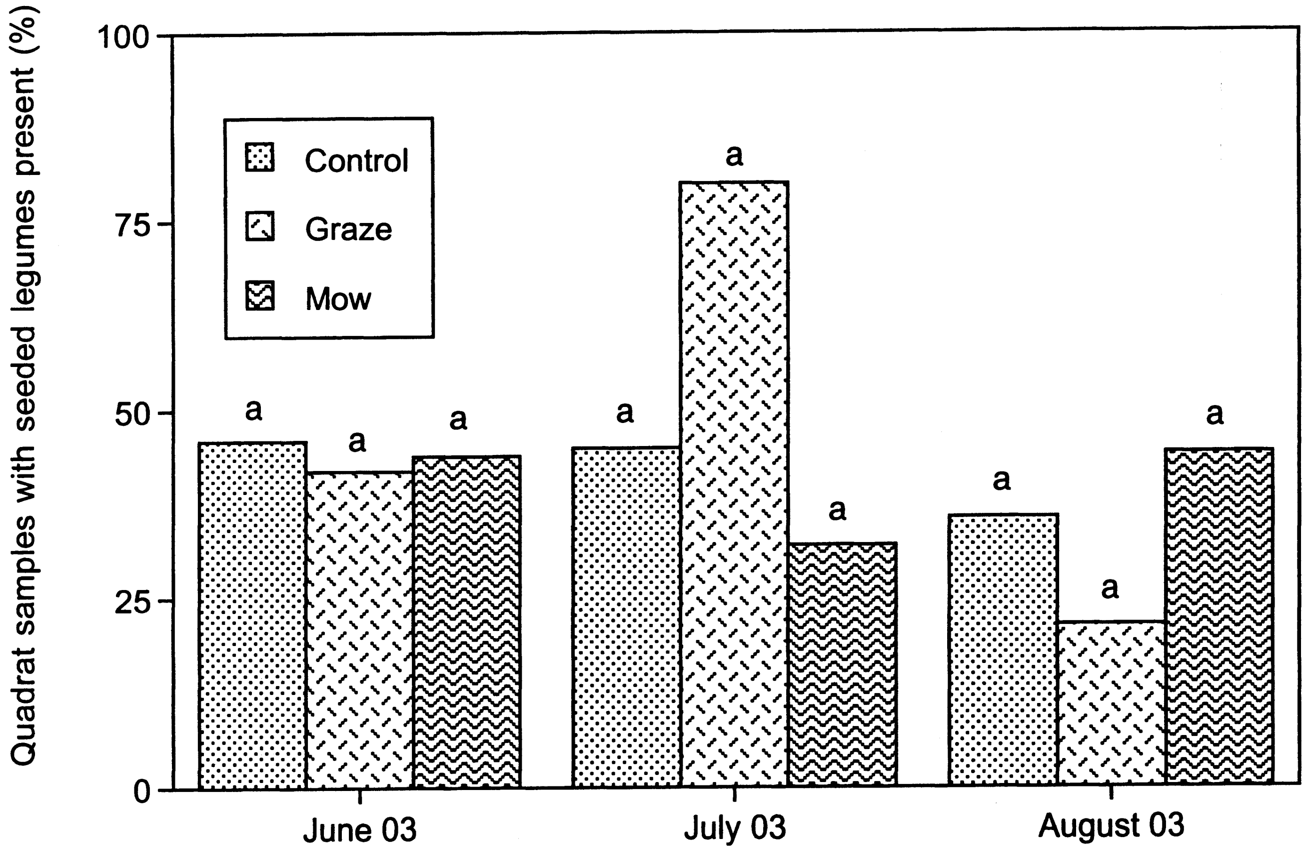

Figure 30. South site native legume species presence in initial year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

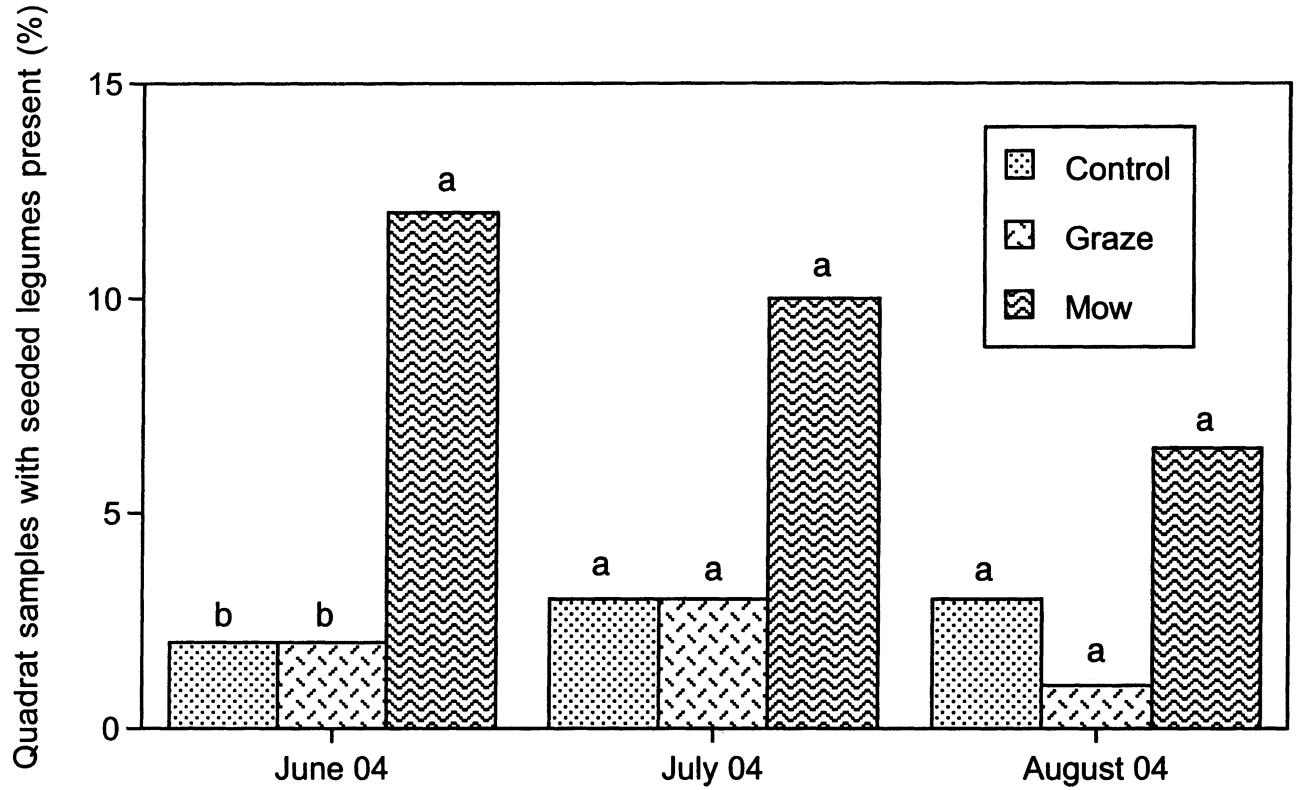

Figure 31. South site native legume species presence in the second year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

