

**The effect of burn season on  
the spider (Araneae) fauna of  
tallgrass prairie and its implication  
on prairie management**

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By

David J. Wade

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THE EFFECT OF BURN SEASON ON THE SPIDER (ARANEAE) FAUNA OF TALLGRASS  
PRAIRIE AND ITS IMPLICATION ON PRAIRIE MANAGEMENT

BY

DAVID J. WADE

A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University  
of Manitoba in partial fulfillment of the requirements of the degree  
of  
Master of Science

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## Abstract

Fire is the primary management tool for tallgrass prairie. Spring burns are the predominant fire season used to manage tallgrass prairie. Alternative fire seasons include summer and fall burns, which occurred historically due to lightning strikes or by Aboriginal people purposely igniting the prairie. The best fire season for tallgrass prairie management has not been thoroughly examined. Researchers have focused on the effects of fire on plant communities whereas arthropod communities, including spiders, have received little attention. To address this issue, a study was developed to determine if there was an optimal season to burn tallgrass prairie using spiders as one of the bioindicators. The burn seasons examined were spring, summer, and fall. All burns were conducted in 1997 and sampling took place from 1997 to 2000. The spider community was positively affected by fire season, based on alpha and beta diversity indices. Of the three seasons, the summer and fall burns were the best overall in that they tended to have the highest diversity and evenness. The spider community of the tallgrass prairie was diverse, containing 126 species, including 8 new provincial records. The tallgrass spider community was initially dominated by *Pardosa moesta* Banks but *P. distincta* (Blackwall) became dominant in the summer and fall burn treatments. The *P. distincta*-dominated community exhibited the highest community stability because it exhibited resilience and resistance. *Pardosa distincta* was not found in the adjacent aspen forest, indicating that it is restricted to the tallgrass prairie. The recommendation to tallgrass prairie managers based on the results of this study is to incorporate all three burn seasons into the long-term fire management plan. A four to five year burn cycle and continued monitoring of the spider community is also recommended.



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## INTRODUCTION

Tallgrass prairie is an important but endangered habitat. Less than 1% of the historic range of tallgrass prairie remains in North America (Morgan 1994, Robertson *et al.* 1997). This 1% is comprised of numerous small fragments spread throughout the central region of North America. One of these fragments is the tallgrass prairie located at the St. Charles Rifle Range. The St. Charles Rifle Range contains 192 hectares of tallgrass prairie but has never been regularly managed (Morgan 1994).

The Department of National Defence (DND) is responsible for the tallgrass prairie found on the St. Charles Rifle Range property. A project was initiated in 1997 to determine the proper management strategy for this tallgrass prairie. Morgan (1994) proposed a preliminary management plan based solely on vegetation data. Morgan's (1994) fourth recommendation was that plant and insect taxa be monitored to evaluate the effectiveness of management activities. His fifth recommendation was that the St. Charles Rifle Range should be burned regularly using controlled burns. Based on Morgan's (1994) recommendations, a burn management project was set up between the University of Manitoba and DND, with Dr. R.E. Roughley as the primary investigator. Previous research on the use of fire as a management tool focused on fire as the treatment, without regard for the timing of the burn, and relied heavily on plants as bioindicators (e.g. Howe 1994). As a result, the effect of summer and fall burns on the tallgrass prairie has been understudied, as has the impact of fire on non-plant taxa such as spiders. To address these issues, the effect of fire season on the tallgrass prairie was examined using ground beetles, spiders, and plants as bioindicators.

There is some terminology that needs to be defined to avoid confusion later on.

The term burn season will refer to the season in which the burn occurs. For example, a spring burn is a burn that occurred in the spring. Burn treatments will be referred to by the season in which the burn occurred. For example, the summer treatment is the portion of the tallgrass prairie that was burned in the summer. If a season is referred to without the words burn or treatment, then reference is to the actual season. The unburned area intended to provide a source of immigrants after fire or as a location for emigrants from fire to escape to is referred to as the refuge treatment. The term refugia will refer to areas that are unburned in future management plans.

The purpose of this project was to determine which burn season is the best in order to manage tallgrass prairie effectively. The objectives of the study were to: (1) determine the effect of burn season on the plant community, (2) determine the effect of burn season on the ground beetle (Coleoptera: Carabidae) community, (3) determine the effect of burn season on the spider (Araneae) community, (4) determine the optimal burn cycle interval, (5) determine if there is an optimal burn season for tallgrass prairie management, and (6) determine the uniqueness of the tallgrass prairie fauna. My component of the project was to examine the third objective and to give input into the last three objectives.

## LITERATURE REVIEW

### **Introduction**

Historically, prairie was a dominant habitat in North America, covering 3.6 million square kilometers (Robertson *et al.* 1997). The area of tallgrass prairie covered 570,000 square kilometers approximately 300 years ago (Howe 1994). It ranged from southern Saskatchewan and Manitoba, south to Texas and eastward to Iowa (Robertson *et al.* 1997). Today, only an estimated 1% remains in North America and less than 1% in Manitoba (Morgan 1994, NCC 2000, Robertson *et al.* 1997). The majority of the tallgrass prairie was destroyed during European settlement in the late 19<sup>th</sup> century, mostly due to conversion to agricultural land (NCC 2000, Robertson *et al.* 1997). Conservation and restoration efforts to protect the remaining areas of tallgrass prairie have been ongoing in Canada and the United States. In Manitoba, the active conservation of remnant tallgrass prairie sites has only been occurring for the past 20 years (NCC 2000). The main tallgrass prairie sites in Manitoba are the Tallgrass Prairie Preserve (1820 hectares), the St. Charles Rifle Range (192 hectares), and the Living Prairie Museum (12 hectares).

Tallgrass prairie was historically maintained by fire and grazing (Howe 1994, Schwartz and Hermann 1997). Tallgrass prairie is adapted to disturbance and therefore active management requires a regular disturbance regime. The historical disturbances (fire and grazing) have been the primary management method but mowing is also used (Howe 1994, Schwartz and Hermann 1997). However, fire is by far the most widely used management technique (Schwartz and Hermann 1997). Without a regular disturbance regime, the dominant species at all taxonomic levels take over and this results in a

reduction in species richness and productivity (Collins and Steinauer 1998, Reed 1997, Schwartz and Hermann 1997). Regular disturbance keeps tallgrass prairie at a high species richness and high productivity. However, the regime necessary to maintain this high diversity and productivity is debatable (Collins and Steinauer 1998, Howe 1994).

The purpose of this literature review is to discuss the role spiders play in tallgrass prairie management. It will include an overview of the historical and current trends in fire management as well as a discussion on the effect of fire on the tallgrass prairie spider community. The use of spiders as bioindicators will also be discussed as well as some of the diversity indices used to monitor the effectiveness of prairie management using bioindicators.

## **Fire management of tallgrass prairie**

### *History*

Prior to European settlement, tallgrass prairie was regularly burned following lightning strikes and by Aboriginal people purposely igniting the habitat (Collins 1990, Howe 1994, Schwartz and Hermann 1997, Warren *et al.* 1987). It has been determined that lightning strikes occurred primarily in the late summer-early autumn and that fires ignited by Aboriginals occurred mainly in early spring or autumn (Schwartz and Hermann 1997). The frequency of pre-European settlement fires is unknown but annual burning is commonly used today (Schwartz and Hermann 1997).

### *Current trends and issues*

Spring is the dominant burn season that prairie managers use to manage tallgrass prairie (Collins and Steinauer 1998, Schwartz and Hermann 1997). Spring burns favour late season grasses such as big blue stem and the other key tallgrass prairie grass species (Schwartz and Hermann 1997). Spring burns are also the least risky in terms of keeping the fire under control (Schwartz and Hermann 1997). Some researchers have used summer and fall burns but these studies have been limited. Howe (1994) recommended summer burns to maximize diversity based on plant species. However, Schwartz and Hermann (1997) pointed out that Howe's study sites were poor in terms of plant species richness prior to the summer burns and therefore the results might not be applicable to species-rich sites. In Manitoba, fire management has used primarily spring burns but only the Tallgrass Prairie Preserve is burned on a regular basis.

Howe (1994) outlined four premises used in current tallgrass prairie management. Of relevance to this discussion is the second premise, that fire itself is the treatment, not fire season, to conserve tallgrass prairie. The current focus of tallgrass prairie management has been spring burns (Howe 1994) as illustrated by the dominance of literature on the effects of those burns (see Howe 1994, Warren *et al.* 1987). Other burn seasons have been less thoroughly examined but are starting to be used or recommended by certain researchers (e.g. Collins *et al.* 1998, Howe 1994, Roughley 2001).

Howe (1994) discussed two aspects in relation to fire season and tallgrass prairie management. The first aspect is whether or not fire season affects the resultant tallgrass prairie community. Howe (1994) used evidence from plants to predict that fire season would have an impact of the resultant tallgrass prairie. Howe (1994) based his prediction

on the results of various studies that support his main criteria on why fire season should affect the tallgrass prairie community. The criteria he used were: (1) differential response to thatch removal and soil warming, (2) differential response in seeding phenology or germination requirements, and (3) differential rhizome recruitment. Howe's (1994) prediction was correct for the tallgrass prairie plant community on the St. Charles Rifle Range (Sveinson 2001). While Howe's (1994) criteria were written from the plant perspective, they can readily be adapted to make predictions for spiders as well.

Different spiders are known to have different phenologies and peak activity periods (Aitchison 1984a). Spiders are also known to show differential recruitment rates in terms of migration into a burned area (Harper *et al.* 2000, Riechert and Reeder 1972). The effect of fire on the reproduction of spiders is not known. Based on the data available, one would predict that the spider community should be affected by fire season as well.

The other aspect Howe (1994) discussed is whether or not dormant season burns (winter and early spring) were part of the normal disturbance regime of tallgrass prairie. Dormant season burns were rare historically, calling into question whether they should be used as the predominate burn season for management. Howe (1994) strongly suggested that we should be using the historical burn season, i.e. summer and fall burns, to manage tallgrass prairie because that is the disturbance regime under which it evolved. Roughley (2001) and Sveinson (2001) both suggested that using a variety of burn seasons is beneficial to the tallgrass prairie habitat. Summer and fall burns are being incorporated into the management plans of some tallgrass prairie sites, such as the Konza tallgrass prairie in Kansas (Collins *et al.* 1998).

### *Effect of fire on prairie spider communities*

The effects of fire on the spider fauna of prairie habitats are not well known (see reviews by Bell *et al.* 2001, Reed 1997, Warren *et al.* 1987). Spiders are important predators and can survive the physical effects of fire by finding protection in places such as cracks in the soil (Warren *et al.* 1987). However, based on the upper lethal temperature of most spiders, it is hypothesized that the majority of spiders do not survive burns and that they recolonize following the burn (Bell *et al.* 2001). Spider survival after a fire also depends on the availability of prey, in terms of both density and diversity, in the burned area (Warren *et al.* 1987). The pioneer spider fauna in grasslands following fire includes certain species of linyphiids, theridiids, and lycosids (Bell *et al.* 2001, Riechert and Reeder 1972). These species prefer bare ground, are more tolerant to microclimate changes, and are relatively less dependant on vegetation for web construction (especially lycosids) (Bell *et al.* 2001). These pioneering species often decline in numbers over time as the habitat recovers from the effects of fire and old growth species increase in abundance over time (Bell *et al.* 2001). This recovery period can be months, years or sometimes decades. In general, species diversity increases over time following fire in grasslands but the short-term responses can vary (Bell *et al.* 2001). Bell *et al.* (2001) recommended that more studies are needed to examine the effect of different burn regimes on spider communities. They also recommended that burning be conducted on large connected habitats with a rotation of regimes to conserve the highest species richness and range of stand ages. It is also important that refugia be maintained and that the inter-burn period be long enough so that the spider fauna can recover (Harper *et al.* 2000).

Although there are no studies of the impact of fire on spiders in tallgrass prairie in Manitoba, there have been studies conducted in similar tallgrass prairie habitats in Illinois (Harper *et al.* 2000, Rice 1932), Wisconsin (Riechert and Reeder 1972), and Kansas (Nagel 1973). Harper *et al.* (2000) found that spider abundance significantly decreased in the 10 weeks following a spring burn. Spider abundance was more negatively affected in the enclosure study sites (i.e. closed system), suggesting that recolonization from unburned areas is important for spiders. Rice (1932) found that spider numbers were lower in burned versus unburned subclimax tallgrass prairie following a spring burn. Riechert and Reeder (1972) also saw the same trend on two separate prairie plots. On the subclimax prairie site, spider abundance recovered within a week and species composition favoured vagrant species. However, on the climax site, spider abundance did not recover but the species composition was unaffected. They also recorded that spiders moved from burned areas to unburned areas. The long-term effect of burning on the spiders was inconclusive, as the abundance of spiders the year following the burn was not significantly different. Similarly, Nagel (1973) found that spider abundance was lower in the burned versus unburned prairie following a spring burn on a prairie in Kansas. Johnson (1995) found that spider abundance and density was higher in annually burned *Spartina pectinata* Link wetlands but species composition was similar. This increase in spider abundance was correlated with increases in insects, the primary food source for spiders.

Although the effect of fire on the spider community of tallgrass prairie in Manitoba was unknown prior to this study, predictions could be made based on what is known about the phenology of spiders in Manitoba. Aitchison (1984a) determined the



phenology of the spider community in a meadow-aspen forest ecotone at Fort Whyte, Manitoba. At the family level, lycosids and thomisids had peak activity periods in the spring. Liocranids, agelenids, and corinnids had their highest activity periods in the fall and linyphiids were mainly active in the winter. During the snow-free period, the most abundant spiders were three lycosid species: *Alopecosa aculeata* (Clerck), *Pardosa moesta* Banks, and *P. distincta* (Blackwall) (Aitchison 1984a). The peak activity period of the adults of these species did not overlap. The peak abundance of *Alopecosa aculeata* was the earliest and *P. distincta* the latest. This agrees with observations made by Vogel (1972) on coexisting *Pardosa* species where the largest species had its peak activity period earliest in the season and the smallest species had its peak activity period latest. Based on these observations, the spider species that recolonize following a fire will depend on which species is active at that time. Another important consideration is the activity of females following the timing of the burn. Depending on the phenology of the species, the females will dictate how many juveniles are present in the burned area. Female lycosids carry their eggsacs with them and tend to be the only sex active from July until snowfall (Aitchison 1984a, Dondale and Redner 1990). Therefore, the relative activity of the various species of lycosids on the tallgrass prairie will determine how many juveniles of that species are present in the burned areas. Females of most other spider families do not carry their eggsacs and therefore recruitment of juveniles into the burned area will depend on suitable egg laying habitat being present. In conclusion, the response of the spider species to fire will depend on its phenology, which in turn affects how quickly it can build up a sustainable population.

## **Spiders as bioindicators**

### *Terrestrial bioindicators*

McGeoch (1998) defines a bioindicator as 'a species or group of species that: readily reflects the abiotic or biotic state of an environment; represents the impact of environmental change on a habitat, community or ecosystem; or is indicative of the biodiversity of a subset of taxa, or of wholesale diversity, within an area.' Her definition encompasses the three types of bioindicators. These are: environmental, ecological, and biodiversity indicators (McGeoch 1998). Environmental indicators are taxa that respond to environmental changes or disturbances. Ecological indicators are taxa used to determine the effect of environmental stress factors on a particular habitat. Ecological indicators differ from environmental indicators in that they are used to demonstrate the effect of environmental stresses, not to monitor environmental change. A biodiversity indicator is a group of taxa or functional group that reflects the diversity of the other taxa in a given habitat. McGeoch (1998) developed these categories for insect bioindicators but they can be applied to any terrestrial taxa, including spiders. She also suggested 32 criteria to use when selecting taxa as potential bioindicators. Of the criteria listed, the more important ones include cost efficiency, abundance in habitat/samples, good taxonomic knowledge, and availability of good identification keys.

Associated with bioindication is the importance of monitoring which is the repeated use of bioindicator taxa to determine the environmental condition of a habitat (McGeoch 1998). Activities related to monitoring can be broken down into three types: survey, surveillance, and monitoring (McGeoch 1998). A survey involves making observations, usually in a set period of time and via a certain method, with no

preconceived notion of what the results should be. Surveillance is a survey extended over a longer period to provide a time series and to determine the variability/range of values that may be encountered. Monitoring is intermittent surveillance to determine how well the taxa follow the predetermined response.

The importance of biodiversity to conservation has led to research into ways in which the biodiversity can be sampled in an effective manner. In a review, Kremen *et al.* (1993) discussed the use of terrestrial arthropod assemblages in conservation planning. They concluded that terrestrial arthropods are exceptional indicator groups because of their diversity of species and functional roles, range of body sizes, and distributional patterns. Kremen *et al.* (1993) looked at terrestrial arthropods as a whole but other researchers have focused their efforts on a particular group and ways of improving the use of that group. Holloway and Stork (1991) focused on moths in their review of the use of invertebrates as bioindicators of human impact. They also suggested that invertebrates are good indicators, listing qualities similar to those given by Kremen *et al.* (1993). Holloway and Stork (1991) gave many examples of how moths have been used as bioindicators. Oliver and Beattie (1993) examined how well non-experts could sort samples into recognizable taxonomic units (RTUs). They used spiders, polychaetes, ants, and mosses for their study. They found that samples of spiders and ants were easily broken down into RTUs, each RTU equaling one species. Mosses were the most difficult to divide into RTUs and polychaetes were slightly better. They suggested that making use of non-specialists to go rapidly through samples may be a viable option for certain taxa but that further testing is needed to determine if their results hold true for other taxa and other locations/habitats.

### *Diversity measures*

Bioindicators are used at many different organismal levels. Bioindication mainly occurs at the species level, the population level, and the community level. Species level bioindication usually involves examining the presence/absence of species. The presence or absence of a particular species can indicate the stage of succession or habitat quality (Bell *et al.* 2001). Population level bioindication involves examining the abundance of individual species and the relative dominance of species. The community level bioindication involves examining what complements of species are present as well as their abundance. This level of bioindication requires the use of various diversity measures, both alpha (within community analysis) and beta (between community analysis), to determine what is happening at the community level. A list of the diversity measures used for this study and their formulae is given in Table 1.

The simplest measure of biodiversity is the total number of species, called species richness. However, species occur in different abundances with some species being common and others rare. One habitat could have the same number of individuals for each species while another habitat could have the same species but one dominant species. They have the same species richness but their evenness differs. This means that the measurement of biodiversity is not a simple problem. Instead, numerous measurements have been developed over the years (Magurran 1988). Magurran (1988) divided species diversity measures into three categories: species richness indices, species abundance models, and proportional species abundance indices. Species richness indices are used to measure the number of species present in a given sampling unit whereas species abundance models are used to describe the distribution of the species abundance.

Proportional species abundance indices combine species richness and evenness, the two components of diversity (Magurran 1988). There are four commonly used species abundance models based on rank/abundance: log normal distribution, geometric series, logarithmic series, and MacArthur's broken stick model. Proportional species abundance measures have been very popular (Magurran 1988). Examples include the Shannon-Wiener index, Simpson index, and Berger-Parker index.

Researchers often have their favourite indices and often researchers studying the same taxa or habitat use the same indices to make comparisons easier. Each diversity index has its strengths and weaknesses. In the spider literature, Shannon-Wiener index, Jaccard index and Sorenson coefficient are some of the more commonly used indices (Marc *et al.* 1999). Bray-Curtis and Morisita-Horn similarity indices are also commonly used (Dobyns 1997, Green 1999, Norris 1999). The Shannon-Wiener index is proportional to the number of species and the relative abundance of those species (i.e. evenness) (Magurran 1988). As such, it is biased towards rare species. Another commonly used index, the Simpson index, is less sensitive to species richness and therefore is biased towards dominant species. The log series alpha index has not been used in spider studies so far but has been used in various insect studies (e.g. Elliott 1997, Holliday 1992, Lafrenière 1994). It is less affected by dominant or rare species. Therefore, log series alpha index tends to have better discriminatory ability and is less affected by sample size than other diversity measures such as Shannon-Wiener index (Magurran 1988). For the similarity indices (beta diversity indices), the Jaccard and Soerenson indices are referred to as qualitative measures because presence/absence data are used (Magurran 1988). Morisita-Horn index is referred to as a quantitative measure

because it takes into account the abundance of the species present. These two types of similarity indices are best used together in that they complement each other. When using diversity indices to analyze data, it is best to use a suite of measures (i.e. qualitative and quantitative measures) to get a better overall idea of what is happening to that community.

### *Spiders as bioindicators for tallgrass prairie*

Increasingly, spiders are receiving interest as bioindicators (Clausen 1986, Marc *et al.* 1999, Ruzicka 1986). Spiders have many characteristics that make them suitable as bioindicators. These are: (1) they are present in large numbers in all habitats; (2) they respond to disturbances, both in the short term and long term; (3) they exhibit strong community variations among the various microhabitats; (4) they are all predatory and are relatively high up in the food chain (Marc *et al.* 1999). The taxonomy and biogeography of spiders is continually progressing, allowing them to be used as bioindicators.

Worldwide, 40,000 species have been described (Marc *et al.* 1999) and the estimated total number of species is 170,000 (Coddington and Levi 1991). In Canada, an estimated 1500 species occur of which approximately 1400 have been described (Dondale 1979, Bennett 1999). The provincial faunas are also well known with lists available for practically all provinces and territories. There are also numerous identification keys available for the spider fauna of North America. The fact that the identification keys exist and that the taxonomy of Canadian species is so well known makes using spiders as bioindicators in Canada relatively easy.