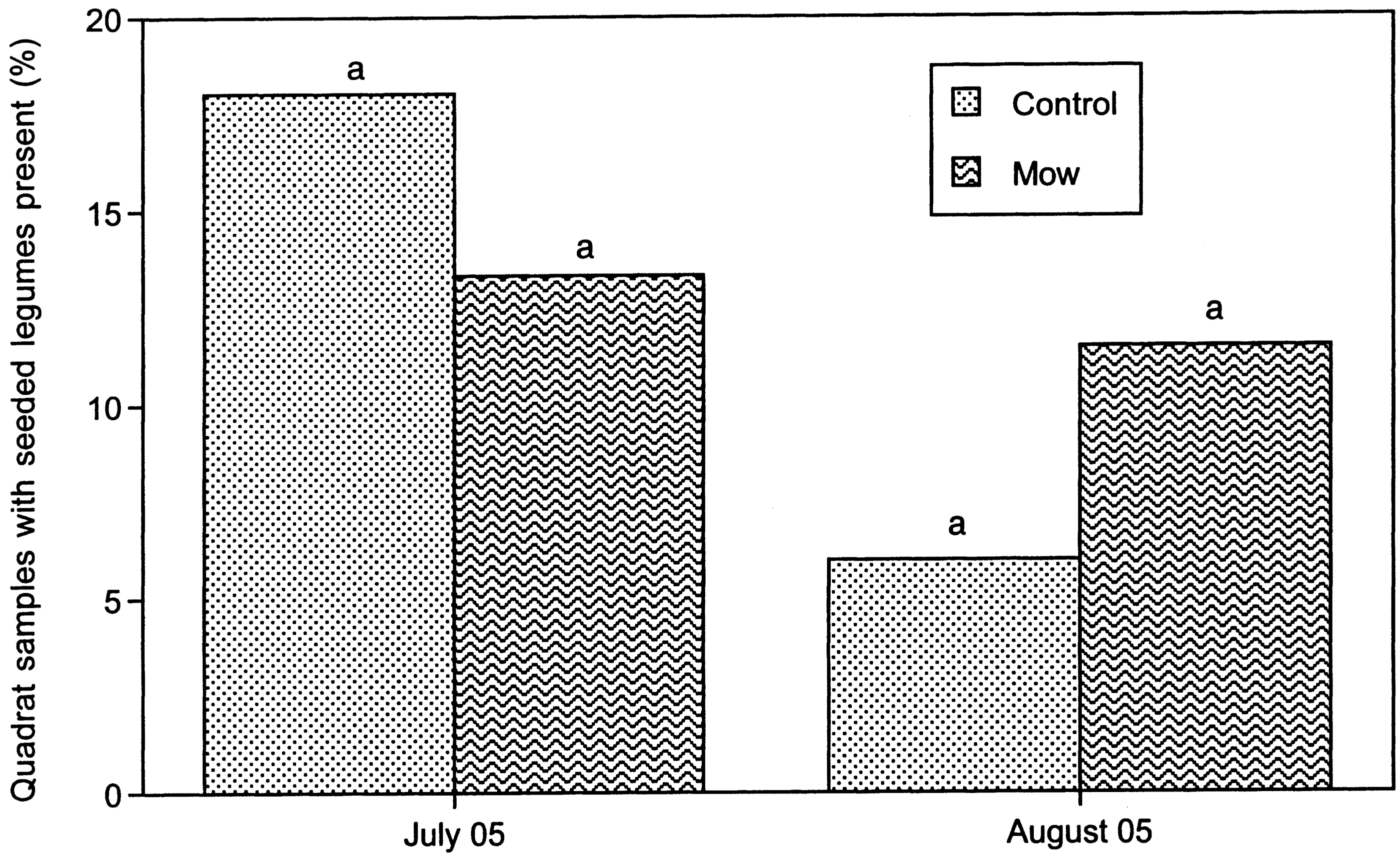

Figure 32. South site native legume species presence in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

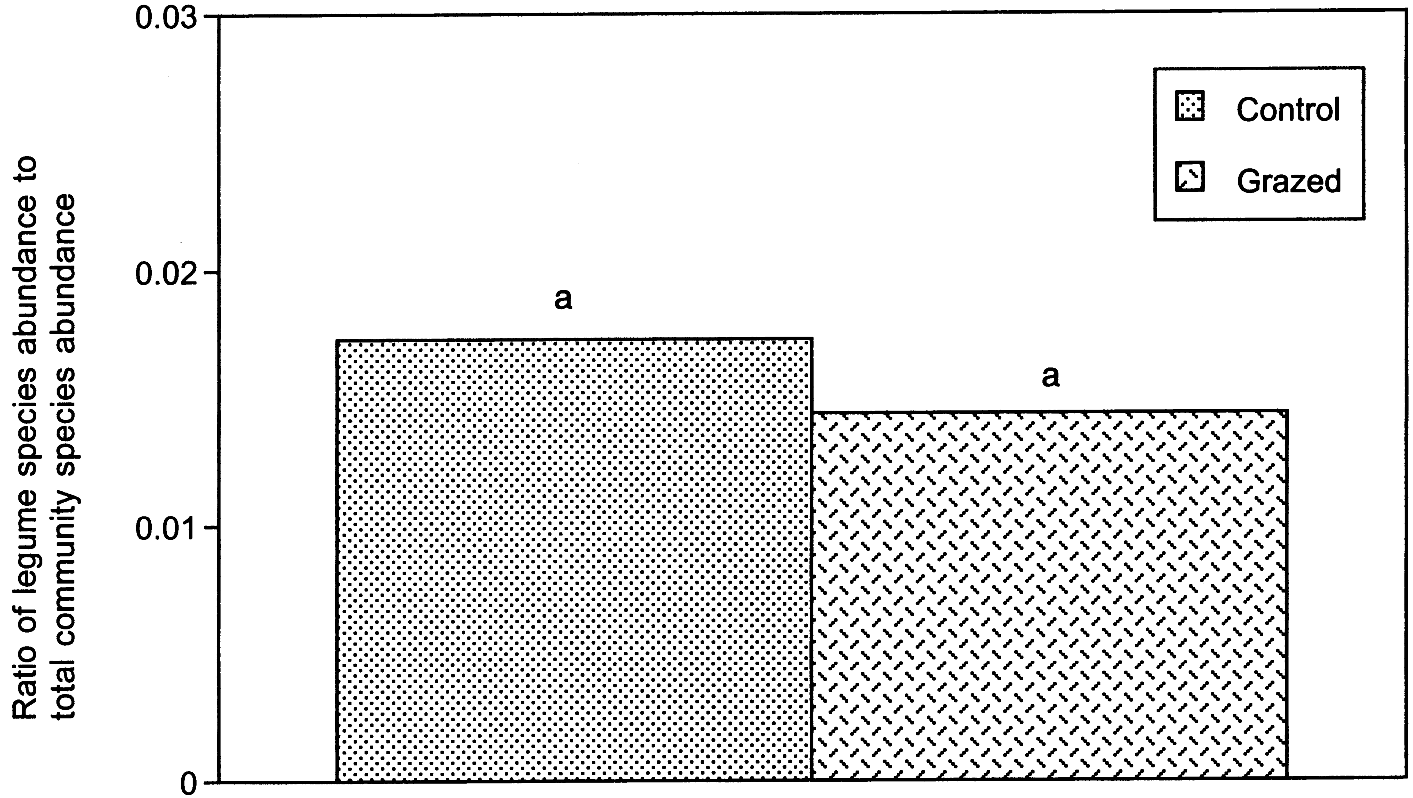

Figure 33. South site legume relative abundance in pasture community. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

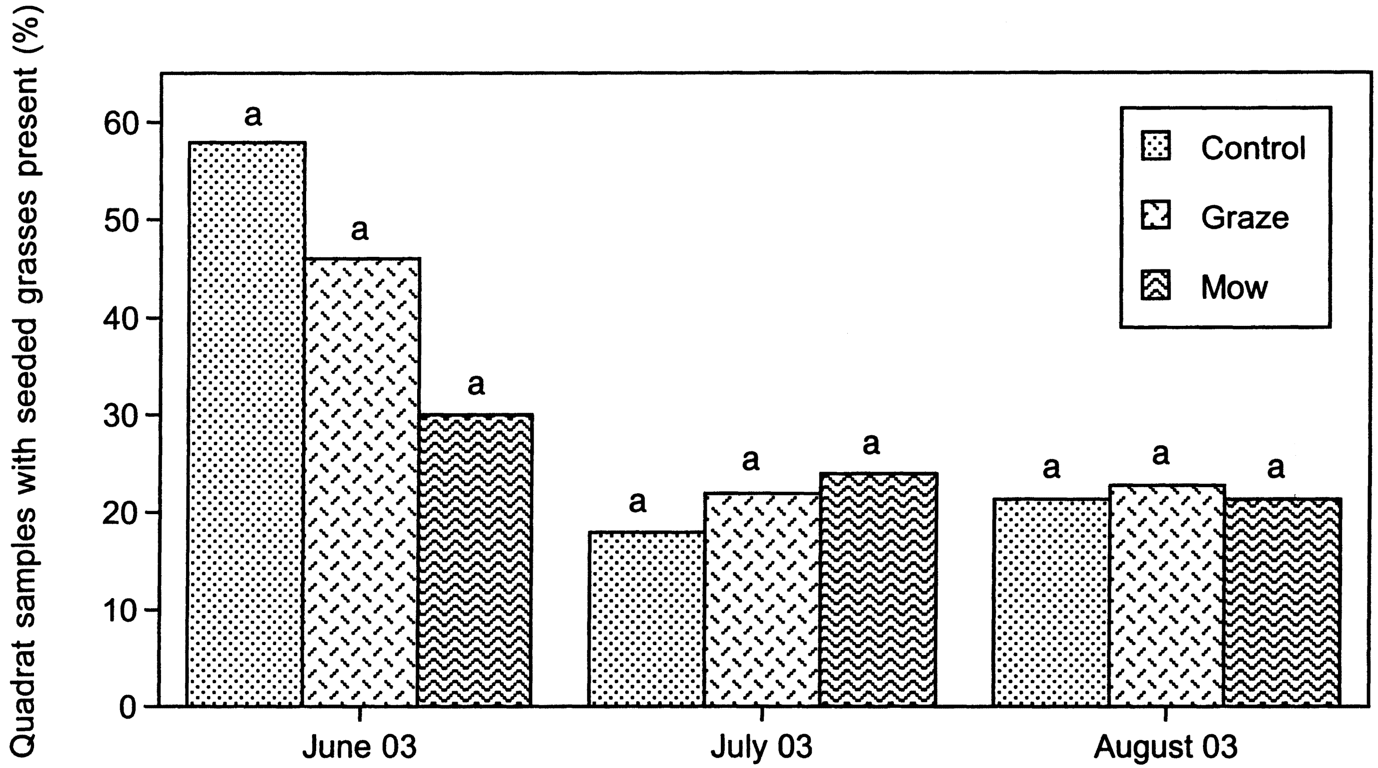

Figure 34. South site seeded grass species presence in the initial year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

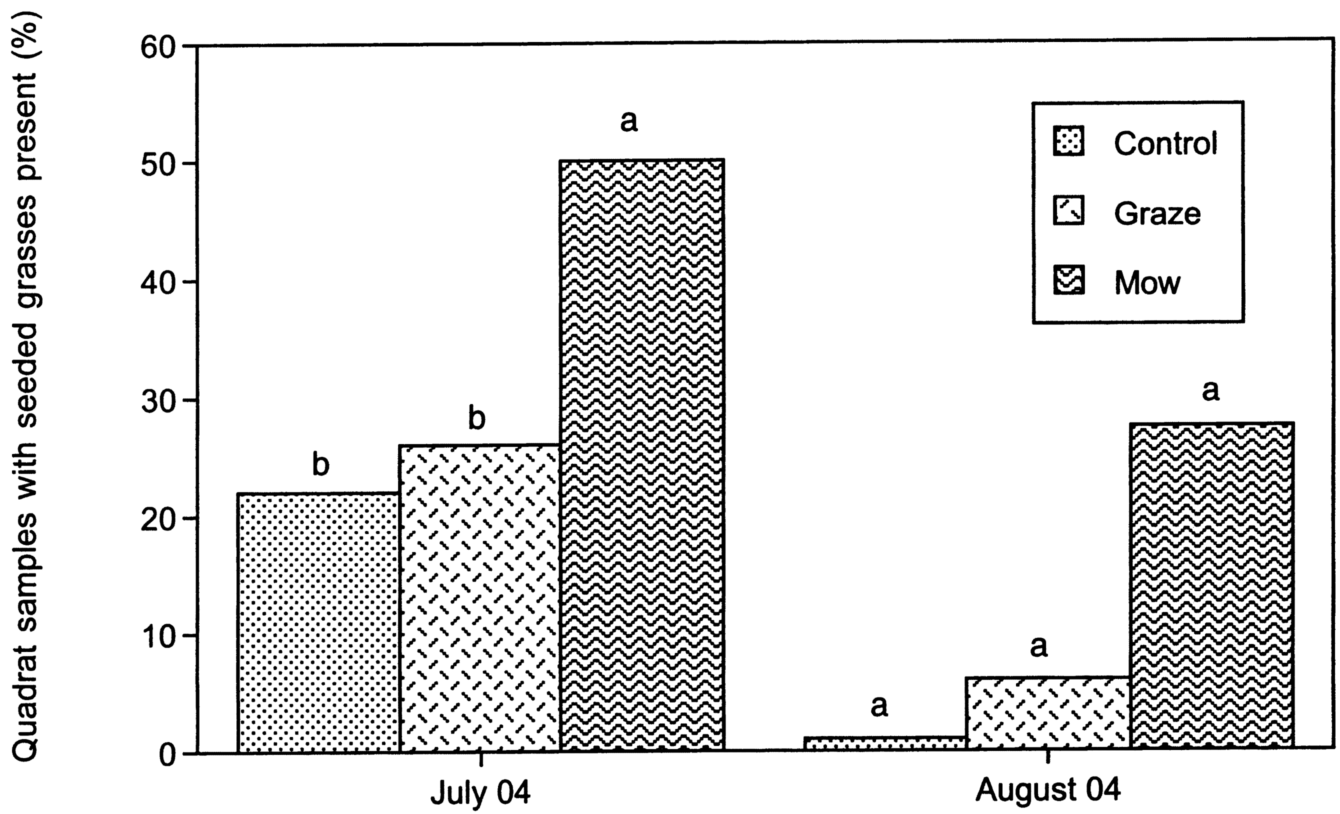

Figure 35. South site seeded grass species presence in the second year of seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