Spiders have been used as bioindicators for prairie studies (e.g. see review by Bell *et al.* 2001). They have also been used as bioindicators in studies in forestry (e.g.

Jennings *et al.* 1988, Pettersson 1996, Buddle *et al.* 2000), succession (e.g. Gibson *et al.* 1992, Hurd and Fagan 1992), bioconcentration of pollutants (e.g. Clausen 1986) and grazing management (e.g. Gibson *et al.* 1992).

Spiders have only been used as bioindicators of tallgrass prairie management in a few studies (e.g. Nagel 1973, Rice 1932, Riechert and Reeder 1972). Spiders have been found to be good bioindicators because they respond to fire and meet the necessary criteria outlined by McGeoch (1998). Different spider species are known to have different phenologies and habitat requirements (Aitchison 1984a) which means they will probably respond differently to different burn seasons. Spiders are easily collected and tend to be very abundant which makes statistical analysis better because there is potentially less variation in the data.

For the bioindication of tallgrass prairie management in Manitoba, spiders are very promising. A provincial species list exists (Aitchison-Benell and Dondale 1992) and the phenology and habitat preferences of those species are well known (Aitchison 1984a, b). A study on the effect of fire on taiga spider species has also been conducted in Manitoba (Aitchison-Benell 1994). All these studies and resources provide a good starting point for using spiders as bioindicators for tallgrass prairie management in Manitoba. New data collected from tallgrass prairie sites can be compared to the data collected by Aitchison and to the other tallgrass prairie studies.

## **Conclusion**

Fire has been used extensively as a management tool for tallgrass prairie conservation. Historically, lightning strikes and fires ignited by Aboriginals maintained the integrity of tallgrass prairie. These fires occurred predominately in the spring or autumn but summer burns were not uncommon. Despite this range in burn seasons, only spring burns are used extensively in management. The use of spring burns has been primarily due to convenience and convention. Thorough studies on which burn season (spring, summer, autumn) is best for conserving the integrity of tallgrass prairie have not been conducted and the effect of burning on non-plant taxa has not been thoroughly examined for any type of fire management. However, if various burn seasons are going to be used in future tallgrass prairie management plans, spiders would be good bioindicators. This is because they are known to have a variety of phenologies and therefore would be predicted to respond differently to the different burn seasons. Spiders are also easily collected and can be identified relatively easily. For Manitoba in particular, there are good background data available (e.g. phenology, ecology) on the species in the province, which support their use in the study of management practices.



## MATERIALS AND METHODS

### **Tallgrass prairie study**

#### *Study area*

The study was conducted at the St. Charles Rifle Range, located just outside of Winnipeg, Manitoba (Fig. 1). The property is owned by the Canadian Department of National Defence and is managed by the 17<sup>th</sup> Wing Air Force Base in Winnipeg. The property is 192 hectares in size with 47.9 hectares of high quality tallgrass prairie (area 1 on Fig. 2) (Morgan 1994). The area has remained undisturbed for at least a hundred years but a portion of the study area may have been cultivated until 50 years ago. This area was coined the “go-back” prairie (areas 5 and 6 on Fig. 2) by Morgan (1994).

The plant and ground beetle diversity of the St. Charles Rifle Range is known (Roughley 2001). The plant diversity includes over 112 species, including the species that are characteristic of tallgrass prairie such as big bluestem (*Andropogon gerardii* Vitman) (Sveinson 2001). The ground beetle fauna includes 104 species, one of which is the rare *Lebia divisa* LeConte (Roughley 2001).

#### *Experimental design*

Three burn treatments (spring, summer, and fall) were used for the experiment (Fig. 3). A refuge treatment, which was never burned, was also used. Each treatment had four replicates and each suite of treatments (referred to from here on as blocks A, B, C, or D) were arranged in a cross pattern (Fig. 3). Each treatment square was 50 meters by 50 meters. All treatments were burned once in 1997 with the spring burn occurring on 6 June, summer burn on 5 August, and the fall burn on 9 September. For each treatment

square, the edges were burned first and then the rest of the block was burned. Any unburned areas within the treatment blocks after the fire had passed through were left intact. Placement of the blocks was to allow for maximum coverage of the study area, which included placing one block (block D) in the "go-back" prairie. In 1998, two control squares (blocks X and Y) were incorporated into the experimental design to ensure the refuge treatment was not being trapped out. The sampling protocol of these two controls was the same as the other blocks except that sampling did not begin until 1 May 1998.

### *Sampling*

Samples were collected from pitfall traps with sixteen traps per square (Fig. 3). Traps were arranged in a 4 x 4 grid with traps being 10 meters apart. The pitfall traps consisted of plastic yellow containers with an outside top diameter of 11.5 cm and a depth of 6.5 cm. These traps were placed into the ground so that the lip of the container was flush with the surface of the ground. A rain cover consisting of a square piece of plywood with nails as supports was placed over each pitfall trap to prevent flooding. Traps were half filled with a saturated salt solution with a drop of dish detergent. Traps were emptied weekly and the contents of the traps were passed through a strainer with a mesh size of 1 mm. The contents of all sixteen pitfall traps for each square were pooled each week and stored in 70% ethanol.

In 1997, sampling began on 28 May and continued until 7 November. In 1998, the traps were run from 3 April to 10 November. In 1999, the traps were run from 20 April to 12 November. In 2000, traps were run from 31 March to 10 November.

### *Sorting and identification*

The bulk samples (weekly pool of 16 pitfall traps) were sorted by various people over the length of the project (see acknowledgements). Target organisms (e.g. spiders and carabid beetles) were sorted out of the bulk samples and placed in separate 3-dram vials. The vials containing spiders were later sorted to species and I identified them, following the nomenclature of Platnick (2002). Spiders were counted and sexed by species and juveniles were identified to species when possible, and to genus when I was not confident of which species they were. However, because I was unable to identify all juveniles to species, only adult spiders are included in the data analysis at the species level.

### *Data analysis*

The data were analyzed using the software programs SYSTAT<sup>®</sup> and BIO-DAP<sup>®</sup>. Analysis included alpha and beta diversity measures. For alpha diversity, the measures examined were species richness, Shannon-Wiener index, log series alpha index, Simpson index, Berger-Parker index, and log series alpha evenness. Beta diversity measures include the Jaccard coefficient and Morisita-Horn index. The formulae for these indices are summarized in Table 1. The values from these indices as well as the abundance data were analyzed using the general linear model ANOVA function in SYSTAT<sup>®</sup> (version 9). Multiple pairwise comparisons were done using the Tukey HSD method, using a significance level of 0.05. Data analysis focused on within year comparisons. Short-term effects of burn season were analyzed by breaking the sampling weeks of 1997 into four burn periods. Period 1 was all weeks prior to the spring burn, period 2 was the weeks

between the spring and summer burns, period 3 was the weeks between the summer and fall burns, and period 4 was the weeks after the fall burn. Between year comparisons were not analyzed statistically because there were too many year to year differences in sampling intensity that would have made data standardization difficult and statistical differences hard to interpret. These year to year differences included: the number of sampling weeks per year, an apparent sorting bias, and varying weather conditions. The apparent sorting bias and varying weather conditions are assumed to be equal among treatments and blocks for each year.

Species richness is simply the total number of species. This measure is a good first calculation of species diversity. However, it is extremely sensitive to sample size and species are all weighted equally (Magurran 1988).

The Shannon-Wiener index is proportional to the number of species and their relative abundance. It is calculated using the following formula:

$$H' = -\sum p_i \ln p_i \quad \text{where } p_i = \text{proportion of } i^{\text{th}} \text{ species}$$

It is sensitive to sample size and assumes that the samples were collected randomly (Magurran 1988).

The log series alpha index is less sensitive to dominant species or rare species. It is calculated using the formula:

$$S = \alpha \ln(1 + N/\alpha) \quad \text{where } N = \text{total number of individuals}$$

The  $\alpha$  value is determined by first estimating the value of  $x$  in the equation:

$$S/N = [1-x]/x [-\ln(1-x)] \quad \text{where } S = \text{total number of species}$$

by using the NONLIN function in SYSTAT<sup>®</sup>. The value of  $x$  was then used to derive  $\alpha$  using the equation  $\alpha = N(1-x)/x$ .

The Simpson index is a type of dominance measure and weights dominant species more than the Shannon-Wiener index does. It is calculated using the formula:

$$D = \sum [n_i(n_i-1)] / N(N-1) \quad \text{where } n_i = \text{number of individuals of } i^{\text{th}} \text{ species}$$

The values of D range from 0 to 1.

The Berger-Parker index is a simple dominance measure that is calculated using the formula:

$$d = N_{\max} / N \quad \text{where } N_{\max} = \text{maximum abundance of any one species.}$$

The values of Berger-Parker index range from 0 to 1.

When using the log series alpha index, an appropriate evenness measure is the alpha evenness, which is equal to the slope of the line from the log abundance versus rank curve. A significant regression curve indicates that the data is appropriate for analysis using the log series alpha index. For this evenness measure, the higher negative (i.e. closer to zero) values mean that there is higher evenness.

The two beta diversity measures were chosen because the Jaccard index is a qualitative similarity measure whereas Morisita-Horn index is a quantitative similarity measure. The values for both indices range from 0, meaning no similarity to 1, meaning 100% similarity. Jaccard index is calculated using the formula:

$$C_j = a / (a + b + c) \quad \text{where } \begin{array}{l} a = \# \text{ species at both sites} \\ b = \# \text{ species at site 1} \\ c = \# \text{ species at site 2} \end{array}$$

Jaccard index reflects how many species the two sites share in common. Species are unweighted as this measure only uses presence/absence data (Magurran 1988).

Morisita-Horn index is a quantitative similarity index in that it takes the proportion of the species into consideration. It is considered less sensitive to sample size

and is more suitable for abundance data (Magurran 1988). It is calculated using the formula:

$$C_{mh} = [2\sum(a_n * b_n) / (d_a + d_b)(a_N * b_N)] \quad (\text{see Table 1 for description of terms})$$

### **Forest transect study**

An additional experiment, referred to as the forest transect study, was established in 1998 to determine if the fauna of the tallgrass prairie was different from the fauna in the aspen forest. A series of 21 traps was set in an L-shape with half of the traps being in the prairie and the other half in the forest (Fig. 4). Each set of five pitfall traps was pooled weekly, following the sampling regime of the tallgrass prairie study except that the transect was not set up until 6 May in 1998. Sorting and identification protocols were the same as for the tallgrass prairie study.

### **Pond margin study**

A pond transect study was set up in 2000 and was located along the southern edge of a man-made pond (Fig. 4). The transect consisted of ten pitfall traps set up as in the other experiments. The transect ran from 10 June to 4 October with the traps being pooled weekly. Sorting and identification protocols were the same as for the tallgrass prairie study. The purpose of this experiment was to maximize the types of habitats sampled via pitfall traps so that we could get a better idea of how the species were distributed in the study area.

## RESULTS

### **Species level analysis of tallgrass prairie study**

#### *Abundance*

A total of 66,362 spiders were collected over the duration of the study, with 54,396 being adults. Table 2 is a summary of the abundance data per block per treatment per year. All results discussed from here on will be based only on the adults.

A total of 126 species representing 17 families were collected on the tallgrass prairie (Table 3). At the family level, lycosids were the most abundant followed by linyphiids. At the species level, *Pardosa moesta* and *P. distincta* were by far the two dominant species accounting for 31.4% and 21.7% of the adults caught respectively (Table 4, Appendices 1-4). Other abundant species included *Alopecosa aculeata* (6.3%), *Agroeca pratensis* Emerton (3.6%), *Hogna frondicola* (Emerton) (3.5%), and *Zelotes fratrisc* Chamberlin (3.1%) (Table 4).

The abundance of *P. moesta* was significantly different among treatments for all four years (1997:  $p=0.00684$ ,  $df=3$ ,  $F=7.913$ ; 1998:  $p=0.000001$ ,  $df=4$ ,  $F=72.135$ ; 1999:  $p=0.0030$ ,  $df=4$ ,  $F=10.148$ ; 2000:  $p=0.00026$ ,  $df=4$ ,  $F=17.858$ ) (Fig. 5). The refuge treatment had the highest number of *P. moesta* for all four years. From 1998 to 2000, *P. moesta* tended to have higher abundances in the spring and refuge treatments than the summer and fall treatments. There were also significant differences in the number of *P. moesta* among blocks in 1997 ( $p=0.0024$ ,  $df=3$ ,  $F=10.85$ ), 1998 ( $p=0.00037$ ,  $df=4$ ,  $F=16.330$ ), 1999 ( $p=0.0095$ ,  $df=4$ ,  $F=6.153$ ), and 2000 ( $p=0.00002$ ,  $df=4$ ,  $F=33.68$ ) (Fig. 6). Block D had the lowest abundance of *P. moesta* for all four years and block X had the highest abundance from 1998 to 2000.

The abundance of *Pardosa distincta* was not significantly different among treatments in any year (Fig. 7) but was significantly different among blocks in 1997 ( $p=0.029$ ,  $df=3$ ,  $F=4.788$ ) (Fig. 8). In 1999 and 2000, *P. distincta* was most abundant in the summer treatment and had the lowest abundance in the spring treatment all four years. *Pardosa distincta* was significantly more abundant in block D in 1997.

In general, *P. moesta* was the dominant species for all treatments in 1997 except for block D, where *P. distincta* was dominant (Appendix 1). In 1999 and 2000, *P. moesta* was dominant only in the spring and refuge treatments for blocks A, B, and C (Appendices 3 and 4). *Pardosa distincta* was the dominant species in all the summer and fall treatments and all treatments in block D in 1999 and 2000. Although the refuge treatment had the highest total abundances, some species were more abundant in the summer or fall treatments than in the refuge treatment. These included *P. distincta*, *H. frondicola*, *Xysticus ampullatus* Turnbull *et al.*, *Arctosa rubicunda* (Keyserling), and *Enoplognatha marmorata* Hentz (in order of abundance in Table 4).

### *Phenology*

The majority of the species reached their peak adult abundance in the spring (Table 5). *Pardosa moesta* peaked, on average, two weeks earlier than *P. distincta* but the females of *P. distincta* tended to be more active later in the year. A few species had peak adult abundances in the summer (e.g. *Pirata minutus* Emerton, *Grammonota pictilis* (O.P.-Cambridge), *Goneatara nasutus* Barrows) and some peaked in autumn (e.g. *Centromerus sylvaticus* (Blackwall), *Cicurina arcuata* Keyserling, *Agroeca pratensis*, *A. ornata* Banks, *Ero canionis* Chamberlin & Ivie).



## Community level analysis of tallgrass prairie study

### *Abundance*

There were significant differences in adult abundances among treatments in 1997 ( $p=0.0012$ ,  $df=3$ ,  $F=13.288$ ), 1998 ( $p=0.00009$ ,  $df=3$ ,  $F=26.133$ ), 1999 ( $p=0.012$ ,  $df=4$ ,  $F=5.965$ ), and 2000 ( $p=0.0300$ ,  $df=3$ ,  $F=4.735$ ) (Fig. 9). The refuge treatment had the highest abundance in all four years and the fall treatment had the lowest abundance from 1998 to 2000. The spring treatment abundances increased steadily from 1997 to 2000. The summer and fall treatments had their lowest abundances in 1998 and increased steadily from 1998 to 2000. When 1997 was broken down by burn period, the abundance tended to decrease for each burn season treatment following its burn time (Fig. 10). These decreases were significant compared to the refuge following the spring and summer burns but not for the fall burn. There were also significant differences among blocks for all years (Fig. 11). Block B tended to have the highest abundance and block D tended to have the lowest.

### *Diversity indices*

#### Species richness

A total of 126 species was collected over the four years (Table 3). There were no significant differences among treatments following the burns in 1997 (Fig. 12) or in any subsequent year (1997:  $F=0.979$ ,  $df=3$ ; 1998:  $F=1.094$ ,  $df=3$ ; 1999:  $F=1.380$ ,  $df=3$ ; 2000:  $F=1.000$ ,  $df=3$ ) (Figs. 13). The differences between blocks were not significant in 1997 ( $F=2.978$ ,  $df=3$ ) or 1998 ( $F=2.018$ ,  $df=5$ ) but they were significant in 1999 ( $p=0.0327$ ,  $df=5$ ,  $F=4.077$ ) and 2000 ( $p=0.0254$ ,  $df=5$ ,  $F=4.460$ ) (Fig. 14).

### Shannon-Wiener index

In 1997, diversity as measured by the Shannon-Wiener index tended to increase following a particular burn for each burn season treatment, although it was only significant following the spring burn (Fig. 15). There was a significant difference among treatments in 1997 ( $p=0.0148$ ,  $df=3$ ,  $F=6.242$ ) and 1998 ( $p=0.039$ ,  $df=3$ ,  $F=4.259$ ) but not in 1999 ( $df=3$ ,  $F=1.658$ ) or 2000 ( $df=4$ ,  $F=0.410$ ) (Fig. 16). In 1997, the spring treatment had the highest diversity and the fall treatment had the highest diversity in 1998. Among blocks, there was a significant difference in 1997 ( $p=0.006$ ,  $df=3$ ,  $F=8.186$ ), but not in the other years (1998:  $df=5$ ,  $F=0.876$ ; 1999:  $df=5$ ,  $F=0.741$ ; 2000:  $df=4$ ,  $F=2.627$ ) (Fig. 17).

### Log series alpha index

In 1997, the burn season treatments increased in diversity as measured by the log series alpha index following their associated burn time (Fig. 18). There were significant differences among treatments in 1997 ( $p=0.0304$ ,  $df=3$ ,  $F=4.714$ ) and 1998 ( $p=0.0083$ ,  $df=4$ ,  $F=6.799$ ) but not in 1999 or 2000 (1999:  $p=0.2017$ ,  $df=4$ ,  $F=1.860$ ; 2000:  $p=0.0615$ ,  $df=3$ ,  $F=3.532$ ) (Fig. 19). Among blocks, significant differences were only observed in 1997 ( $p=0.0041$ ,  $df=3$ ,  $F=9.281$ ) (Fig. 20).

### *Dominance indices*

#### Simpson index

In 1997, the diversity of the burn treatments as measured by the Simpson index tended to decrease following their associated burn time (Fig. 21). There were no significant differences among treatments in any year (1997:  $F=2.928$ ; 1998:  $F=2.164$ ;

1999:  $F=0.311$ ; 2000:  $F=0.110$ ) (Figs. 22) with the refuge treatment having the highest values all four years. A significant difference between blocks was observed in 1997 ( $p=0.011$ ,  $df=3$ ,  $F=6.769$ ) (Fig. 23) but not in any other year.

#### Berger-Parker index

In 1997, the value of the Berger-Parker index tended to decrease following their associated burn (Fig. 24). There were no significant differences among treatments in any year (1997:  $F=2.346$ ; 1998:  $F=0.959$ ; 1999:  $F=0.354$ ; 2000:  $F=0.080$ ) (Fig. 25). A significant difference between blocks was observed in 1997 ( $p=0.030$ ,  $df=3$ ,  $F=4.706$ ) (Fig. 26) but not in any other year.

#### Log series alpha evenness

The slopes of the regression lines of rank abundance against log abundance for each analysis were significant at  $p=0.05$ . The evenness values of the burn treatments tended to increase following their burn times (Fig. 27). There were significant differences among treatments in 1998 ( $p=0.0428$ ,  $df=3$ ,  $F=4.118$ ) and 2000 ( $p=0.0287$ ,  $df=4$ ,  $F=4.488$ ) but not in 1997 or 1999 (Figs. 28). There were no significant differences between blocks in any year (Figs. 29) and no block consistently had the highest evenness value from year to year.

### *Similarity indices*

#### Jaccard index

In 1997, spring/refuge treatments were most similar ( $C_j=0.634$ ) and summer/fall treatments had the next highest similarity value ( $C_j=0.605$ ) (Table 6). In 1998, summer and fall treatments were most similar ( $C_j=0.737$ ). In 1999, spring and fall treatments had the highest similarity ( $C_j=0.736$ ) and in 2000, the spring and refuge treatments were again the most similar ( $C_j=0.758$ ) (Table 6). In 2000, the similarity values among treatments were fairly similar, ranging from 0.630 (summer/control) to 0.758 (spring/refuge).

The similarity among the refuge treatment among years remained fairly constant (1997/1998 = 0.610, 1998/1999 = 0.584, 1999/2000 = 0.604) (Table 7). The controls also remained fairly constant (1998/1999 = 0.639, 1999/2000 = 0.613). However, the values for the other treatments varied more (spring: 97/98 = 0.635, 98/99 = 0.636, 99/00 = 0.688; summer: 97/98 = 0.585, 98/99 = 0.675, 99/00 = 0.674; fall: 97/98 = 0.632, 98/99 = 0.750, 99/00 = 0.674) (Table 7).