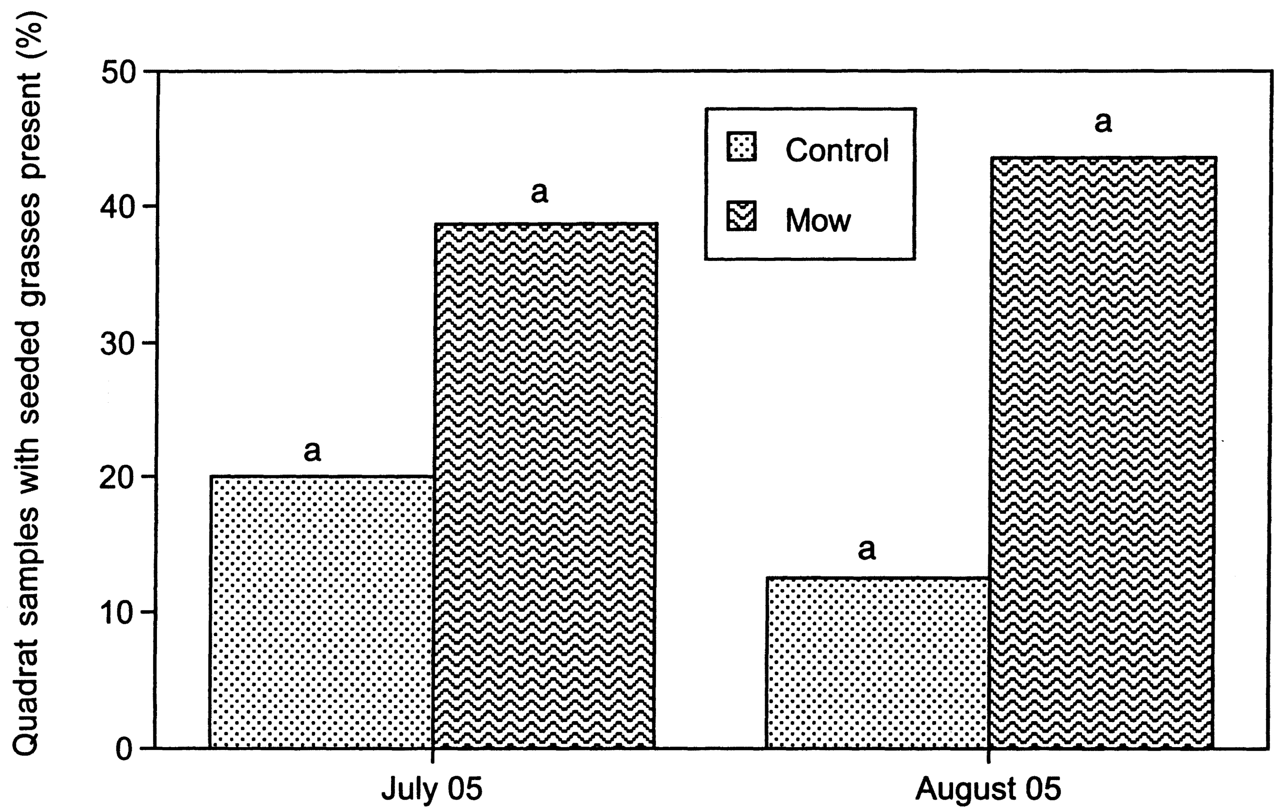

Figure 36. South site seeded grass species presence in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

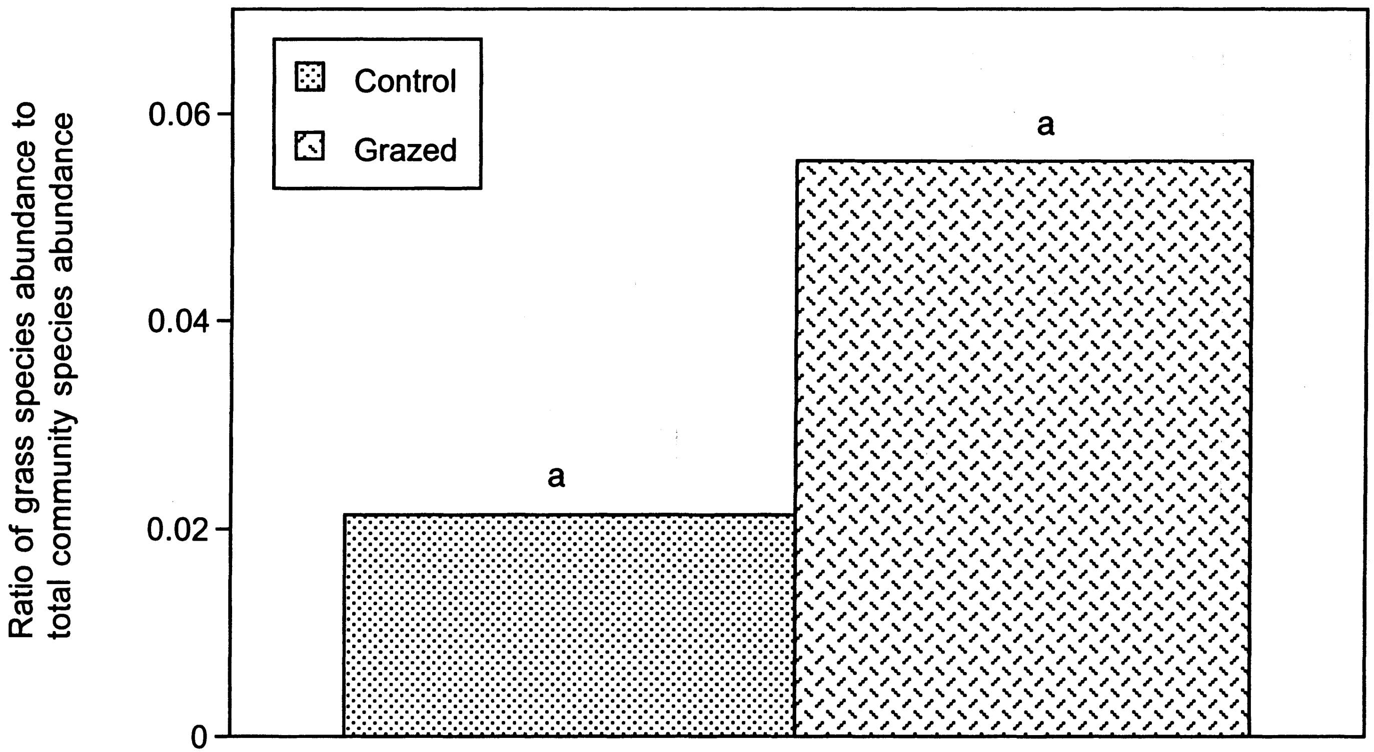

Figure 37. South site native grass relative abundance in pasture community in the third year after seeding. Bars within the same sampling period with the same letter above them are not significantly different at the $P = 0.05$ level.

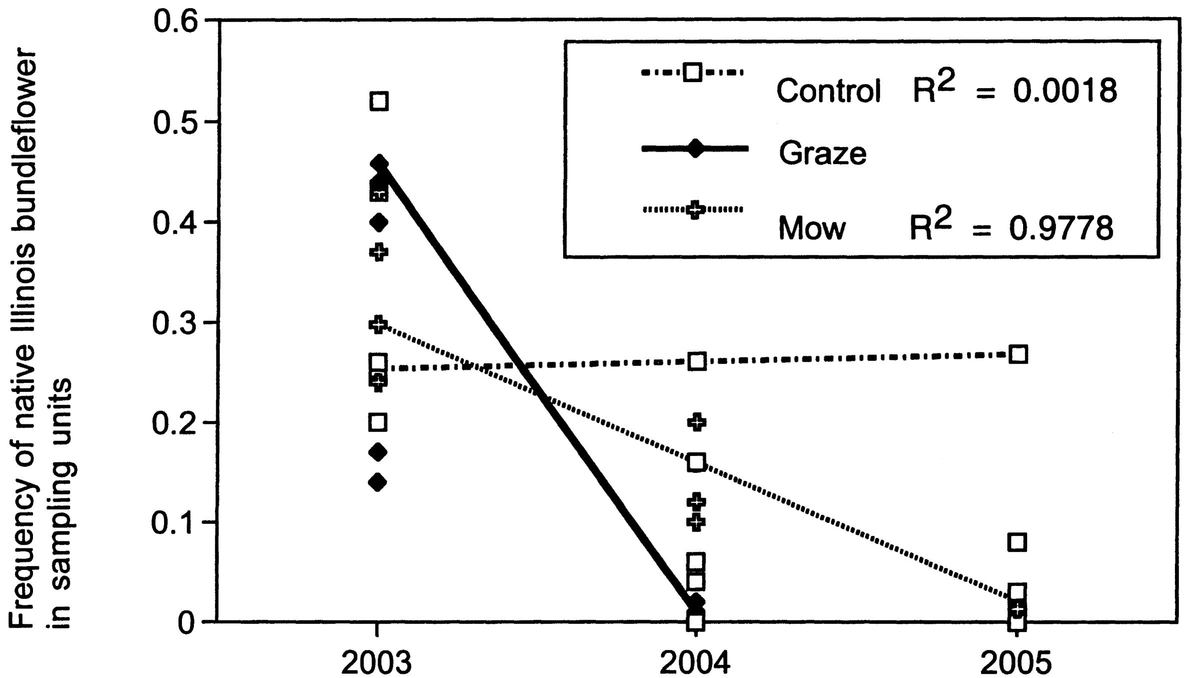

Figure 38. South site Illinois bundleflower presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 150 samples per two sampling periods.

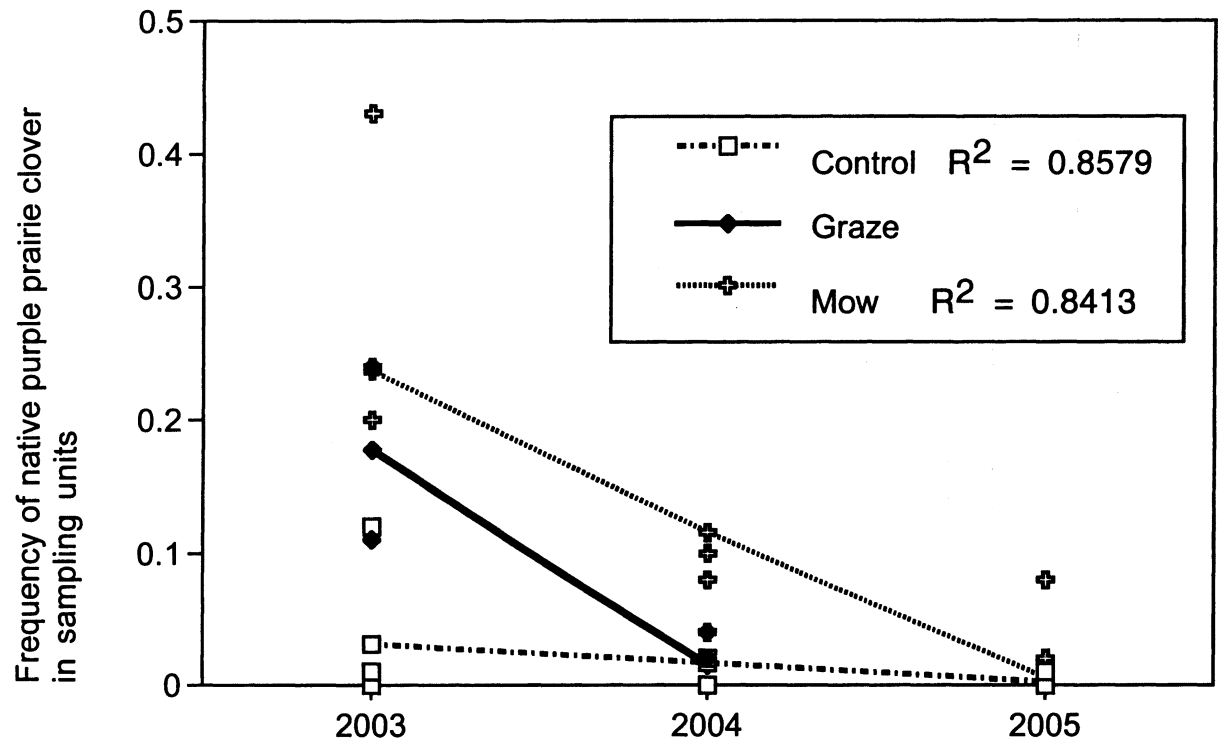

Figure 39. South site purple prairie clover presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 150 samples per two sampling periods.