#### Morisita-Horn index

In 1997, the similarity values between treatments ranged from 0.924 (spring/refuge) to 0.996 (summer/fall) (Table 8). In 1998, the values diverged with spring/refuge ( $C_{mh}=0.993$ ) and summer/fall ( $C_{mh}=0.983$ ) having the two highest similarity values. The other similarity values ranged between 0.494 and 0.907. The high similarity values between the spring/refuge treatments and the summer/fall treatments continued in 1999 ( $C_{mh}=0.994$  and 0.995 respectively) and 2000 ( $C_{mh}=0.991$  and

0.985 respectively) (Table 8). The remaining similarity values rebounded in 1999, ranging from 0.809 (fall/refuge) to 0.969 (spring/control). In 2000, the other similarity values ranged from 0.765 (spring/fall) to 0.935 (summer/control).

The similarity values for the refuge treatment between years were constant and relatively high (1997/1998 = 0.989, 1998/1999 = 0.955, 1999/2000 = 0.944) (Table 9). The controls also remained relatively high (1998/1999 = 0.970, 1999/2000 = 0.930). The values for the spring treatment between years also remained constant and relatively high (1997/1998 = 0.953, 1998/1999 = 0.953, 1999/2000 = 0.950). The values for the summer and fall treatments had greater variation but also had high values for the later year comparisons (summer: 1997/1998 = 0.705, 1998/1999 = 0.946, 1999/2000 = 0.937; fall: 1997/1998 = 0.644, 1998/1999 = 0.906, 1999/2000 = 0.944) (Table 9).

### **Analysis of forest transect and pond margin studies**

#### *Forest transect study*

Over the three years of the study, 4,499 adult spiders, representing 94 species, were collected in the forest transect (Appendix 5). *Pardosa moesta* was the most common species, accounting for 43.7% of the adults caught (Table 10). Species that were present in the forest study but absent in the main study were *Castianeira cingulata* (C.L. Koch), *Clubiona kastoni* Gertsch, *Grammonota gigas* Banks, *Ozyptila sincera canadensis* Dondale & Redner, *Pardosa mackenziana* (Keyserling), *Pirata montanus* Emerton, *Robertus banksi* (Kaston), *Titanoeca nivalis* Simon, and *Xysticus elegans* Keyserling (Table 3). *Clubiona kastoni* was only found in the grassland pitfalls of the forest study whereas *O. sincera canadensis* and *R. banksi* were found in both the forest

and grassland traps. Some species, including *P. distincta*, showed a strong preference for the grassland pitfalls as compared to the forest pitfalls. For example, 380 adults of *P. distincta* were collected in the grassland pitfalls but only two adults were collected in the forest pitfalls of the forest transect study (Table 10).

#### *Pond margin study*

For the pond study, 790 adult spiders were collected representing 44 species (Table 11). *Pardosa moesta* was the most common species, accounting for 41.6% of the adults caught. Species that were present in the pond study but absent in the tallgrass prairie study were *Hypomma marxi* (Keyserling), *Neon ellamae* Gertsch & Ivie, *Scironis tarsalis* (Emerton) and *Titanoeca nivalis* (Table 3). *Titanoeca nivalis* was also found in the forest study. Presumably, certain early and late season species were missed due to the restricted collecting period. However, the species that was most notably missing, whose activity overlapped with the collection period, was *P. distincta*.

Table 1. The common name of the diversity measure, its formula, diversity type and diversity group are listed for each diversity measure.

Diversity measure	Formula	Diversity type	Diversity group
Species richness	$s = \text{total \# of species}$	alpha	diversity
Shannon-Wiener index	$H' = -\sum p_i \ln p_i$	alpha	diversity
Log series alpha index	$S = \alpha \ln(1 + N/\alpha)$	alpha	diversity
Simpson index	$D = \sum [(n_i(n_i-1))/N(N-1)]$	alpha	dominance
Berger-Parker index	$d = N/N_{\max}$	alpha	dominance
Morisita-Horn index	$C_{mh} = [2\sum (a_n \cdot b_n)] / [(da + db)(aN \cdot bN)]$	beta	similarity
Jaccard index	$C_j = a/(a + b + c)$	beta	similarity

$p_i$  = proportion of  $i^{\text{th}}$  species

$N$  = total # of individuals

$n_i$  = # individuals of  $i^{\text{th}}$  species

$a$  = # of taxa at both sites

$b$  = # of taxa at site 1

$c$  = # of taxa at site 2

$aN$  = # of individuals in site a

$bN$  = # of individuals in site b

$a_n$  = # of individuals of the  $i^{\text{th}}$  species at site a

$b_n$  = # of individuals of the  $i^{\text{th}}$  species at site b

$da = \sum a_n^2 / aN^2$

$db = \sum b_n^2 / bN^2$

Table 2. Effect of burn season treatment, block and year on the number of spiders collected on the St. Charles Rifle Range.

Block	Treatment															
	Spring			Summer			Fall			Refuge						
	1997	1998	1999	2000	1997	1998	1999	2000	1997	1998	1999	2000				
A	760	1150	1123	2340	760	666	904	1891	726	653	841	1364	1009	1413	1068	1736
B	489	1183	1189	2168	684	640	834	1695	634	530	906	1383	894	2080	1554	2128
C	416	1205	1131	1974	530	432	984	2043	543	465	635	1691	676	1220	1091	2243
D	355	559	596	776	652	499	594	866	705	472	613	884	817	1048	1045	1207
<b>Total</b>	<b>2020</b>	<b>4097</b>	<b>4039</b>	<b>7258</b>	<b>2626</b>	<b>2237</b>	<b>3316</b>	<b>6495</b>	<b>2608</b>	<b>2120</b>	<b>2995</b>	<b>5322</b>	<b>3396</b>	<b>5761</b>	<b>4758</b>	<b>7314</b>



Table 3. Comparison of the spider species collected from the three study areas on the St. Charles Rifle Range. Prairie = tallgrass prairie study (1997-2000), Forest = forest transect (1998-2000), Pond = pond margin (2000 only). Asterisk = species was collected.

Family	Species	Prairie	Forest	Pond
Agelenidae	<i>Agelenopsis actuosa</i> (Gertsch & Ivie)	*	*	
Araneidae	<i>Acanthepeira stellata</i> (Walckenaer)	*		
	<i>Araneus trifolium</i> (Hentz)	*		
	<i>Argiope trifasciata</i> (Forskål)	*		
	<i>Hypsosinga pygmaea</i> (Sundevall)	*		
	<i>Neoscona arabesca</i> (Walckenaer)	*		
	<i>Singa keyserlingi</i> McCook	*		
Clubionidae	<i>Clubiona abboti</i> L. Koch	*		*
	<i>Clubiona johnsoni</i> Gertsch	*	*	*
	<i>Clubiona kastoni</i> Gertsch		*	
	<i>Clubiona moesta</i> Banks	*		
Corinnidae	<i>Castianeira cingulata</i> (C.L. Koch)		*	
	<i>Castianeira descripta</i> (Hentz)	*		
	<i>Castianeira longipalpa</i> (Hentz)	*	*	*
Dictynidae	<i>Argenna obesa</i> Emerton	*	*	*
	<i>Cicurina arcuata</i> Keyserling	*	*	
	<i>Dictyna foliacea</i> (Hentz)	*		
Gnaphosidae	<i>Drassyllus depressus</i> (Emerton)	*	*	
	<i>Drassyllus niger</i> (Banks)	*	*	
	<i>Gnaphosa parvula</i> Banks	*	*	
	<i>Haplodrassus hiemalis</i> (Emerton)	*	*	*
	<i>Haplodrassus signifer</i> (C.L. Koch)	*		*
	<i>Micaria gertschi</i> Barrows & Ivie	*		
	<i>Micaria pulicaria</i> (Sundevall)	*	*	*
	<i>Micaria rossica</i> Thorell	*	*	*
	<i>Sergiolus decoratus</i> Kaston	*		
	<i>Sergiolus ocellatus</i> (Walckenaer)	*	*	
	<i>Zelotes fratris</i> Chamberlin	*	*	*
	<i>Zelotes lasalanus</i> Chamberlin	*		
	<i>Zelotes sula</i> Lowrie & Gertsch	*		
	Hahniidae	<i>Hahnia cinerea</i> Emerton	*	*
<i>Neoantistea magna</i> (Keyserling)		*	*	*
Linyphiidae	<i>Agyneta allosubtilis</i> Loksa	*	*	*
	<i>Allomengea dentisetis</i> (Grube)	*	*	*
	<i>Bathypantes canadensis</i> (Emerton)	*	*	
	<i>Bathypantes pallidus</i> (Banks)	*	*	*
	<i>Centromerus sylvaticus</i> (Blackwall)	*	*	*
	<i>Ceraticelus fissiceps</i> (O.P.-Cambridge)	*	*	*
	<i>Ceraticelus laetus</i> (O.P.-Cambridge)	*	*	*
	<i>Ceraticelus laticeps</i> (Emerton)	*	*	*
	<i>Ceratinella brunnea</i> Emerton	*		
	<i>Collinsia plumosa</i> (Emerton)	*	*	
	<i>Eperigone trilobata</i> (Emerton)	*	*	*
	<i>Eridantes utilis</i> Crosby & Bishop	*	*	
	<i>Erigone atra</i> Blackwall	*	*	*
	<i>Erigone blaesa</i> Crosby & Bishop	*		
	<i>Gonatium crassipalpus</i> Bryant	*		

Table 3 cont'd

Family	Species	Prairie	Forest	Pond
Linyphiidae cont'd	<i>Goneatara nasutus</i> Barrows	*	*	
	<i>Grammonota angusta</i> Dondale	*		
	<i>Grammonota gigas</i> (Banks)		*	
	<i>Grammonota ornata</i> (O.P.-Cambridge)	*		
	<i>Grammonota pictilis</i> (O.P.-Cambridge)	*	*	
	<i>Hypomma marxi</i> (Keyserling)			*
	<i>Islandiana flaveola</i> (Banks)	*	*	
	<i>Islandiana longisetosa</i> (Emerton)	*		
	<i>Islandiana princeps</i> Braendegaard	*		
	<i>Kaestneria pullata</i> (O.P.-Cambridge)	*		
	<i>Neriere clathrata</i> (Sundevall)	*	*	*
	<i>Neriere radiata</i> (Walckenaer)	*		
	<i>Pelecopsis mengei</i> (Simon)	*	*	*
	<i>Pocadicnemis americana</i> Millidge	*	*	*
	<i>Scironis tarsalis</i> (Emerton)			*
	<i>Stemonyphantes blauveltae</i> Gertsch	*		
	<i>Tapinocyba minuta</i> (Emerton)	*	*	
	<i>Walckenaeria directa</i> (O.P.-Cambridge)	*	*	*
	<i>Walckenaeria exigua</i> Millidge	*	*	
	<i>Walckenaeria palustris</i> Millidge	*		
	<i>Walckenaeria pinocchio</i> (Kaston)	*		
	<i>Walckenaeria spiralis</i> (Emerton)	*	*	
	<i>Walckenaeria tibialis</i> (Emerton)	*	*	
Liocranidae	<i>Agroeca ornata</i> Banks	*	*	
	<i>Agroeca pratensis</i> Emerton	*	*	*
	<i>Phrurotimpus borealis</i> (Emerton)	*	*	
	<i>Scotinella pugnata</i> (Emerton)	*	*	*
Lycosidae	<i>Alopecosa aculeata</i> (Clerck)	*	*	*
	<i>Arctosa emertoni</i> Gertsch	*		
	<i>Arctosa raptor</i> (Kulczyn'ski)	*		
	<i>Arctosa rubicunda</i> (Keyserling)	*	*	
	<i>Hogna frondicola</i> (Emerton)	*	*	
	<i>Pardosa distincta</i> (Blackwall)	*	*	
	<i>Pardosa dromaea</i> (Thorell)	*		*
	<i>Pardosa fuscula</i> (Thorell)	*		*
	<i>Pardosa mackenziana</i> (Keyserling)		*	
	<i>Pardosa modica</i> (Blackwall)	*	*	*
	<i>Pardosa moesta</i> Banks	*	*	*
	<i>Pardosa ontariensis</i> Gertsch	*		
	<i>Pardosa xerampelina</i> (Keyserling)	*	*	
	<i>Pirata insularis</i> Emerton	*	*	*
	<i>Pirata minutus</i> Emerton	*	*	
	<i>Pirata montanus</i> Emerton		*	
	<i>Pirata piraticus</i> (Clerck)	*	*	*
	<i>Schizocosa crassipalpata</i> Roewer	*	*	
	<i>Schizocosa retrorsa</i> (Banks)	*	*	
	<i>Trochosa terricola</i> Thorell	*	*	*

Table 3 cont'd

Family	Species	Prairie	Forest	Pond
Mimetidae	<i>Ero canionis</i> Chamberlin & Ivie	*	*	
	<i>Mimetus epeiroides</i> Emerton	*		
Philodromidae	<i>Ebo iviei</i> Sauer & Platnick	*	*	
	<i>Philodromus histrio</i> (Latreille)	*	*	
	<i>Thanatus coloradensis</i> Keyserling	*		
	<i>Thanatus formicinus</i> (Clerck)	*	*	*
	<i>Thanatus rubicellus</i> (Mello-Leitão)	*		
	<i>Thanatus striatus</i> C.L. Koch	*	*	*
	<i>Tibellus maritimus</i> (Menge)	*	*	
	<i>Tibellus oblongus</i> (Walckenaer)	*	*	
Pisauridae	<i>Dolomedes striatus</i> Giebel	*	*	
	<i>Dolomedes triton</i> (Walckenaer)	*	*	*
Salticidae	<i>Evarcha hoyi</i> (Peckham & Peckham)	*	*	
	<i>Habronattus decorus</i> (Blackwall)	*	*	
	<i>Neon ellamae</i> Gertsch & Ivie			*
	<i>Pelegrina insignis</i> (Banks)	*		
	<i>Phidippus whitmani</i> Peckham & Peckham	*	*	
	<i>Salticus scenicus</i> (Clerck)	*		
	<i>Sitticus striatus</i> Emerton	*		
	<i>Talavera minuta</i> (Banks)	*	*	
	<i>Tutelina similis</i> (Banks)	*	*	
	Tetragnathidae	<i>Pachygnatha dorothea</i> McCook	*	
<i>Pachygnatha tristriata</i> C.L. Koch		*	*	
<i>Pachygnatha xanthostoma</i> C.L. Koch		*		
<i>Tetragnatha laboriosa</i> Hentz		*		
Theridiidae	<i>Enoplognatha marmorata</i> (Hentz)	*		
	<i>Euryopsis funebris</i> (Hentz)	*	*	
	<i>Euryopsis gertschi</i> Levi	*		
	<i>Euryopsis saukeya</i> Levi	*		
	<i>Robertus banksi</i> (Kaston)		*	
Thomisidae	<i>Steatoda americana</i> (Emerton)	*		
	<i>Bassaniana utahensis</i> (Gertsch)	*		
	<i>Ozyptila conspurcata</i> Thorell	*	*	*
	<i>Ozyptila sincera canadensis</i> Dondale & Redner		*	
	<i>Xysticus ampullatus</i> Turnbull, Dondale & Redner	*	*	
	<i>Xysticus discursans</i> Keyserling	*	*	
	<i>Xysticus elegans</i> Keyserling		*	
	<i>Xysticus emertoni</i> Keyserling	*	*	*
	<i>Xysticus ferox</i> (Hentz)	*	*	
	<i>Xysticus luctans</i> (C.L. Koch)	*	*	
	<i>Xysticus pallax</i> O.P.-Cambridge	*		
	<i>Xysticus triguttatus</i> Keyserling	*		
<i>Xysticus winnipegensis</i> Turnbull, Dondale & Redner	*	*		
Titanoecidae	<i>Titanoeca nivalis</i> Simon		*	*
<b>17 families</b>	<b>Totals</b>	<b>126</b>	<b>94</b>	<b>29</b>

Table 4. Abundance of adults by burn season treatment of the 25 most abundant spider species collected on St. Charles Rifle Range from 1997 to 2000. Spr = spring, Sum = summer, Fall = fall, Ref = refuge, Con= control. Note: controls are not directly comparable to other treatments due to differences in sampling intensity.

Species	Treatment					Total	% of total
	Spr	Sum	Fall	Ref	Con		
<i>Pardosa moesta</i>	4675	2286	1831	6890	1390	<b>17072</b>	31.38
<i>Pardosa distincta</i>	1990	2987	2770	2773	1281	<b>11801</b>	21.69
<i>Alopecosa aculeata</i>	843	563	550	920	565	<b>3441</b>	6.32
<i>Agroeca pratensis</i>	444	358	300	611	219	<b>1932</b>	3.55
<i>Hogna frondicola</i>	394	514	542	346	85	<b>1881</b>	3.46
<i>Zelotes frateris</i>	433	238	220	574	240	<b>1705</b>	3.13
<i>Xysticus ampullatus</i>	250	291	355	257	114	<b>1267</b>	2.33
<i>Ozyptila conspurcata</i>	279	130	240	331	173	<b>1153</b>	2.12
<i>Centromerus sylvaticus</i>	287	199	171	344	139	<b>1140</b>	2.10
<i>Xysticus ferox</i>	221	196	232	272	123	<b>1044</b>	1.92
<i>Trochosa terricola</i>	343	132	104	279	121	<b>979</b>	1.80
<i>Goneatara nasutus</i>	237	260	158	218	27	<b>900</b>	1.65
<i>Pirata minutus</i>	173	236	94	144	37	<b>684</b>	1.26
<i>Pardosa modica</i>	208	124	52	202	48	<b>634</b>	1.17
<i>Thanatus striatus</i>	173	141	108	157	36	<b>615</b>	1.13
<i>Arctosa rubicunda</i>	97	149	157	90	12	<b>505</b>	0.93
<i>Schizocosa crassipalata</i>	101	81	87	167	41	<b>477</b>	0.88
<i>Xysticus emertoni</i>	108	52	61	130	105	<b>456</b>	0.84
<i>Cicurina arcuata</i>	69	89	125	55	24	<b>362</b>	0.67
<i>Gnaphosa parvula</i>	76	48	31	147	56	<b>358</b>	0.66
<i>Agroeca ornata</i>	90	61	92	93	16	<b>352</b>	0.65
<i>Euryopsis funebris</i>	87	69	76	74	37	<b>343</b>	0.63
<i>Ceraticelus laetus</i>	137	21	21	121	24	<b>324</b>	0.60
<i>Collinsia plumosa</i>	90	135	35	47	17	<b>324</b>	0.60
<i>Enoplognatha marmorata</i>	57	117	106	29	9	<b>318</b>	0.58

Table 5. Weekly abundance of the adult spiders for the 25 most abundant species collected on the St. Charles Rifle Range in 2000.  
 Week 1 = 31.iii-7.iv, week 32 = 3-10.xi. Abundance value in bold is the peak abundance for that species.

Species	Week number																																Totals	
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32		
<i>Pardosa moesta</i>	0	0	0	0	0	1	72	242	628	<b>885</b>	238	259	118	135	40	174	198	165	86	59	132	163	52	109	81	35	24	13	5	5	0	0	<b>3919</b>	
<i>Pardosa distincta</i>	0	0	0	0	0	0	0	3	27	127	86	174	<b>290</b>	260	37	109	186	252	211	120	129	194	106	235	177	165	179	109	61	51	4	0	<b>3292</b>	
<i>Alopecosa aculeata</i>	0	0	1	32	129	<b>287</b>	215	276	135	122	12	10	3	3	4	11	7	1	0	2	3	7	3	4	1	0	0	0	0	0	0	0	<b>1268</b>	
<i>Centromeris sylvaticus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	4	1	3	28	51	114	225	<b>254</b>	185	58	29	<b>955</b>	
<i>Goneatara nasutus</i>	0	0	0	0	0	0	0	0	0	6	0	3	0	0	0	0	0	0	29	7	68	<b>123</b>	50	27	46	75	53	42	41	36	93	51	<b>750</b>	
<i>Hogna frondicola</i>	19	10	86	<b>140</b>	64	64	15	18	18	7	2	2	2	0	0	1	1	2	4	9	19	22	3	6	2	1	6	1	5	0	0	<b>529</b>		
<i>Zelotes fratris</i>	0	1	7	<b>81</b>	46	28	26	27	23	21	6	4	9	12	12	23	31	20	17	20	14	11	3	16	6	2	2	1	0	0	0	<b>469</b>		
<i>Trochosa terricola</i>	2	4	38	<b>104</b>	82	47	17	5	5	4	0	1	1	0	1	0	10	16	1	6	13	22	6	7	18	17	6	9	6	5	1	0	<b>454</b>	
<i>Ozyptila conspurcata</i>	1	2	0	3	5	6	3	6	30	<b>72</b>	40	28	16	17	3	1	0	7	14	16	20	17	6	9	10	6	16	3	5	4	4	1	<b>371</b>	
<i>Agroeca pratensis</i>	10	6	6	4	12	6	8	22	22	27	<b>49</b>	12	20	17	13	12	3	10	1	0	0	1	0	0	1	13	23	32	36	1	0	<b>367</b>		
<i>Pirata minutus</i>	0	0	0	0	0	0	0	0	0	5	1	4	1	9	2	10	18	<b>82</b>	32	15	15	19	15	9	21	9	28	15	12	11	1	0	<b>334</b>	
<i>Collinsia plumosa</i>	8	11	27	<b>77</b>	12	1	1	2	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1	0	1	26	44	28	37	6	7	<b>290</b>	
<i>Xysticus ferox</i>	0	0	0	0	0	2	3	13	38	<b>73</b>	28	36	29	17	12	6	5	1	10	2	2	1	0	0	0	0	1	0	0	0	0	0	<b>279</b>	
<i>Grammonota pictilis</i>	2	2	0	1	2	4	19	11	33	<b>62</b>	<b>62</b>	13	12	3	2	8	5	0	9	6	2	4	0	0	0	1	2	1	1	3	2	1	<b>273</b>	
<i>Ceraticelus laetus</i>	0	0	2	36	53	34	<b>63</b>	21	10	8	2	0	1	1	0	1	0	0	0	1	0	0	1	2	1	6	7	12	4	0	0	<b>268</b>		
<i>Schizocosa crassipalata</i>	0	0	0	0	0	0	8	45	71	<b>78</b>	17	5	1	2	1	8	14	6	2	3	1	1	0	1	1	0	0	1	0	0	0	<b>266</b>		
<i>Agroeca ornata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	10	32	<b>174</b>	19	7	<b>243</b>
<i>Xysticus ampullatus</i>	0	0	0	0	0	9	16	30	57	<b>68</b>	26	16	10	5	2	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	<b>243</b>	
<i>Pardosa modica</i>	0	1	3	<b>40</b>	30	18	21	13	17	6	6	0	6	6	2	7	5	4	5	0	0	1	1	0	1	0	0	0	0	0	0	0	<b>193</b>	
<i>Xysticus emertoni</i>	0	0	0	0	0	13	20	<b>39</b>	<b>39</b>	35	9	6	1	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	<b>165</b>	
<i>Eperigone trilobata</i>	3	4	10	25	<b>54</b>	0	12	7	3	2	1	2	0	2	0	0	3	1	0	0	1	0	0	0	1	3	2	6	3	3	4	3	<b>155</b>	
<i>Cicurina arcuata</i>	1	1	4	6	4	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	4	27	<b>37</b>	27	7	2	<b>124</b>	
<i>Gnaphosa parvula</i>	0	0	2	2	3	6	0	5	19	<b>21</b>	5	5	9	6	5	4	4	4	2	1	1	0	1	3	2	0	0	2	1	2	0	0	<b>115</b>	
<i>Arctosa rubicunda</i>	0	0	1	0	0	0	0	3	5	32	<b>42</b>	7	4	3	1	0	0	0	2	2	1	3	2	0	0	0	0	0	0	1	0	0	<b>109</b>	
<i>Pachygnatha tristriata</i>	0	1	1	3	8	8	3	2	0	2	0	2	0	1	0	0	0	0	0	0	1	2	3	2	4	9	6	4	14	<b>18</b>	6	2	<b>102</b>	

Table 6. Jaccard index values between pairs of burn season treatments for each year for the adult spiders collected on the St. Charles Rifle Range. Spr = spring, Sum = summer, Fall = fall, Ref = refuge, Con= control.