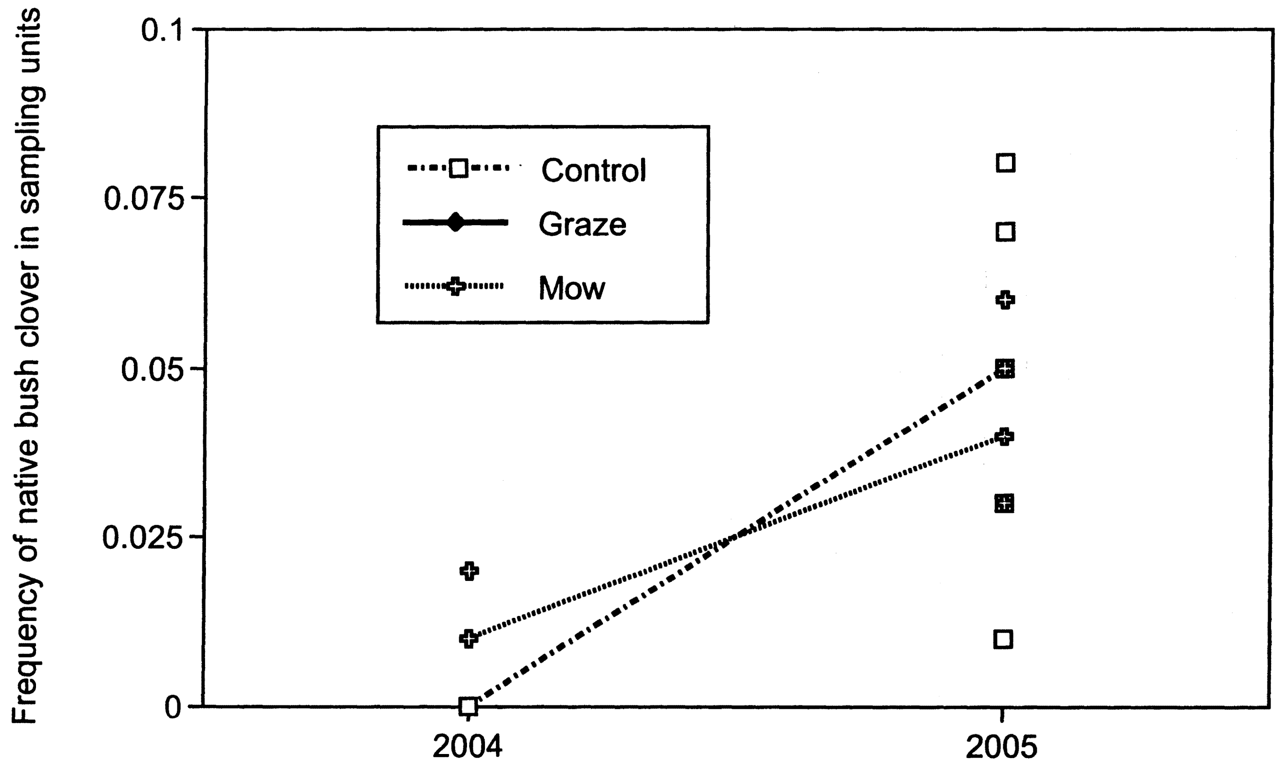

Figure 40. South site bush clover presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 150 samples per two sampling periods.

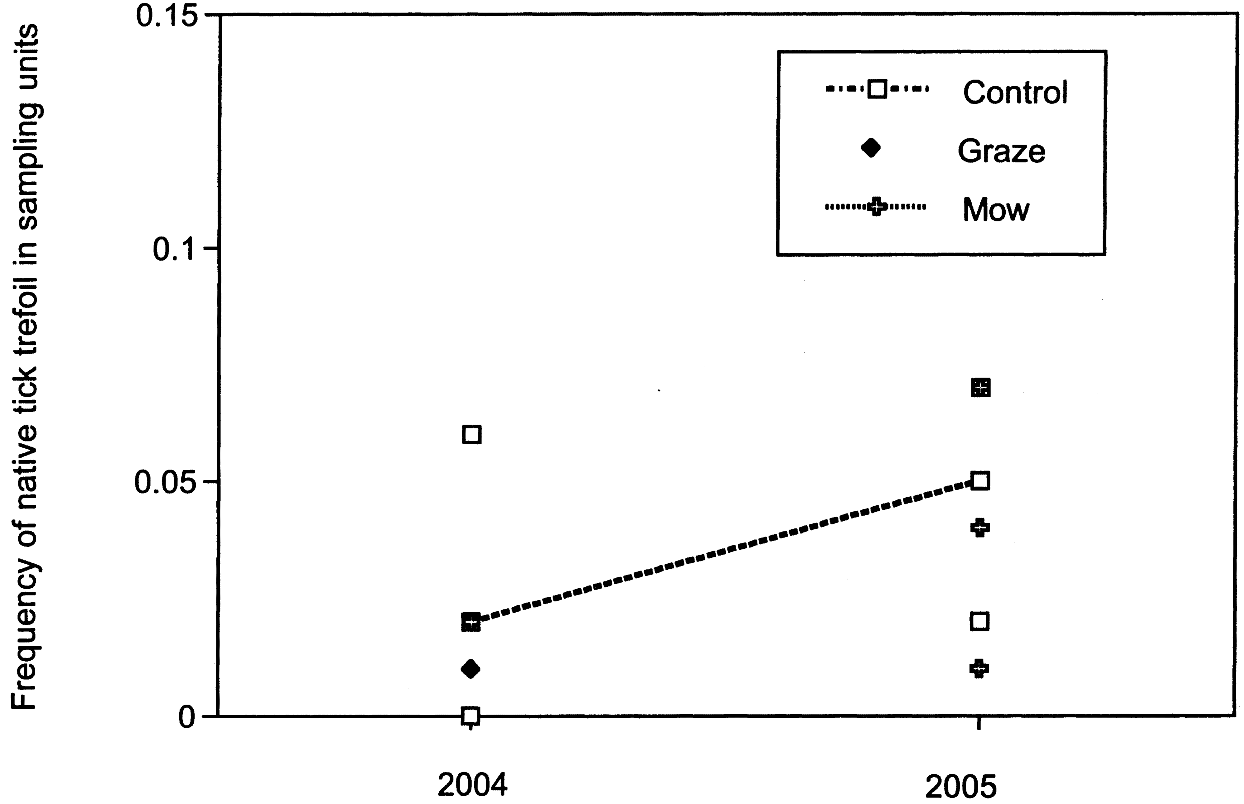

Figure 41. South site tick trefoil presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 150 samples per two sampling periods.

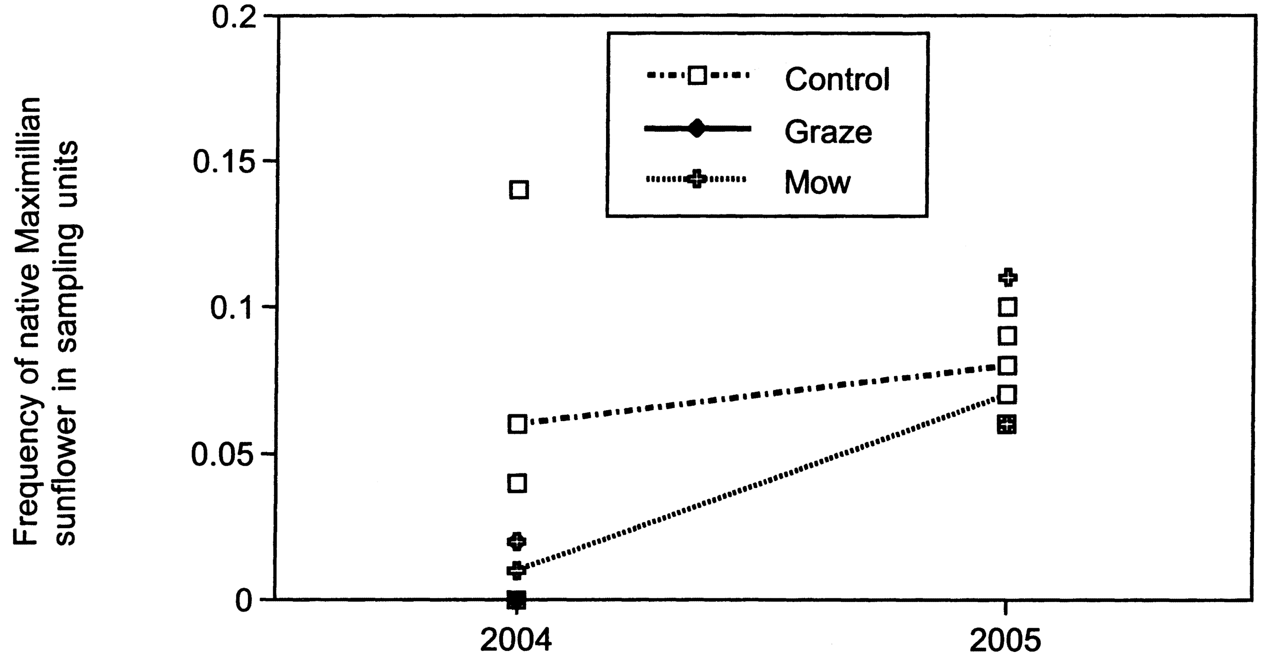

Figure 42. South site Maximillian sunflower presence across experimental years. Lines have been fit across treatment means. In 2003, the mean is derived from 50 samples per two sampling periods; in 2004, the mean is derived from 100 samples per two sampling periods; and in 2005, the mean is derived from 150 samples per two sampling periods.

Appendix A. North Experimental Site Community Inventory.

Common name	**Scientific name**
Alfalfa	*Medicago sativa* L.
American elm	*Ulmus americana*
American germander	*Teucricum canadense* L.
Aster species	*Aster* spp.
Birdsfoot trefoil	*Lotus corniculatus* L.
Black medic	*Medicago lupulina* L.
Blackseed plantain	*Plantago rugelii* Dcne.
Blue violet	*Viola sororia* Willd.
Bristly foxtail	*Setaria verticillata* L.
Buckbrush	*Symphoricarpos orbiculatus* Moench
Buckhorn plantain	*Plantago lanceolata* L.
Canada anenome	*Anemone canadensis* L.
Clammy ground cherry	*Physalis heterophylla*
Common cinquefoil	*Potentilla simplex* Michx
Common milkweed	*Asclepia syriaca*
Common ragweed	*Ambrosia artemisifolia* L.
Common yarrow	*Achillea millefolium* L.
Croton	Euphorbiaceae family
Dandelion	*Taraxacum officinale* Weber
Deptford pink	*Dianthus armeria* L.
Disk mayweed	*Matricaria discoidea* DC.
Flowering spurge	*Duphorbia corollata* L.
Giant ragweed	*Ambrosia trifida* L.
Goldenrod	*Solidago* spp.
Gooseberry	*Ribes* spp.
Heal-all	*Prunella vulgaris*
Hedge bindweed	*Calystegia sepium* L.
Honey locust	*Gleditsia triacanthos* f. *inermis*
Horse nettle	*Solanum carolinense* L.
Hoseweed	*Conyza canadensis* L.
Ironweed	*Vernonia* spp. Schreb.
Kentucky bluegrass	*Poa pratensis* L.
Musk thistle	*Carduus nutans* L
Narrow-leaved mountain mint	*Pycnanthemum virginianum*
Nightshade	*Sollanum* spp.
Orchardgrass	*Dactylis glomerata* L.
Panicgrass a	*Panicum* L.
Panicgrass b	*Panicum* L.

Pigweed	Amaranthus L.
Prairie crabapple	*Pyrus ioensis*
Prairie dogbane	*Apocynum cannabinum*
Prairie rose	*Rosa arkansana* Porter.
Prickly lettuce	*Lactuca serriola* L.
Purple-top	*Bidens flavus*
Raspberry	*Rubus spp.*
Red clover	*Trifolium pratense* L.
Rosinweed	*Silphium integrefolium* Michx.
Rough fleabane	*Erigeron strigosus* Muhl.
Rue	*Sopyrum* spp.
Rush	*Scirpus* spp.
Sedge	*Carax* spp.
Smooth brome	*Bromus inermis* Leyss.
Tall fescue	*Festuca arundinacea* Schreb.
Unidentified[z]	
White clover	*Trifolium repens* L.
Wild bergamot	*Monarda fistulosa* L.
Wild carrot	*Daucus carota* L.
Wild grape	*Vitis* spp.
Wild petunia	*Ruellia humilis* L.
Wild strawberry	*Fragaria* L.
Woodsorrel	*Oxalis* L.
Woolly plantain	*Plantago patagonica* Jacq.
Wooly cupgrass	*Eriochloa villosa* (Thunb.) Kunth
Yellow nutsedge	*Cyperus esculentus* L.

[z]Unidentified species include 7 unidentified broadleaves, 1 unidentified shrub, and 4 unidentified grasses and sedges.

Appendix B. South Experimental Site Community Inventory.

Common name	Scientific name
Alfalfa	*Medicago sativa* L.
American elm	*Ulmus americana*
American germander	*Teucricum canadense* L.
Aster species	*Aster* spp.
Birdsfoot trefoil	*Lotus corniculatus* L.
Black medic	*Medicago lupulina* L.
Blackseed plantain	*Plantago rugelii* Dcne.
Blue violet	*Viola sororia* Willd.
Bristly foxtail	*Setaria verticillata* L.
Buckbrush	*Symphoricarpos orbiculatus* Moench
Buckhorn plantain	*Plantago lanceolata* L.
Canada anenome	*Anemone canadensis* L.
Clammy ground cherry	*Physalis heterophylla*
Common cinquefoil	*Potentilla simplex* Michx
Common milkweed	*Asclepia syriaca*
Common ragweed	*Ambrosia artemisifolia* L.
Common yarrow	*Achillea millefolium* L.
Croton	Euphorbiaceae family
Dandelion	*Taraxacum officinale* Weber
Deptford pink	*Dianthus armeria* L.
Disk mayweed	*Matricaria discoidea* DC.
Flowering spurge	*Duphorbia corollata* L.
Giant ragweed	*Ambrosia trifida* L.
Goldenrod	*Solidago* spp.
Gooseberry	*Ribes* spp.
Heal-all *Prunella vulgaris*	*Prunella vulgaris*
Hedge bindweed	*Calystegia sepium* L.
Honey locust	*Gleditsia triacanthos* f. *inermis*
Horse nettle	*Solanum carolinense* L.
Hoseweed	*Conyza canadensis* L.
Ironweed	*Vernonia* spp. Schreb.
Kentucky bluegrass	*Poa pratensis* L.
Musk thistle	*Carduus nutans* L
Narrow-leaved mountain mint	*Pycnanthemum virginianum*
Nightshade	*Sollanum* spp.
Orchardgrass	*Dactylis glomerata* L.
Panicgrass a	*Panicum* L.
Panicgrass b	*Panicum* L.