Year	Treatment comparison									
	Spr/Sum	Spr/Fall	Spr/Ref	Spr/Con	Sum/Fall	Sum/Ref	Sum/Con	Fall/Ref	Fall/Con	Ref/Con
1997	0.558	0.600	0.634	N/A	0.605	0.556	N/A	0.573	N/A	N/A
1998	0.724	0.727	0.671	0.594	0.737	0.679	0.652	0.725	0.586	0.620
1999	0.727	0.736	0.682	0.595	0.711	0.674	0.605	0.648	0.545	0.658
2000	0.724	0.717	0.758	0.693	0.710	0.713	0.630	0.724	0.655	0.699

Table 7. Jaccard index values between years for each burn season treatment for the adult spiders collected on the St. Charles Rifle Range.

Year	Treatment				
	Spring	Summer	Fall	Refuge	Control
1997/1998	0.635	0.585	0.632	0.610	N/A
1998/1999	0.636	0.675	0.750	0.584	0.639
1999/2000	0.688	0.674	0.674	0.604	0.613

Table 8. Morisita-Horn index values between pairs of burn season treatments for each year for the adult spiders collected on the St. Charles Rifle Range. Spr = spring, Sum = summer, Fall = fall, Ref = refuge, Con= control.

Year	Treatment comparisons									
	Spr/Sum	Spr/Fall	Spr/Ref	Spr/Con	Sum/Fall	Sum/Ref	Sum/Con	Fall/Ref	Fall/Con	Ref/Con
1997	0.988	0.993	0.924	N/A	0.996	0.958	N/A	0.941	N/A	N/A
1998	0.618	0.506	0.993	0.908	0.983	0.609	0.831	0.494	0.741	0.907
1999	0.854	0.834	0.994	0.969	0.995	0.831	0.939	0.809	0.925	0.955
2000	0.824	0.765	0.991	0.901	0.985	0.868	0.935	0.820	0.932	0.930



Table 9. Morisita-Horn index values between years for each burn season treatment for the adult spiders collected on the St. Charles Rifle Range.

Year	Treatment				
	Spring	Summer	Fall	Refuge	Control
1997/1998	0.953	0.705	0.644	0.989	N/A
1998/1999	0.953	0.946	0.906	0.955	0.970
1999/2000	0.950	0.937	0.936	0.944	0.930

Table 10. Abundance of adults for the 25 most abundant spider species collected from the forest transect study on the St. Charles Rifle Range from 1998-2000. Pitfalls 1-5 and 16-21 were in tallgrass prairie. Pitfalls 6-10 and 11-15 were in aspen forest.

Species	Pitfalls 1-5	Pitfalls 6-10	Pitfalls 11-15	Pitfalls 16-21	Total	% of total
<i>Pardosa moesta</i>	420	694	541	311	1966	47.45
<i>Pardosa distincta</i>	208	0	2	172	382	9.22
<i>Agroeca ornata</i>	17	136	97	55	305	7.36
<i>Centromerus sylvaticus</i>	27	39	118	73	257	6.20
<i>Alopecosa aculeata</i>	87	15	67	82	251	6.06
<i>Goneatara nasutus</i>	17	23	44	76	160	3.86
<i>Zelotes fratris</i>	50	23	18	23	114	2.75
<i>Trochosa terricola</i>	23	15	37	35	110	2.66
<i>Agroeca pratensis</i>	26	6	5	34	71	1.71
<i>Ceraticelus laetus</i>	6	18	19	18	61	1.47
<i>Pelecopsis mengei</i>	2	6	47	2	57	1.38
<i>Arctosa rubicunda</i>	9	1	2	38	50	1.21
<i>Castianaira longipalpa</i>	15	5	2	18	40	0.97
<i>Xysticus ferox</i>	23	0	1	9	33	0.80
<i>Islandiana flaveola</i>	2	14	9	7	32	0.77
<i>Hahnia cinerea</i>	6	8	12	5	31	0.75
<i>Xysticus emertoni</i>	11	0	8	12	31	0.75
<i>Robertus banksi</i>	1	15	13	1	30	0.72
<i>Hogna frondicola</i>	7	0	0	21	28	0.68
<i>Haplodrassus hiemalis</i>	6	9	6	6	27	0.65
<i>Grammonota gigas</i>	0	15	8	0	23	0.56
<i>Agyneta allosubtilis</i>	4	3	13	2	22	0.53
<i>Pirata piraticus</i>	5	11	5	1	22	0.53
<i>Gnaphosa parvula</i>	4	5	5	6	20	0.48
<i>Xysticus ampulattus</i>	8	0	0	12	20	0.48

Table 11. Abundance of adult spiders collected from a pond margin on the St. Charles Rifle Range in 2000.

<b>Species</b>	<b>Total</b>
<i>Pardosa moesta</i>	329
<i>Centromerus sylvaticus</i>	92
<i>Pocadenemis americana</i>	61
<i>Hahnia cinerea</i>	58
<i>Pelecopsis mengei</i>	51
<i>Trochosa terricola</i>	34
<i>Alopecosa aculeata</i>	24
<i>Ceraticelus fissiceps</i>	18
<i>Ceraticelus laetus</i>	14
<i>Pirata insularis</i>	9
<i>Micaria pulicaria</i>	9
<i>Agyreta allosubtilis</i>	8
<i>Scotinella pugnata</i>	7
<i>Clubiona johnsoni</i>	7
<i>Zelotes fratris</i>	6
<i>Pardosa modica</i>	6
<i>Pirata piraticus</i>	5
<i>Neriere clathrata</i>	5
<i>Pardosa fuscata</i>	4
<i>Haplodrassus hiemalis</i>	4
<i>Xysticus emertoni</i>	3
<i>Ozyptila conspurcata</i>	3
<i>Micaria rossica</i>	3
<i>Erigone atra</i>	3
<i>Ceraticelus laticeps</i>	3
<i>Allomengea dentisetis</i>	3
<i>Pachygnatha dorothea</i>	2
<i>Neoantistea magna</i>	2
<i>Hypomma marxi</i>	2
<i>Walckenaeria directa</i>	1
<i>Titanoeca nivalis</i>	1
<i>Thanatus striatus</i>	1
<i>Thanatus formicinus</i>	1
<i>Scironis tarsalis</i>	1
<i>Pardosa dromaea</i>	1
<i>Neon ellamae</i>	1
<i>Haplodrassus signifer</i>	1
<i>Eperigone trilobata</i>	1
<i>Dolomedes triton</i>	1
<i>Clubiona abbotti</i>	1
<i>Castianaira longipalpa</i>	1
<i>Bathyphantes pallidus</i>	1
<i>Argenna obesa</i>	1
<i>Agroeca pratensis</i>	1

Fig. 1. Location of the study site, the St. Charles Rifle Range, relative to Winnipeg, Manitoba.

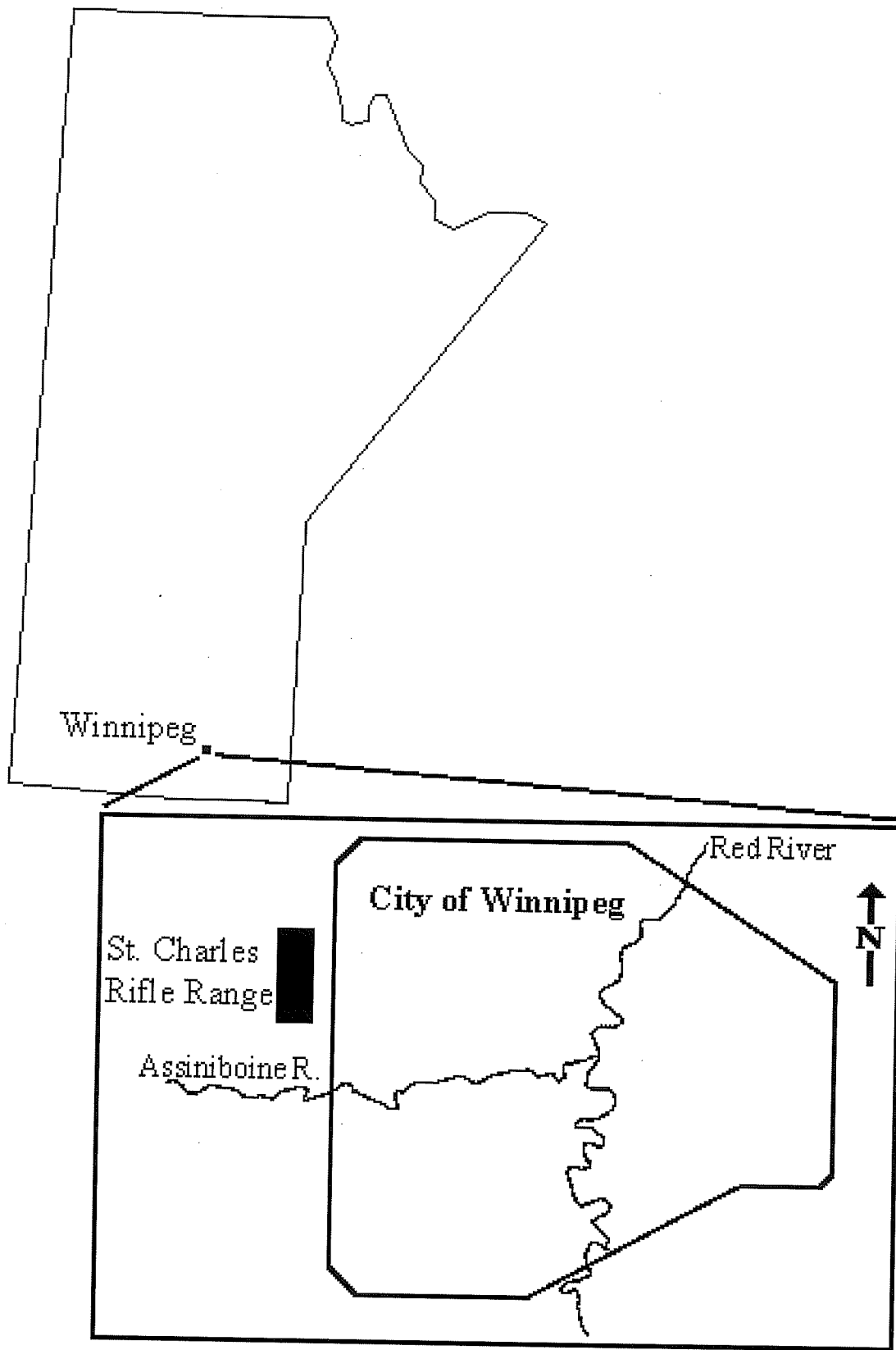


Fig. 2. Vegetation map of the St. Charles Rifle Range based on aerial photos taken in 1993 (from Morgan 1994). Boxed-in area is the area where study was conducted.

Legend:

- High quality prairie 1
- Mowed prairie 2
- Mowed "go-back" prairie 3
- Wet meadow 4
- "Go-back" prairie A 5
- "Go-back" prairie B 6
- Wet shrub meadow 7
- Aspen forest 8
- Building sites/roads
- Cultivated land

Scale = 1:13,000

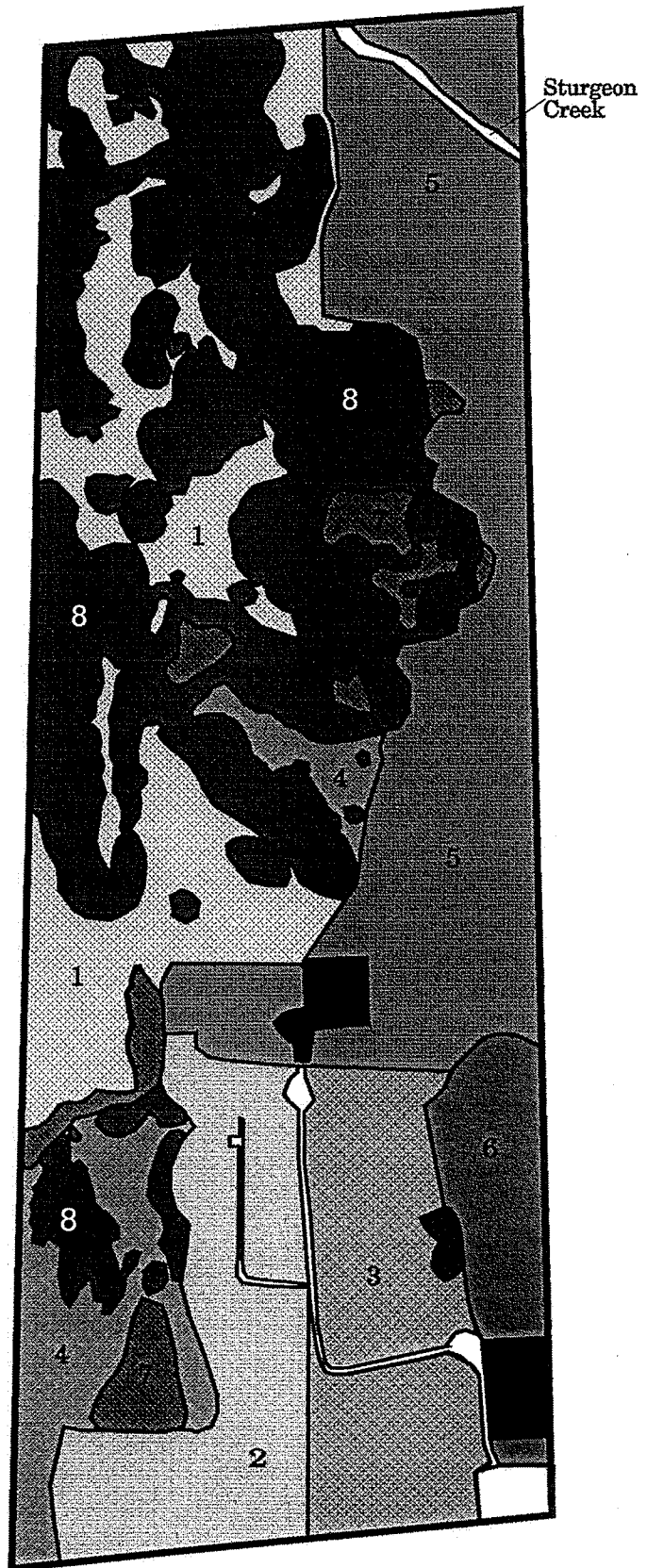
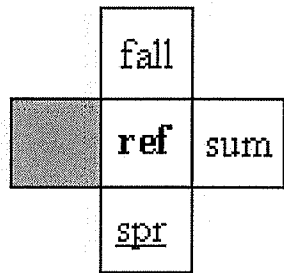
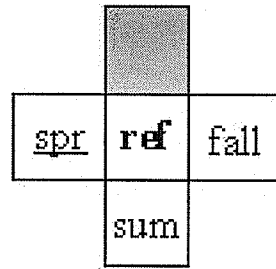
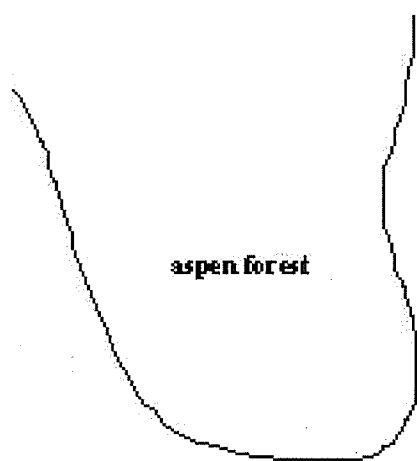
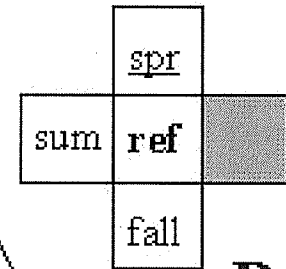
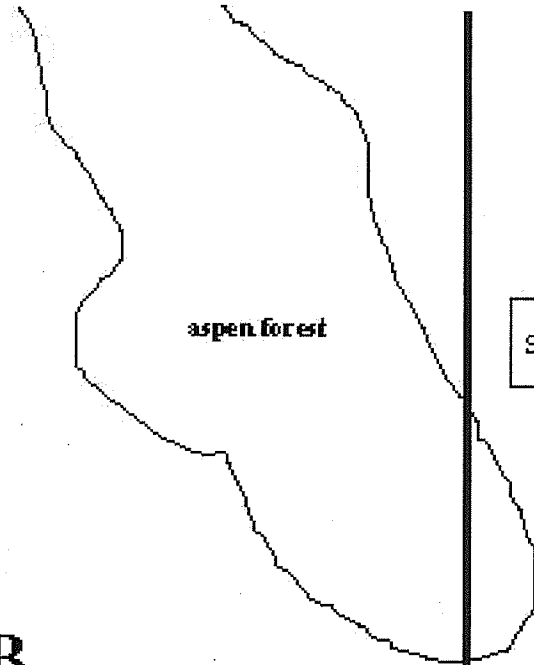
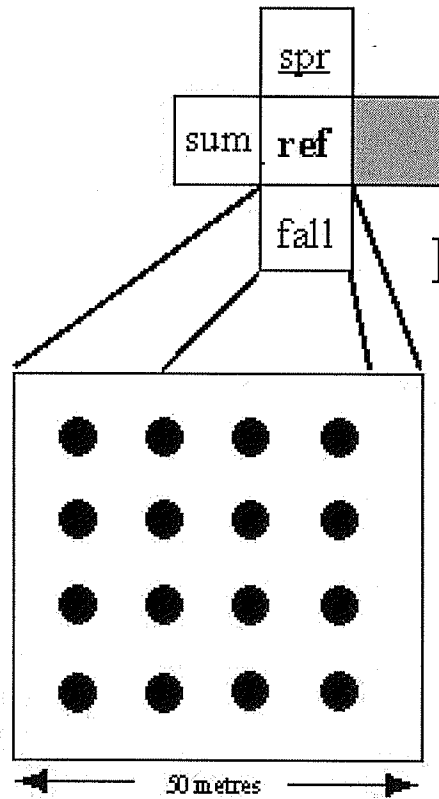


Fig. 3. Schematic diagram of experimental design for the St. Charles Rifle Range tallgrass prairie project. spr = spring treatment, sum = summer treatment, fall = fall treatment, ref = refuge treatment, con = control treatment. Grey square represents the botanical standard (modified from Roughley 2001).





C



D



Y

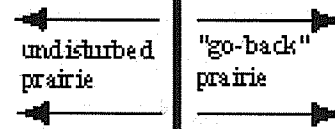


Fig. 4. Location and schematic diagram of the forest transect and pond margin study areas (modified from Roughley 2001).