Pigweed	Amaranthus L.
Prairie crabapple	*Pyrus ioensis*
Prairie dogbane	*Apocynum cannabinum*
Prairie rose	*Rosa arkansana* Porter.
Prickly lettuce	*Lactuca serriola* L.
Purple-top	*Bidens flavus*
Raspberry	*Rubus spp.*
Red clover	*Trifolium pratense* L.
Rosinweed	*Silphium integrefolium* Michx.
Rough fleabane	*Erigeron strigosus* Muhl.
Rue	*Sopyrum* spp.
Rush	*Scirpus* spp.
Sedge	*Carax* spp.
Smooth brome	*Bromus inermis* Leyss.
Tall fescue	*Festuca arundinacea* Schreb.
Unidentified[z]	
White clover	*Trifolium repens* L.
Wild bergamot	*Monarda fistulosa* L.
Wild carrot	*Daucus carota* L.
Wild grape	*Vitis* spp.
Wild petunia	*Ruellia humilis* L.
Wild strawberry	*Fragaria* L.
Woodsorrel	*Oxalis* L.
Woolly plantain	*Plantago patagonica* Jacq.
Wooly cupgrass	*Eriochloa villosa* (Thunb.) Kunth
Yellow nutsedge	*Cyperus esculentus* L.

[z] Unidentified species include 5 unidentified broadleaves, 1 unidentified shrub, and 3 unidentified grasses and sedges.

Chapter Five. General Conclusions

Grassland Multifunctionality in the Marion County Community

At the farm level, this research sought to explore (i) what do marginal land grass-based farmers perceive as their motivation, incentives, and limitations within their farming systems; (ii) how do infrastructural institutions and general social relationships influence the farmers; and (iii) what internal household factors, and external biological, physical, and socioeconomic factors influence decisions, and how are these perceived in light of risk. By using Farming Systems Research (FSR) and the embeddedness perspective in addressing the motivations and limitations of the farm households in my study, I identified the variable relevance of livelihood and lifestyle to different households of the grass-based farmers. I can generally conclude that each operation type uses, and is affected by, social relations, infrastructure, policy and risk differently. These observations are poignant within a changing socioeconomic community.

As farm-supply store manager in Marion County, Iowa, summarized,

> "It used to be that everyone in this county had 10 cows or so. Not anymore. The little herds are almost gone. Now a very high percent of our customers have 100 cows, like me. And they have a full-time job in town. The farms have gotten bigger, acreages have gotten bigger, and also you have the doctors and lawyers coming and buying all of this land. It's so hard for the little guy to compete with those people. The cash rent is high; it's very tough to be a small farmer."

Cow-calf operators are working with these changes in different ways, but as a community banker stated and my research verified, "Your financial situation basically influences everything you *want* to do." The financial situation of cow-calf operators influences their livelihood strategies, which in turn influences their land use practices and the application or relevance of their values in their lifestyles. Social relationships with family and peers (Carroll et al., 2003; Hinrichs, 1998), as well as infrastructure (Cruise and Lyson, 1991), influence financial and cultural outcomes as well.

For the informants in my study, a combination of these factors led to the sustained use of a grass-based operation and had various outcomes. The part-time exclusive cow-calf operators were strongly influenced by lifestyle parameters such as their children or the challenge, and the farm may have served functions such as a land ownership strategy or as an identity. The full-time integrated operations relied on income from the cow-calf operation, although it also may have functioned for risk-reduction, pragmatic land use, and as a complement to a commodity grain base. The integrated part-time operators strategy appeared to blend these functions. For all of the informants, the cow-calf, grass-based operations complemented or supplemented a household income, and sustained or contributed to a farmer or countryside dweller identity. Some felt that cow-calving was beneficial to their children, to the landscape, to the environment, or to local businesses such as the sale barn. The operators felt that they helped to populate the countryside, feed people, and continue a proud farming heritage.

This range of benefits could be considered multifunctional to the farm household (Maier, 2001), although one community leader commented about the role of agriculture and cow-calf operations within Marion County, "It's kind of behind the scenes. A lot of it is taken for granted, but if it is gone, then people will realize it really quickly." This subliminal nature of cow-calving was inferred by many of the people I talked to in my study in Marion County, although several also recognized the range of present functions served by pastures in the county. Commenting on the increasing ownership of pasture by absentee hunters, an agricultural professional observed,

> "If you have 200 acres in grass, and you leave it all to trees and wildlife and every now and then you come to hunt, you're not producing income off of that land. But if you have cattle on there, you not only have the wildlife, but you are producing beef, which helps the local economy. The person buys the equipment, the veterinarian services, and his inputs. Plus he's selling a product. So really it's all economic development, you're passing dollars through the system. But the hunting land contributes little to the local economy."

This multifunctionality concept is acknowledged in policies worldwide (Brouwer, 2004; van Huylenbroeck and Durand, 2003) and it could influence the household level cow-calf systems of Marion County in the near future.

My field experiment on the feasibility of "pasture-prairies" demonstrated that a diverse community of native species can be successfully established on current pasture using organic management practices that are compatible with many of the constraints faced by current operators. Such practices open doors to high-value organic certification, while contributing to the conservation and restoration of the native tallgrass prairie ecosystem (Jackson, 1999) and the multifunctionality of pasture systems.

Future Studies Integrating Social and Agroecological Research on Grass-Based Farming

A more systematic examination of the external factors affecting the farm households in my study, such as off-farm income, the effect of changing demographics, policy changes, or farmers' perspectives on regional natural resources would be relevant to the formation of policy recommendations that would more directly benefit the small cow-calf operations. Some argue that FSR does not adequately deal with the interplay between on-farm and off-farm activities (Robotham, 2001) or with the stocks and flows of materials and resources both within and off the farm (Dalsgaard and Oficial, 1997). Future research about these perspectives in grass-based agriculture may benefit from the pluriactivity perspective which holds that the farm plays a *strategic role* in the income generated by the household (Fuller, 1990; Munton, 1989) although this role is not always associated with economic conditions (Ellis et al., 1999). With pluriactivity, the interface between the on-farm and off-farm activities is pivotal.

Increasing the contributions of agricultural, and specifically pasture lands to species diversity and wildlife is a common prerogative in multifunctional policies (Hopkins and Hopkins, 1994) and can be readily extrapolated to existing pastures on marginal lands in Marion County today. My research demonstrated that grazing management strategies can permit native species with diverse lifecycles to be sustained in pasture niches, and this strategy may be rewarded through government policies such as the Conservation Security Program. However, questions framed by pluriactivity would also enhance conclusions regarding the process and success of organically establishing native species pastures.

At the field level, my research sought to evaluate the effect of organic management practices an existing pasture community to determine if particular strategies more effectively foster the seeded species growth relative to existing species suppression. All practices successfully established native species to varying degrees although each practice was marked by strengths and drawbacks such as labor, extensive physical capital, and risk. Ellis et al. (1999) framed the pasture management strategies used by Scottish farm households with pluriactivity, and was able to associate floristic diversity-enhancing management with existing livelihood strategies. Viable pasture management strategies were structured by *how they fit* in livelihood strategies. In future studies of the Marion County community, a more detailed analysis of the types and relevance of off-farm income to cow-calf operators and farm households would contribute to a greater understanding of policies needed to help maintain diverse, grass-based systems in Marion County, Iowa.

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