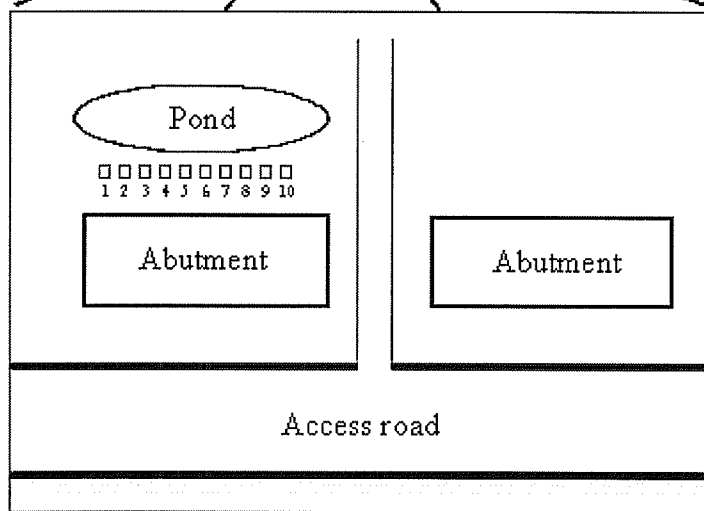
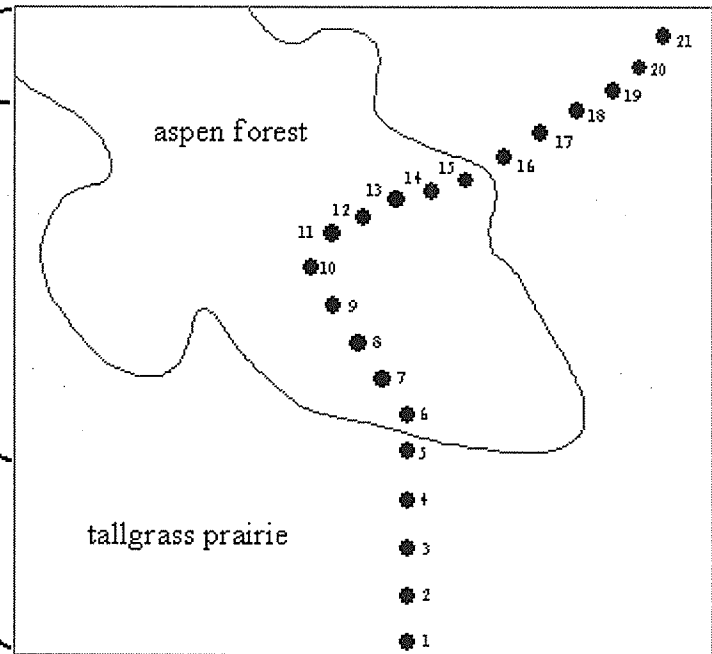
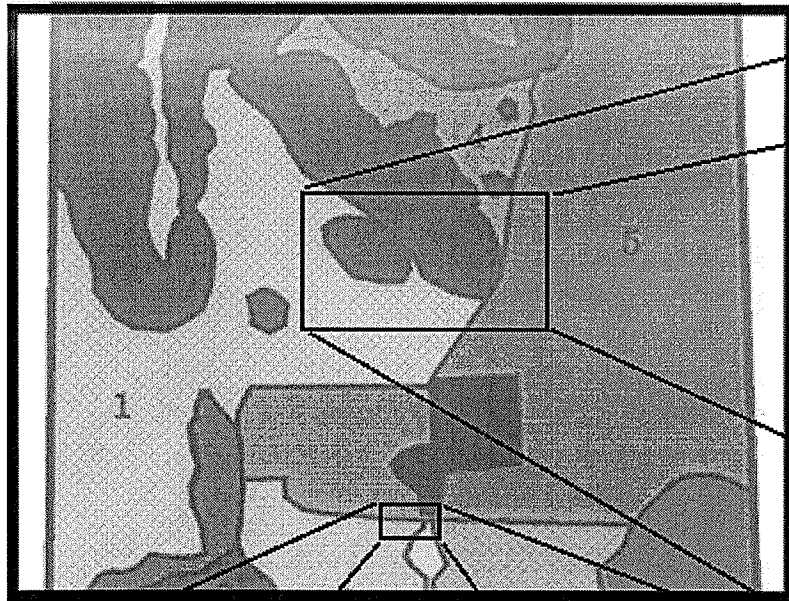


Figure 5: Effect of burn season on the natural log abundance per treatment square (mean  $\pm$  SEM) of adult *Pardosa moesta* collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

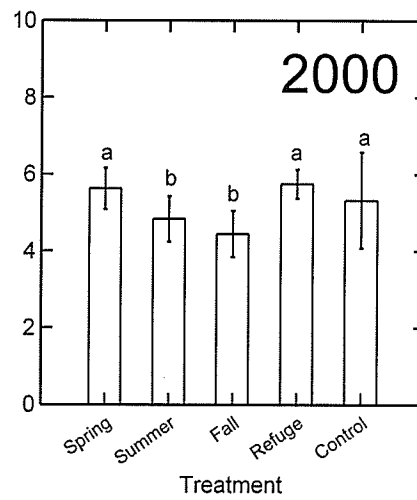
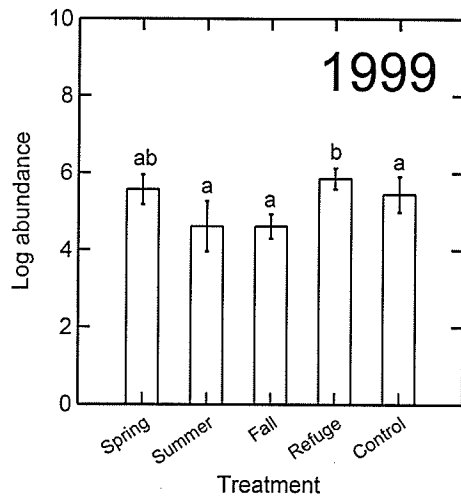
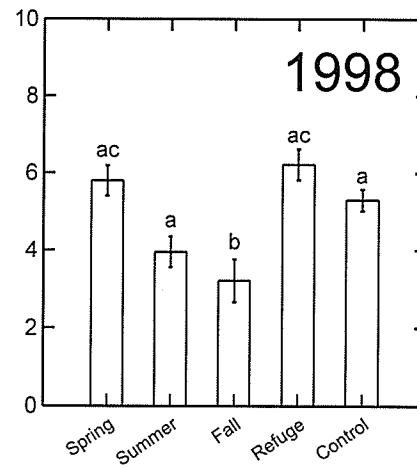
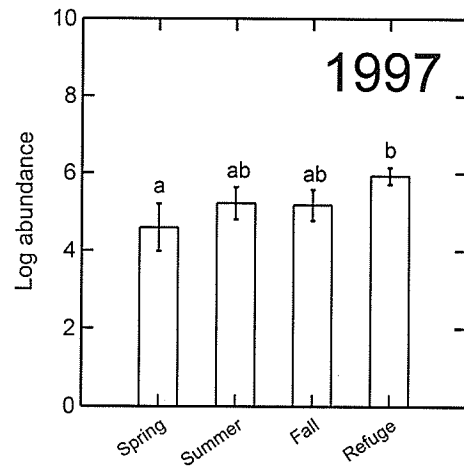


Figure 6: Effect of block on the natural log abundance per treatment square (mean  $\pm$  SEM) of adult *Pardosa moesta* collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

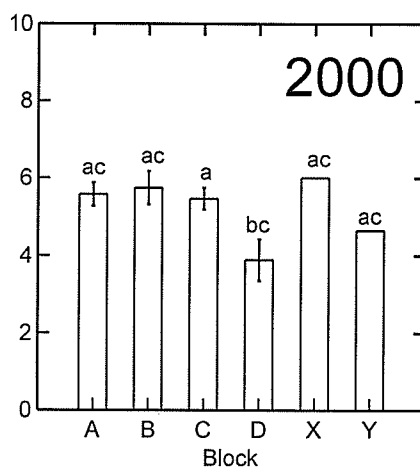
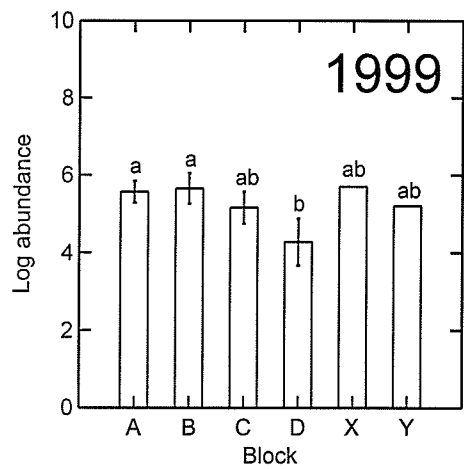
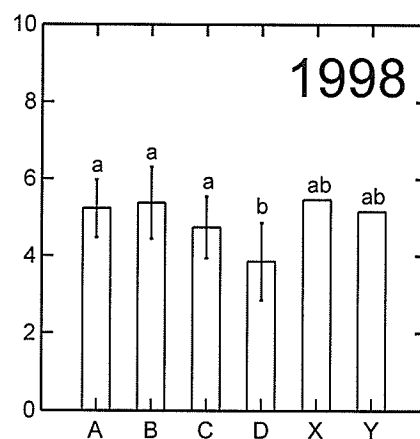
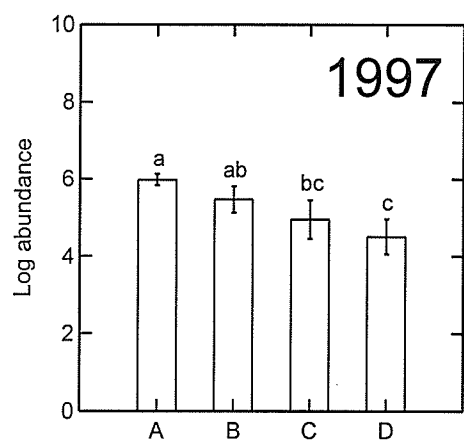


Figure 7: Effect of burn season on the natural log abundance per treatment square (mean  $\pm$  SEM) of adult *Pardosa distincta* collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.



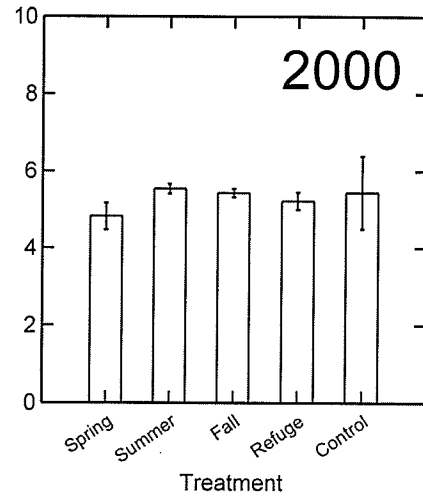
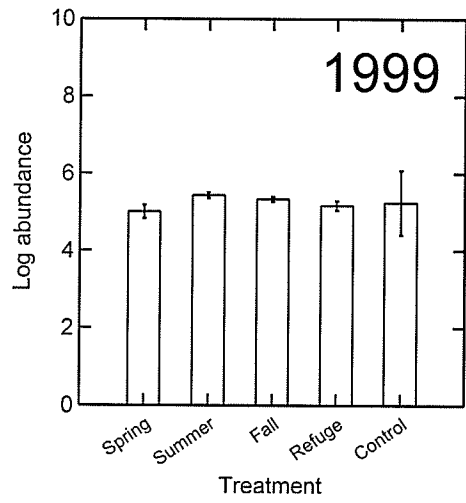
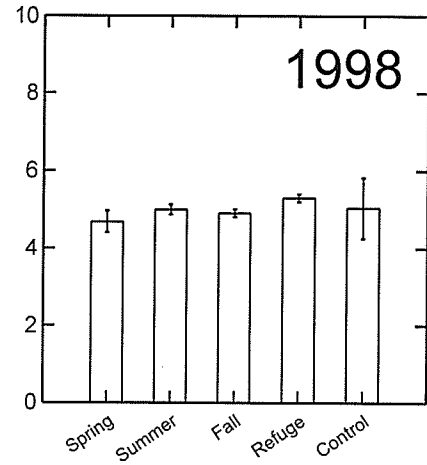
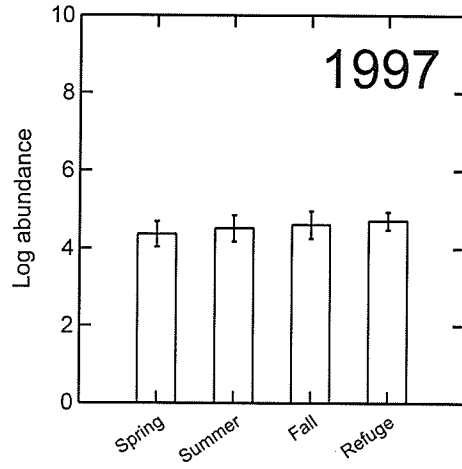


Figure 8: Effect of block on the natural log abundance per treatment square (mean  $\pm$  SEM) of adult *Pardosa distincta* collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

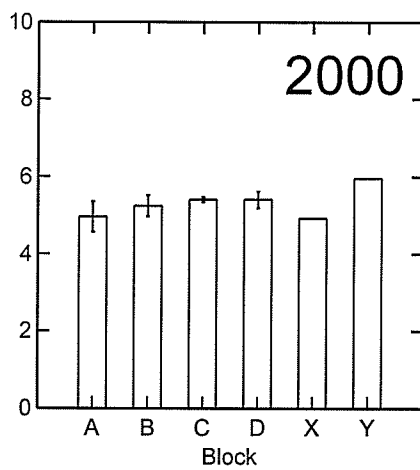
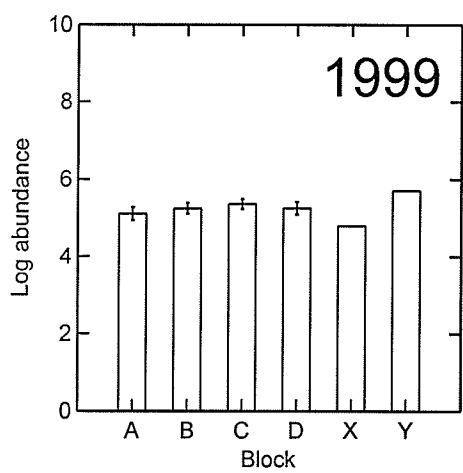
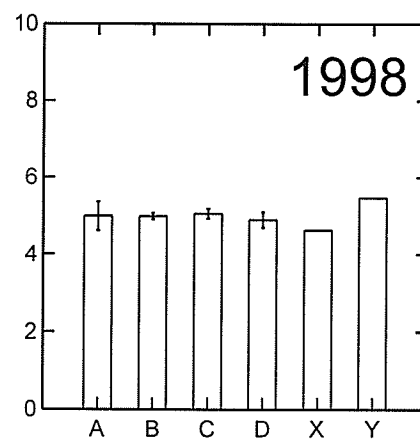
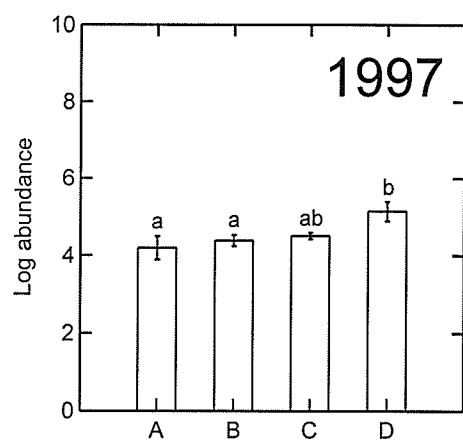


Figure 9: Effect of burn season on the natural log abundance per treatment square (mean  $\pm$  SEM) of adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

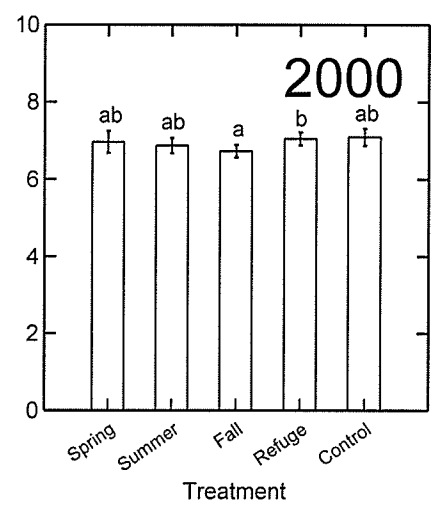
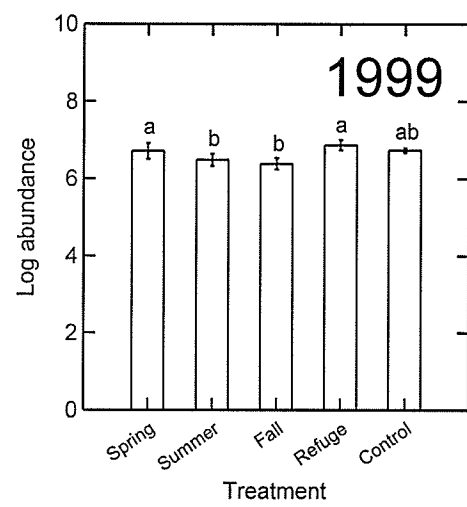
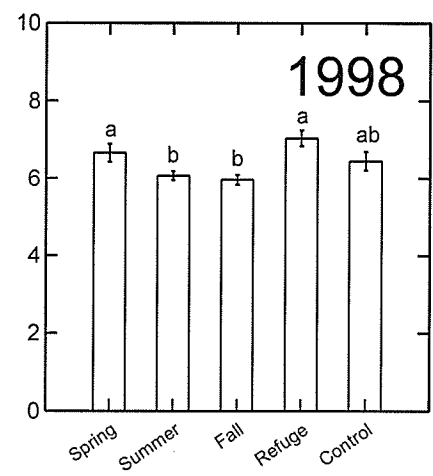
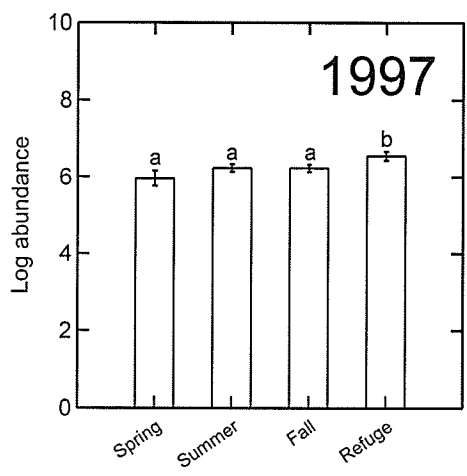


Figure 10: Effect of burn season on the natural log abundance per treatment square (mean  $\pm$  SEM) of adult spiders collected on the St. Charles Rifle Range in 1997 by burn period. Period 1 = pre-spring burn interval, period 2 = spring to summer burn interval, period 3 = summer to fall burn interval, and period 4 = post fall burn interval. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

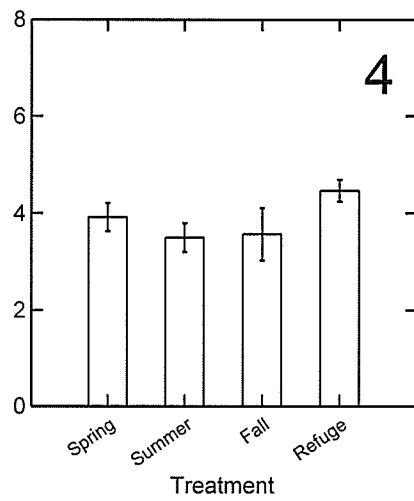
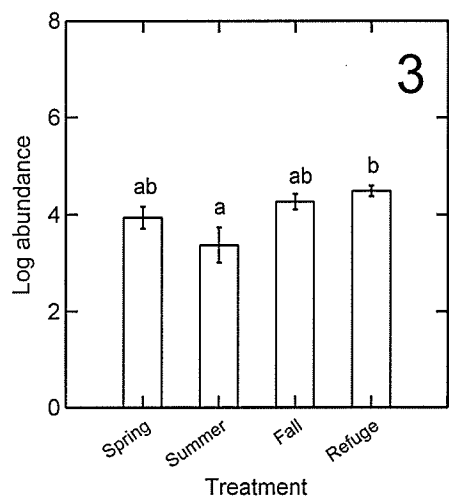
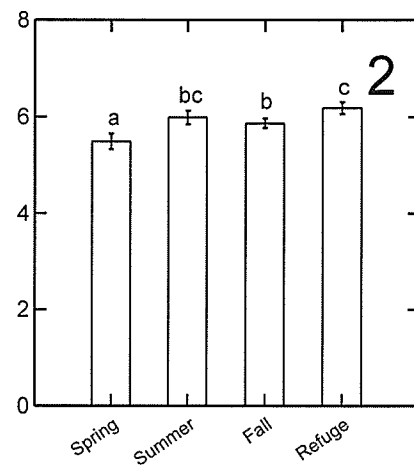
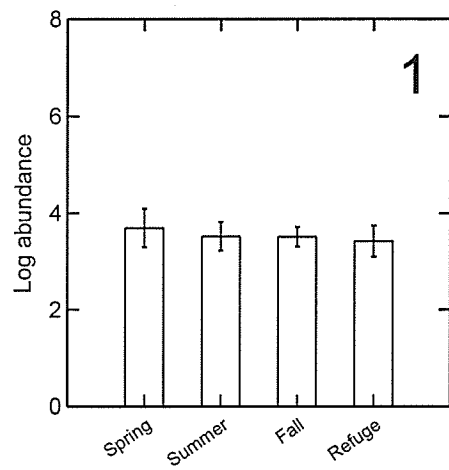


Figure 11: Effect of block on the natural log abundance per treatment square (mean  $\pm$  SEM) of adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.



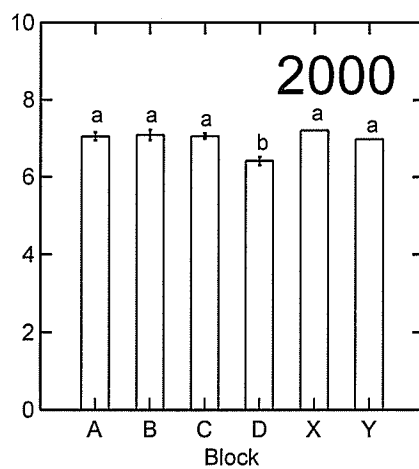
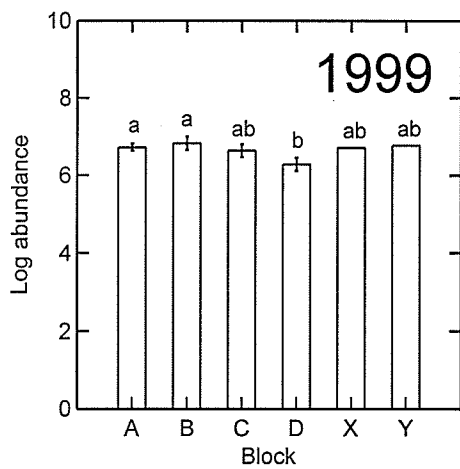
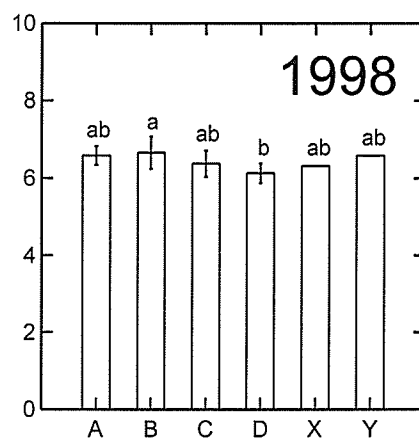
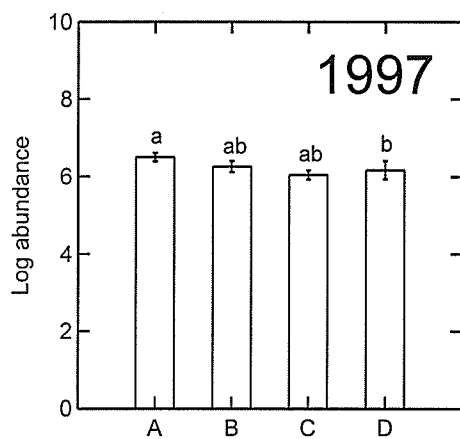


Figure 12: Effect of burn season on the natural log species richness (mean  $\pm$  SEM) of adult spiders collected on the St. Charles Rifle Range in 1997 by burn period. Period 1 = pre- spring burn interval, period 2 = spring to summer burn interval, period 3 = summer to fall burn interval, and period 4 = post fall burn interval. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

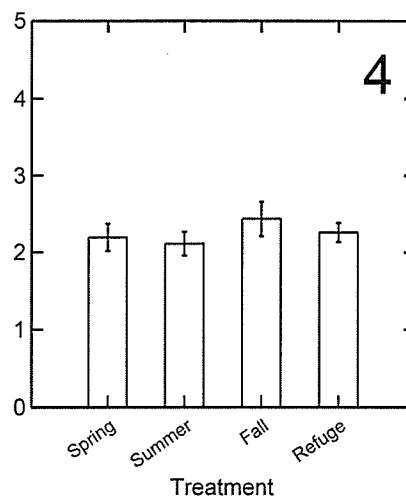
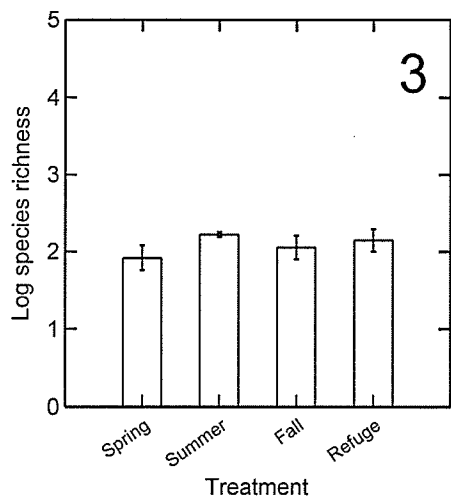
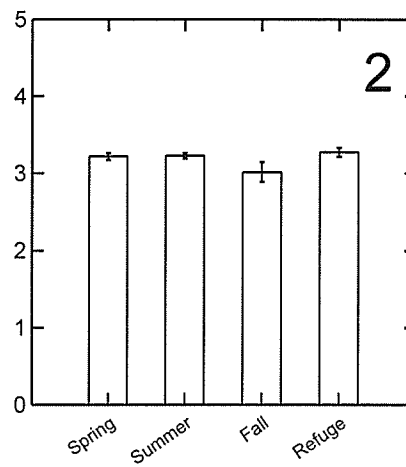
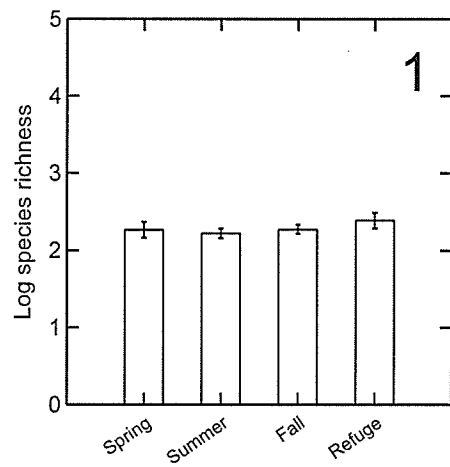


Figure 13: Effect of burn season on the natural log species richness (mean  $\pm$  SEM) of adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

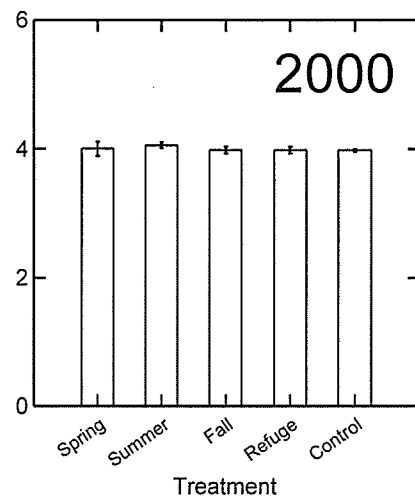
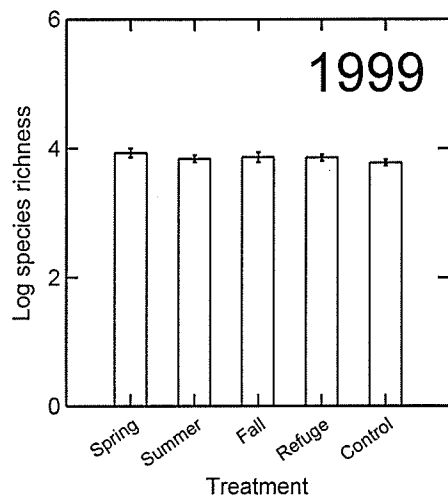
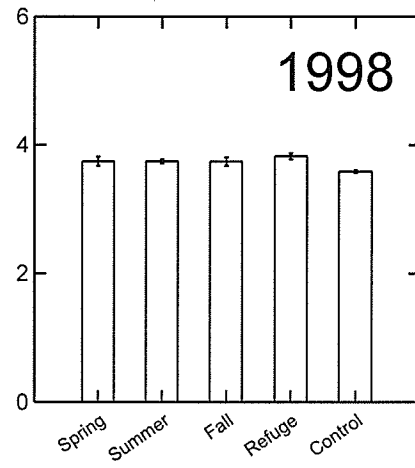
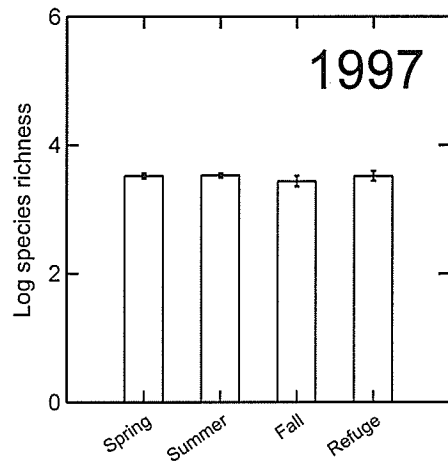


Figure 14: Effect of block on the natural log species richness (mean  $\pm$  SEM) of adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

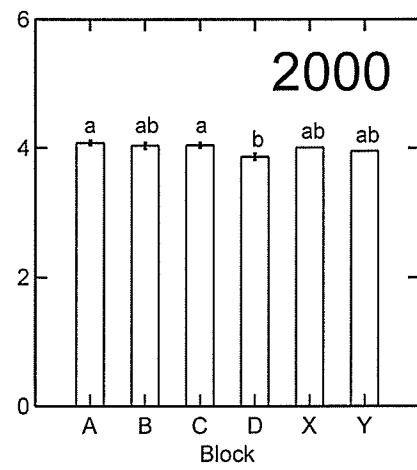
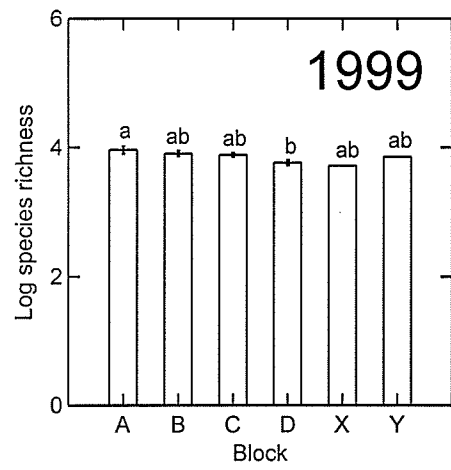
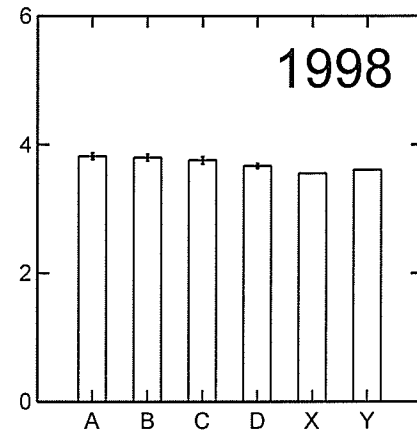
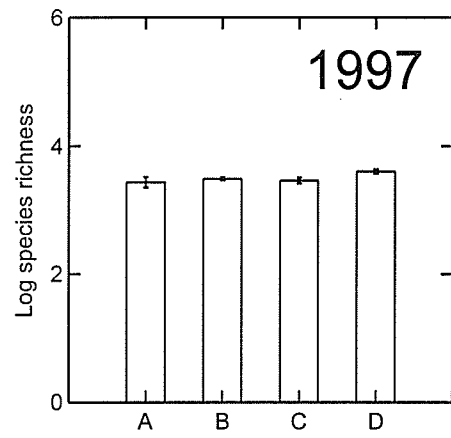


Figure 15: Effect of burn season on the Shannon-Wiener diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range in 1997 by burn period. Period 1 = pre- spring burn interval, period 2 = spring to summer burn interval, period 3 = summer to fall burn interval, and period 4 = post fall burn interval. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.



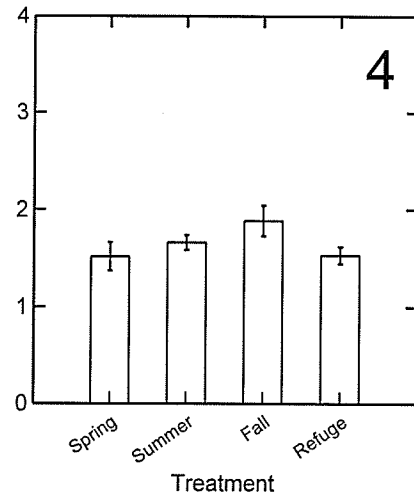
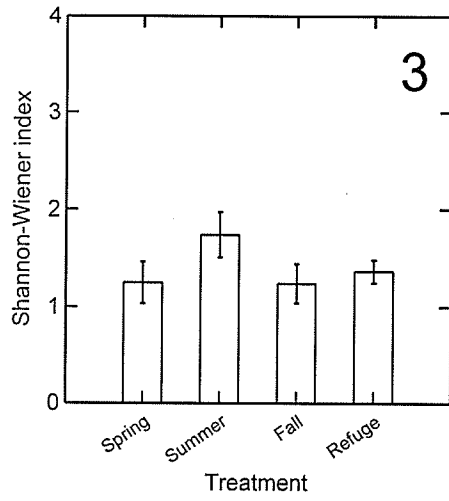
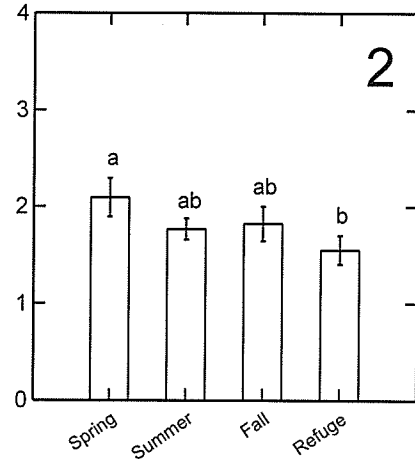
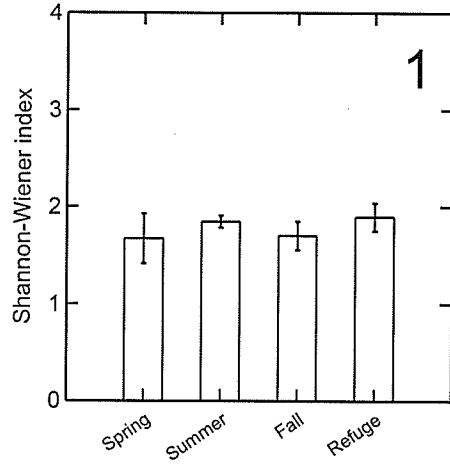


Figure 16: Effect of burn season on the Shannon-Wiener diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

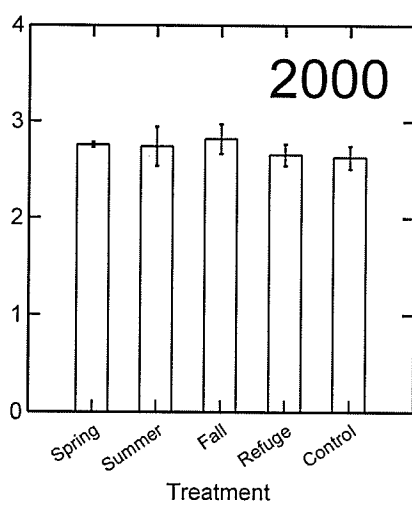
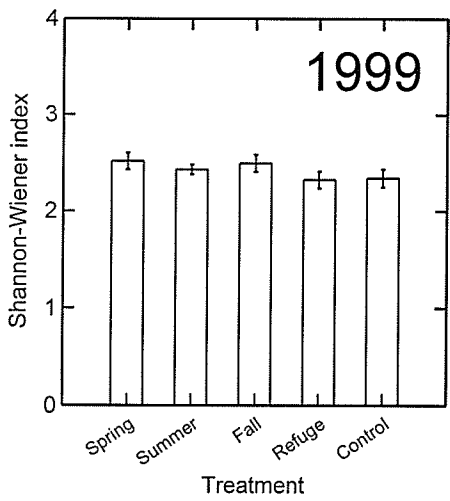
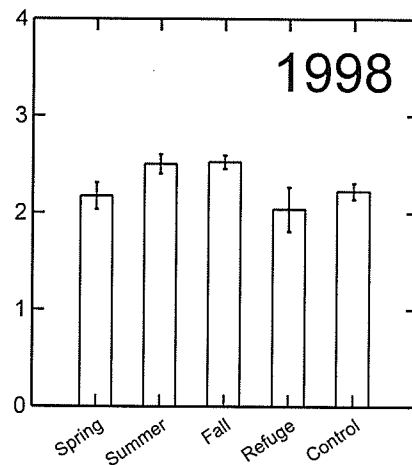
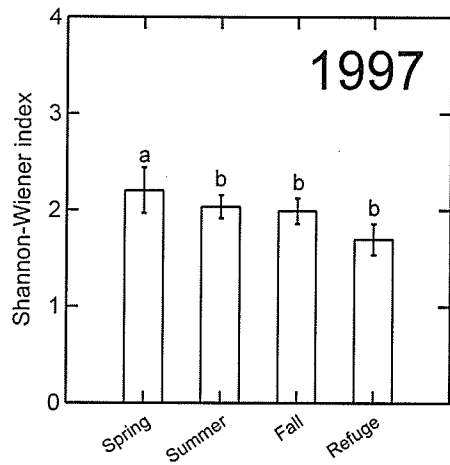


Figure 17: Effect of block on the Shannon-Wiener diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

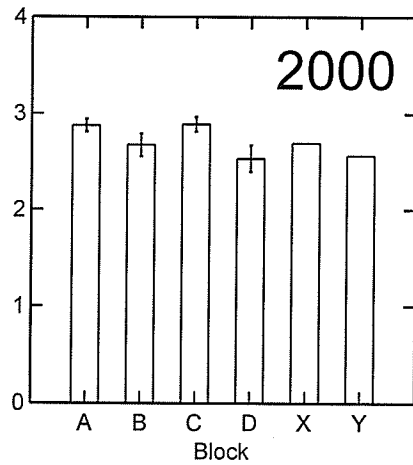
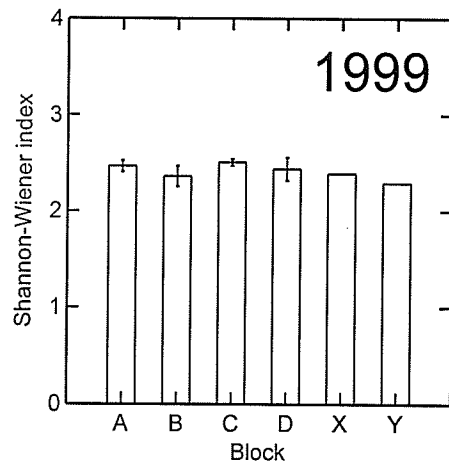
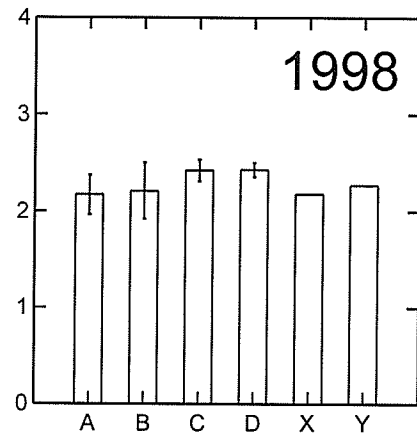
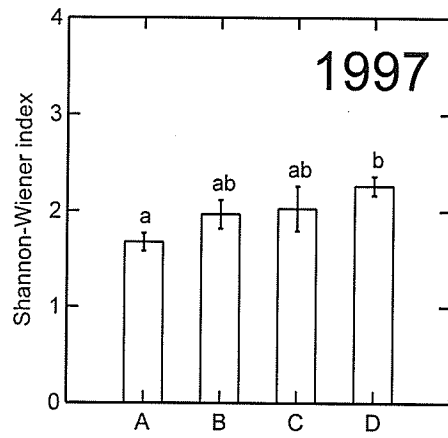


Figure 18: Effect of burn season on the log series alpha diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range in 1997 by burn period. Period 1 = pre- spring burn interval, period 2 = spring to summer burn interval, period 3 = summer to fall burn interval, and period 4 = post fall burn interval. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

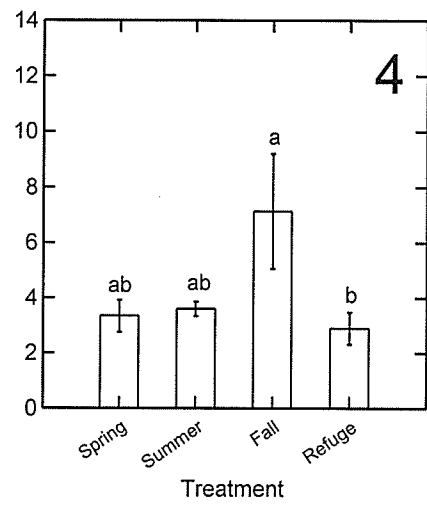
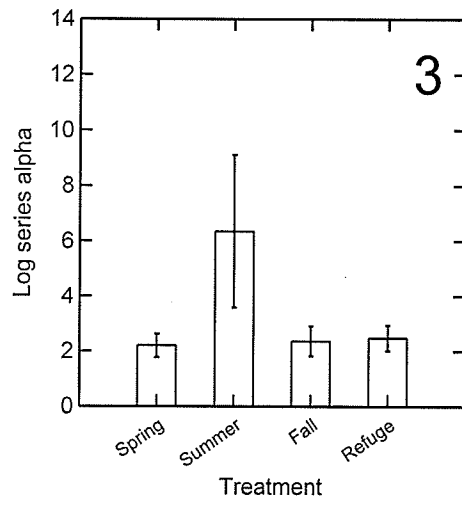
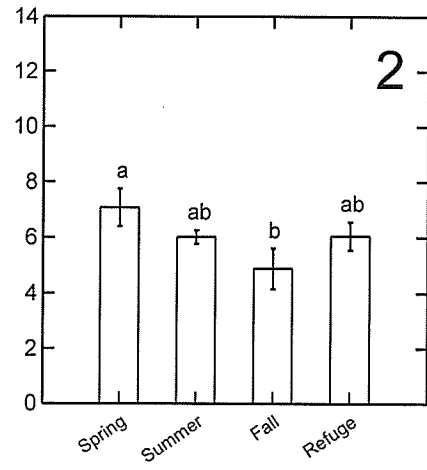
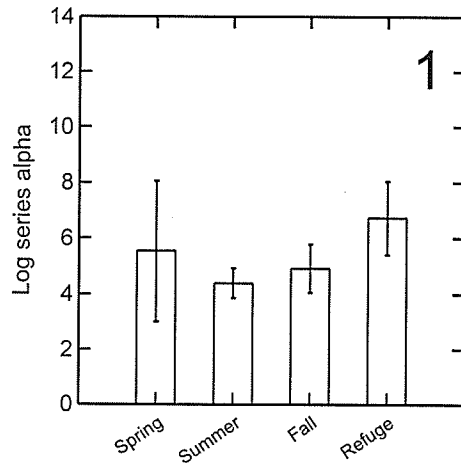


Figure 19: Effect of burn season on the log series alpha diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.



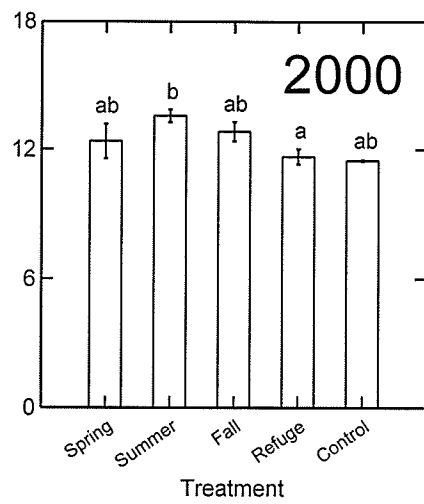
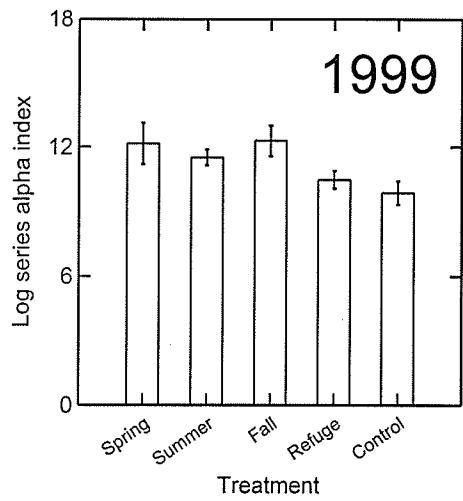
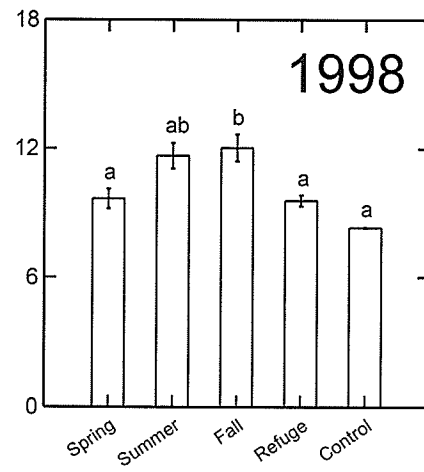
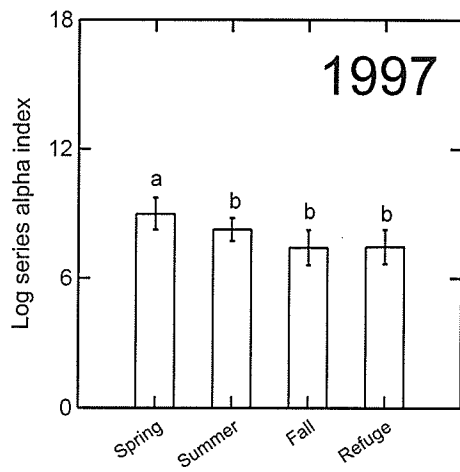


Figure 20: Effect of block on the log series alpha diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

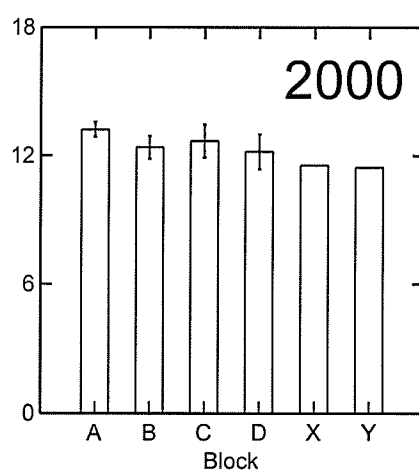
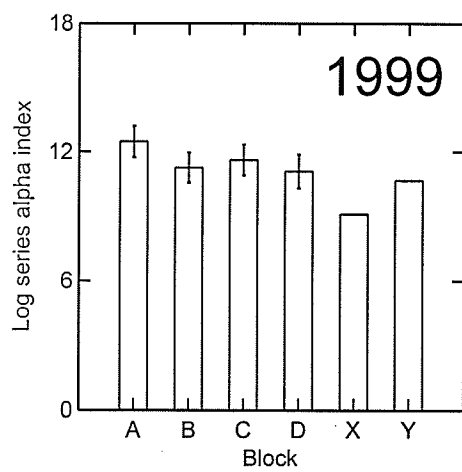
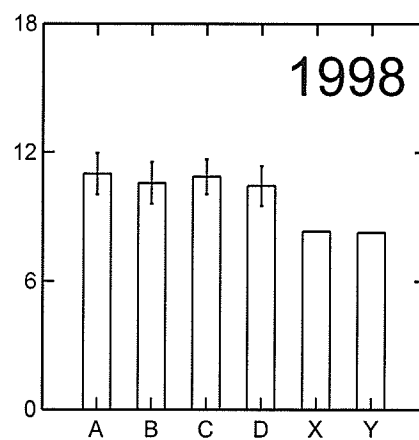
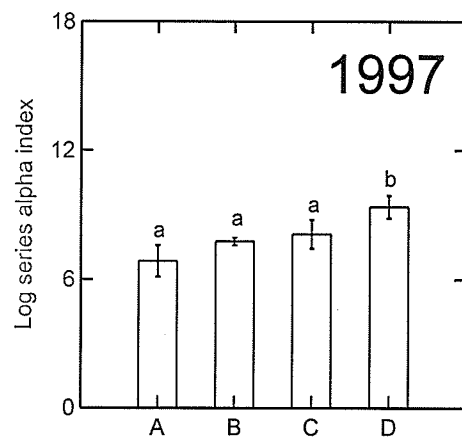


Figure 21: Effect of burn season on the Simpson diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range in 1997 by burn period. Period 1 = pre-spring burn interval, period 2 = spring to summer burn interval, period 3 = summer to fall burn interval, and period 4 = post fall burn interval. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

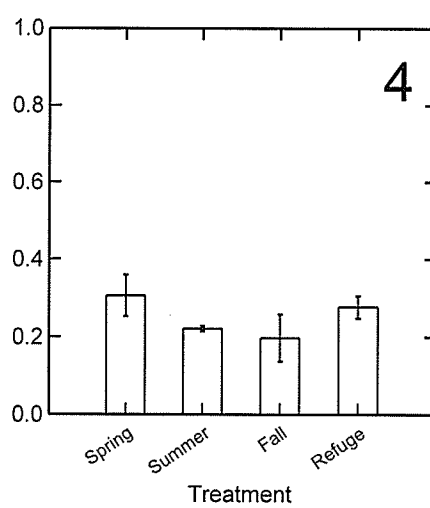
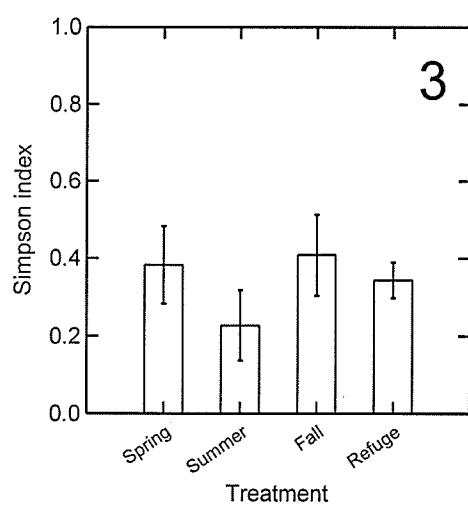
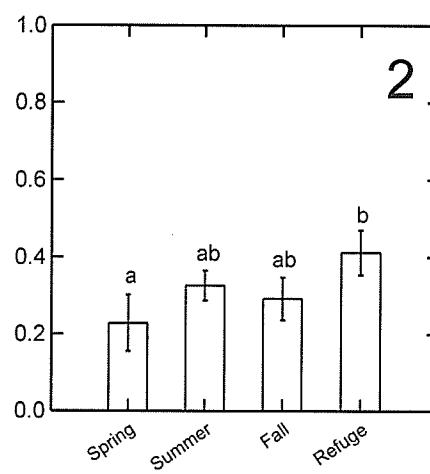
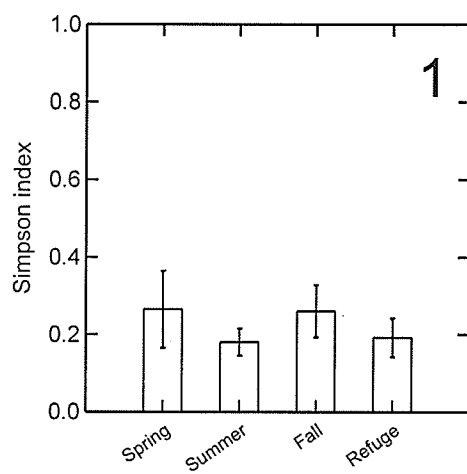


Figure 22: Effect of burn season on the Simpson diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

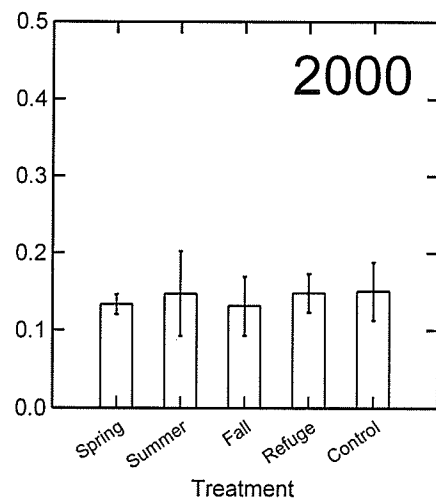
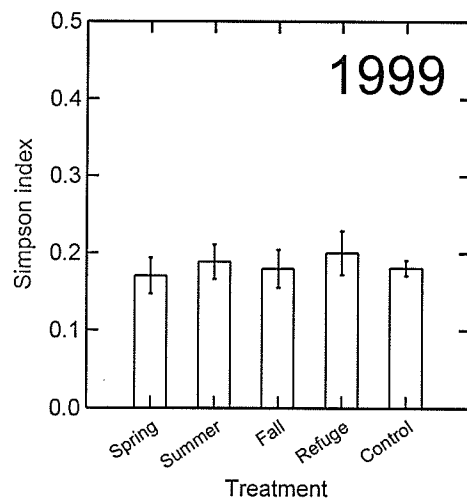
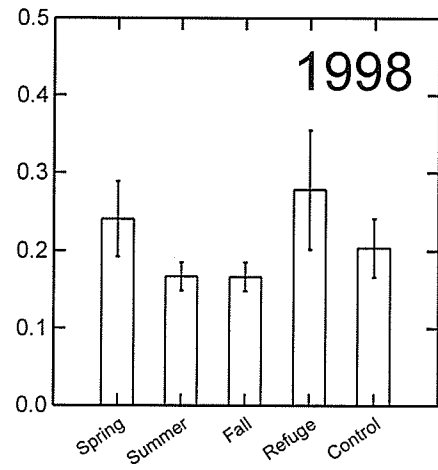
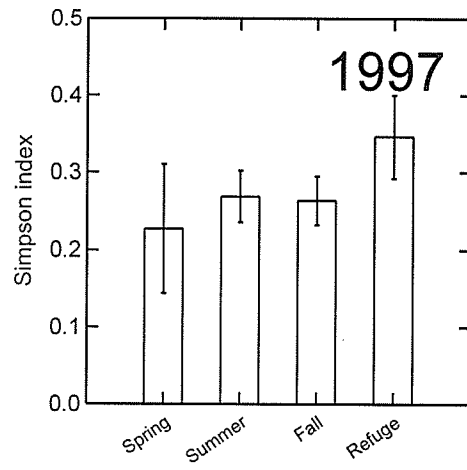


Figure 23: Effect of block on the Simpson diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.



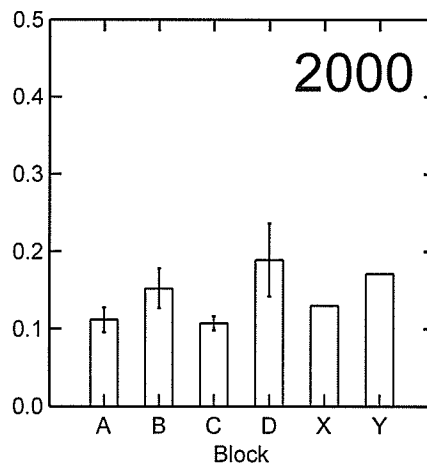
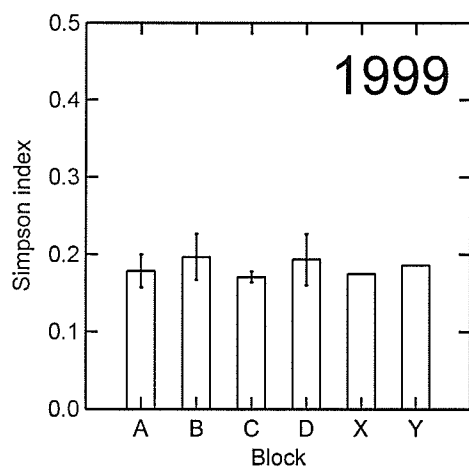
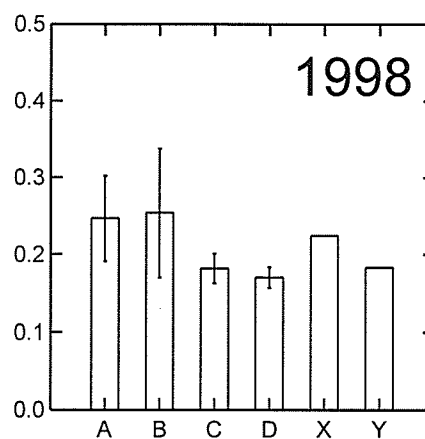
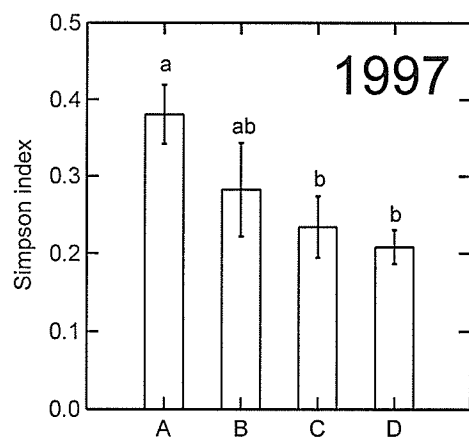


Figure 24: Effect of burn season on the Berger-Parker diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range in 1997 by burn period. Period 1 = pre-spring burn interval, period 2 = spring to summer burn interval, period 3 = summer to fall burn interval, and period 4 = post fall burn interval. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

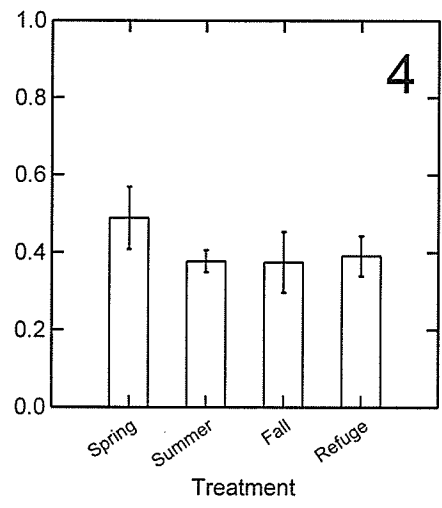
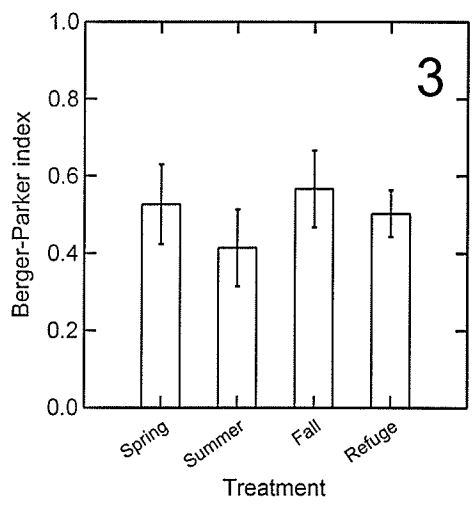
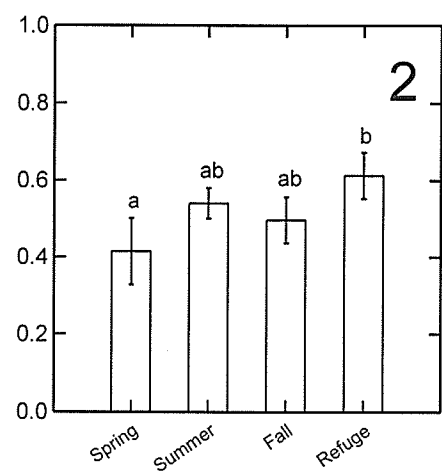
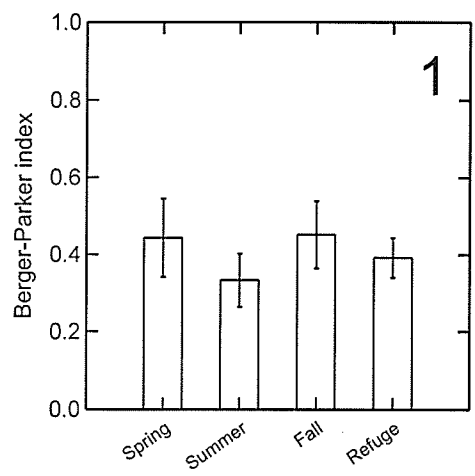


Figure 25: Effect of burn season on the Berger-Parker diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

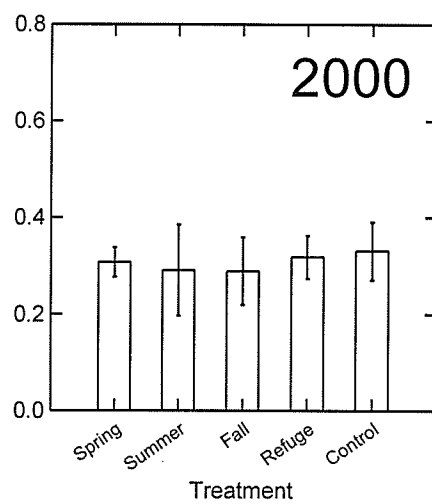
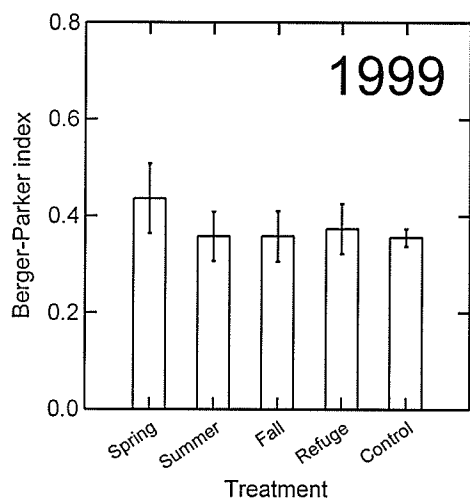
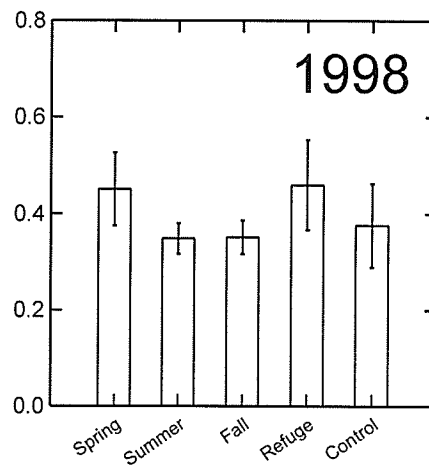
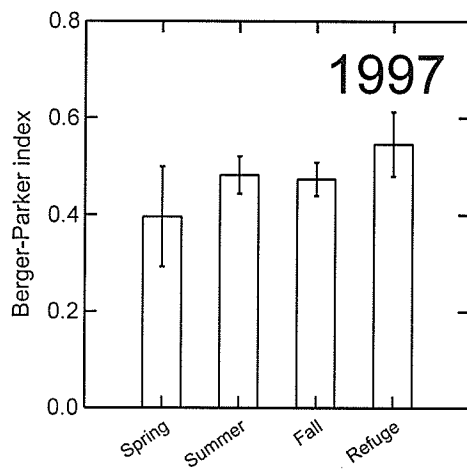


Figure 26: Effect of block on the Berger-Parker diversity index (mean  $\pm$  SEM) for adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

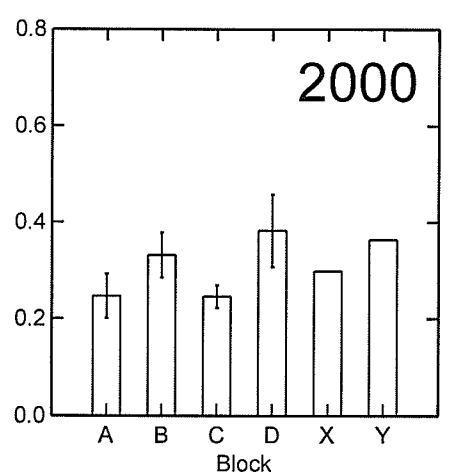
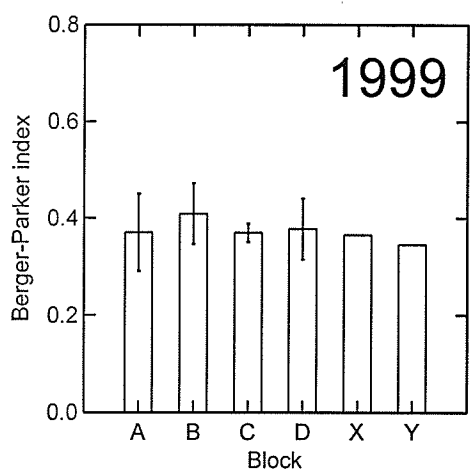
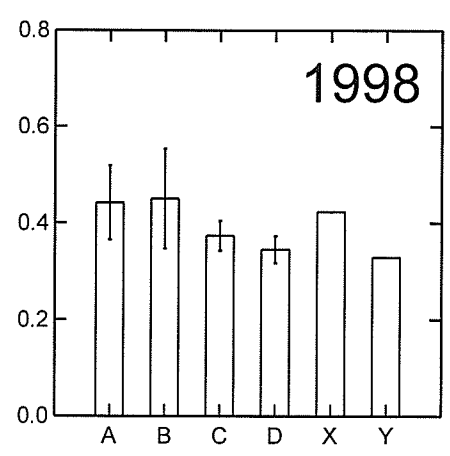
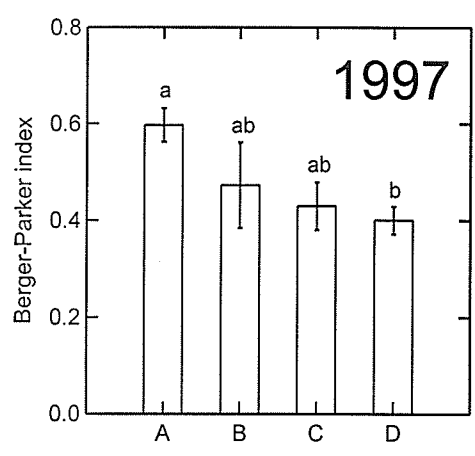


Figure 27: Effect of burn season on the log series alpha evenness (mean  $\pm$  SEM) of adult spiders collected on the St. Charles Rifle Range in 1997 by burn period. Period 1 = pre-spring burn interval, period 2 = spring to summer burn interval, period 3 = summer to fall burn interval, and period 4 = post fall burn interval. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.



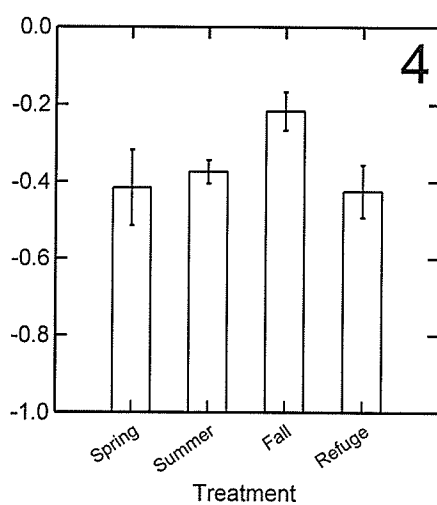
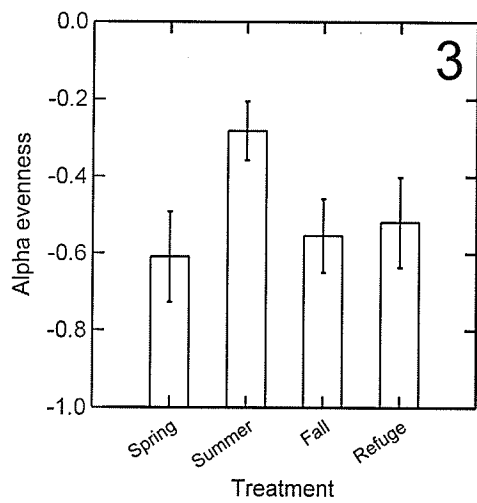
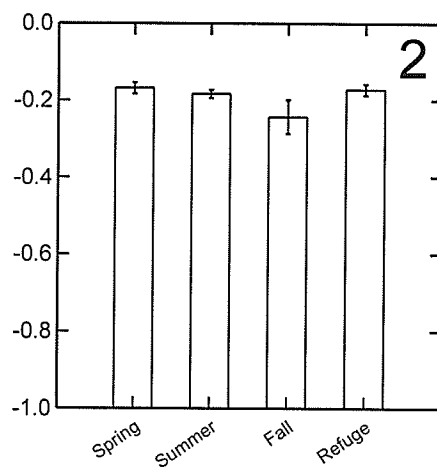
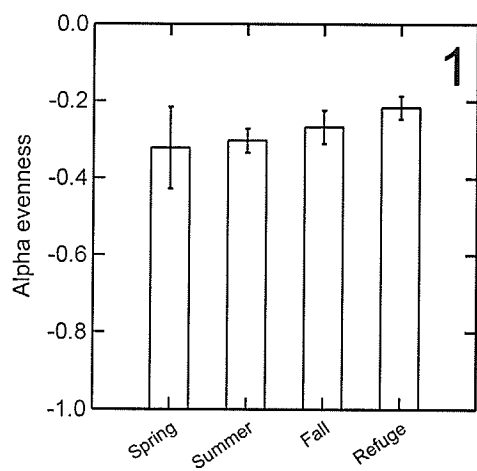


Figure 28: Effect of burn season on the log series alpha evenness (mean  $\pm$  SEM) of adult spiders Collected on the St. Charles Rifle Range from 1997 to 2000. All burns were conducted in 1997. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.

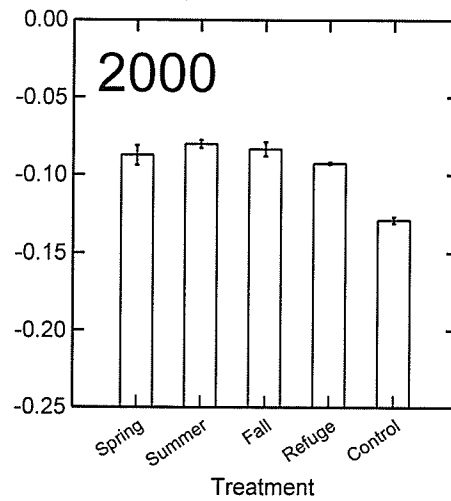
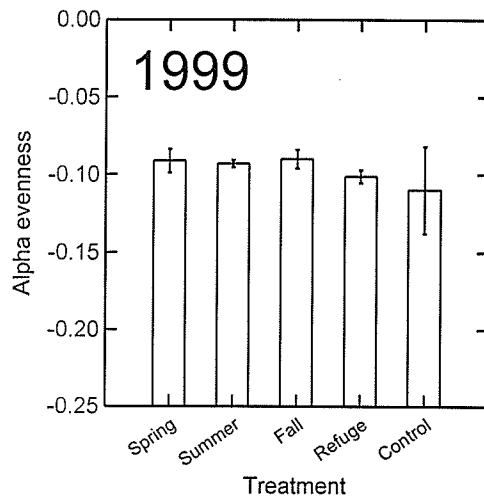
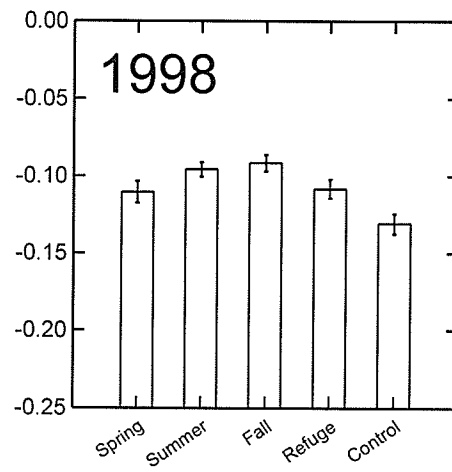
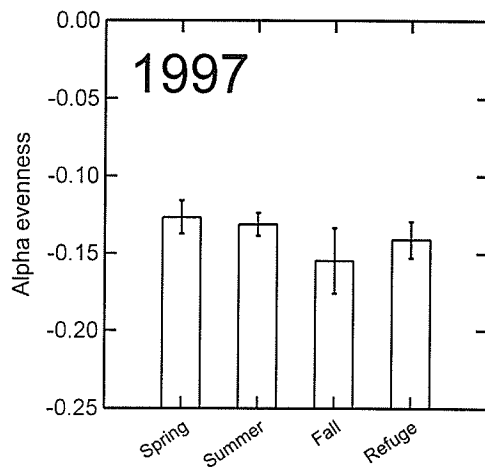
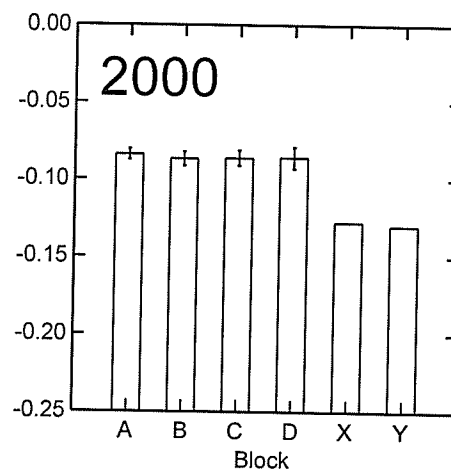
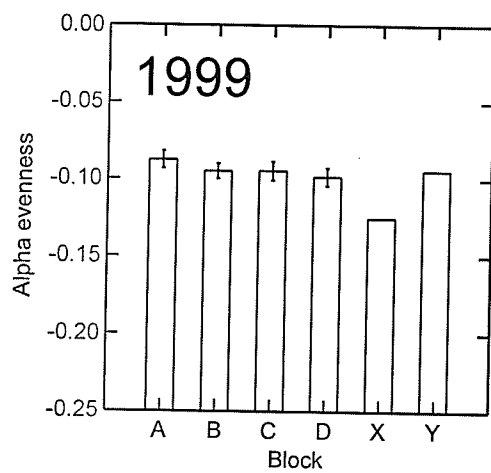
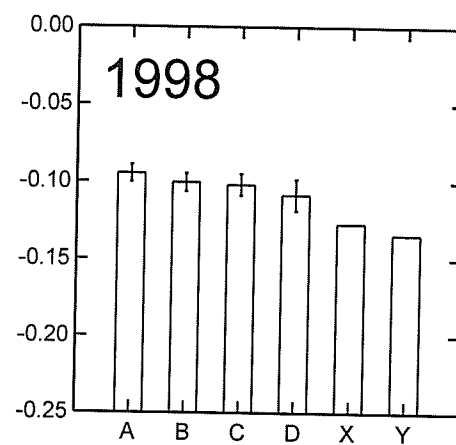
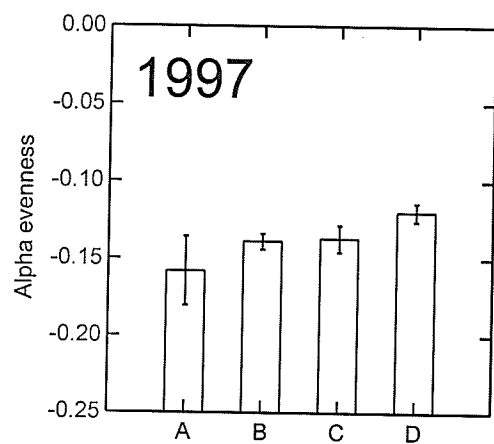


Figure 29: Effect of block on the log series alpha evenness (mean  $\pm$  SEM) of adult spiders collected on the St. Charles Rifle Range from 1997 to 2000. Bars with different lower case letters are significantly different at  $p = 0.05$  level of significance based on Tukey HSD multiple pairwise comparisons.



## DISCUSSION

The discussion has been divided into seven sections. The first two sections deal with the effect of fire season on the alpha and beta diversity. Section three is a discussion of the effect of fire on the spider communities. Section four is a discussion of the species composition of the St. Charles Rifle Range. In section five, the experimental design is discussed in relation to its effect on the results. In section six, recommendations to tallgrass prairie managers and proposed future studies are made. In section seven, a synthesis of the discussion is presented.

### **Effect of fire season on alpha diversity**

Until now, the effect of fire season on the spider diversity of tallgrass prairie has only been examined for spring burns and none of these studies were conducted in Canada. In these studies, spider populations decreased following the fire but species composition was not significantly affected (Nagel 1973, Rice 1932, Riechert and Reeder 1972). The results from this study agree with that trend, for both the abundance and species richness data. The effect of the spring burn was immediate in that the abundance of spiders in the spring treatment was lower in 1997 than in any other year. The impact of the summer and fall burns on spider abundance was not observed until the second year (1998) and neither treatment had recovered to the abundance level of the refuge treatment by 2000. Refuge treatments are considered to be analogous to unburned prairie even though they were surrounded by treatment squares. However, the abundance levels of the refuge treatments may have been abnormally elevated due to migration from the adjacent burn treatments during 1997. This dispersal may have occurred at the time of

the burns or may have been due to the spiders avoiding the burned treatments after the burns had occurred. Based on the 1997 data, spiders did move into the refuge treatments following each of the burn seasons. Even if the spider abundance in the refuge treatments was abnormally elevated, it appears that all treatments were approaching equilibrium in 2000. As for species richness, overall there were no significant differences among treatments in any year, which follows observations made by Johnson (1995) and Riechert and Reeder (1972). Based on the abundance and species richness data, the results of this study parallel those of previous studies and agree with the hypothesis that fire is the primary treatment effect, not the timing of the burn.

However, the hypothesis that fire is the primary treatment effect does not hold up when the results from the diversity indices are used. Although some of the results were not significant, the overall pattern was that the summer and fall treatments were ecologically the best treatments and the refuge treatment was the worst. I am defining ecologically best as having the highest species diversity index values (e.g. Shannon-Wiener, log series alpha index) but the lowest dominance diversity indices (e.g. Simpson index, Berger-Parker index). This combination of high and low values for the various diversity indices means that overall, the treatment has high species richness and high evenness. The summer and fall treatments have this combination of diversity values. This is important to prairie conservation because summer and fall burn seasons have not been thoroughly examined or implemented as management options (Howe 1994, Collins *et al.* 1998). The summer and fall treatments were significantly greater for the majority of the diversity measures in 1997 and 1998. However, by 2000 the differences were no longer significant. Four years was sufficient time for the spider community to return to

pre-burn conditions. Overall, all three burn treatments were better than the refuge and control treatments. Based on the more detailed data analysis, the hypothesis that fire is the primary treatment is false. The specific timing of the burn did have a major impact on the resulting spider community as predicted by Howe (1994). However, the hypothesis that the burn treatments are better than the refuge treatment is confirmed.

### **Effect of fire season on beta diversity**

The refuge and control treatments remained fairly similar for the duration of the study although the similarity values were never the highest among the various treatment comparisons. Although the treatments had similar alpha diversity values in 2000, the summer and fall treatments were more similar to each other than to the other treatments based on the beta diversity analysis. Also, the spring and refuge treatments were more similar to each other than to the other treatments. The similarity of the spring/refuge and summer/fall treatment groups in terms of beta diversity also occurred in 1998 and 1999. So although the four communities were similar at the community level, something occurred at the species level to make them split into these two groupings. In examining the species abundance for 2000, the spring and refuge treatments were dominated by *Pardosa moesta* in all blocks except block D. In contrast, *P. distincta* was the dominant species in the summer and fall treatments as well as all treatments in block D. This was the main difference at the species level and this difference affected the similarity values (i.e. beta diversity) the most. Other species that were more abundant in the summer and fall treatments were *Hogna frondicola* and *Arctosa rubicunda*. These species all exhibited positive responses to the summer and fall burns in that they had abundance



levels greater than those of the refuge. The original hypothesis based on previous studies was that each species should have its greatest abundance in the refuge treatment. These species do not follow this hypothesis and are therefore exhibiting a positive response to fire season, specifically to summer and fall burns.

The beta diversity indices can also be used as an indicator of the biological significance of differences seen in the alpha diversity indices. Although the alpha diversity indices have biological meaning, a significant difference in the values between two treatments might not be. For example, in 1998, the log series alpha index value for the fall treatment (11.9) was significantly greater than the refuge treatment (9.4). This difference of 2.5 could be due to differences in abundance of one species or all 128 species. The Morisita-Horn index value between the fall and refuge treatments in 1998 was 0.494 meaning that there was only 49.4% similarity between the two treatments. Therefore, the statistical significance of the difference in log series alpha values also has biological meaning because the two treatments were so different. In contrast, the Morisita-Horn index values for the spring/refuge treatment comparison was 0.993 and value of the summer/fall treatment comparison was 0.983. This means that any significant difference in the alpha diversity values of these treatment pairs are unlikely to have any biological significance. As the similarity between treatments increases, the biological significance of any numerically significant differences decreases. By using the similarity indices, it is easier to tell if there are any biologically significant differences, especially when the species richness is high as in this study. However, it is important to keep in mind that the beta diversity measures also have their associated biases and therefore caution should be taken when using them to determine biological significance.

### **Effect of fire on the spider communities**

The spider species living on the tallgrass prairie have a wide spectrum of phenologies (Table 5). This results in the spider community responding differently to different burn seasons as was predicted by Howe (1994) for plants. The phenologies seen in the species present on the tallgrass prairie agree with published data (Aitchison 1984a), although the specific timing of the peaks does differ. Aitchison (1984a) discussed the various types of life histories in great detail. However, for this discussion, I will simply refer to the life histories types by which season they had their peak adult abundance (e.g. spring, summer, autumn). The majority of the species had peak abundances in the spring, a few in the summer, and quite a few in the autumn. The fact that the majority of the species peaked in the spring helps explain why all previous research on the effect of spring burns primarily found an effect only on abundance not species richness. Early spring burns would occur prior to the peak activity periods of most if not all spider species. Therefore, they would readily recolonize the burned areas as they were moving about, provided that the habitat and food availability were suitable. Abundance levels would be less because the recruitment may not be great enough to balance those that were displaced from the habitat initially. However, when a summer or fall burn is conducted, it differentially affects the species present. It favours the species whose peak activity periods are closest to the time of the burn. This specific timing of the burn could affect competitive interactions among species. This seems to have been the case with the two abundant species. The spring burn occurred before the peak activity period for *P. moesta*, and therefore, *P. moesta* readily dispersed into the burned area soon after the fire occurred. The activity of females of *P. distincta* later in the year was greater than that of

*P. moesta* (personal observation). Therefore, *P. distincta* females (presumably with eggsacs) moved into the summer and fall burn treatments at a faster rate than *P. moesta*. This difference in phenology resulted in two distinct spider communities forming: the *P. distincta*-dominated community and the *P. moesta*-dominated community.

An important consideration when deciding which burn season is best is community stability (Collins 2000). A community that has high stability will be able to resist disturbances and maintain its functionality (Holling 1973). An important aspect of community stability is resilience, which is the rate at which a system returns to its former state following a disturbance (Holling 1973). If fire is to become a predominant management technique, then the community that is most resilient to the effects of fire would be preferred. The *P. distincta*-dominated community is more resilient than the *P. moesta*-dominated communities. In block D in 1997, the spring treatment was dominated by *P. distincta*, but *P. moesta* became the dominant species in 1998 as it was in the other blocks. In 1999, *P. distincta* once again became the dominant species and maintained this dominance in 2000. In the summer and fall treatments of blocks A, B and C, *P. moesta* was the dominant species in 1997. However, in 1998, *P. distincta* became the dominant species and maintained this dominance for the remainder of the study. The *P. distincta*-dominated community is more resilient in that it was able to return to its former state faster than the *P. moesta*-dominated community. The *P. distincta*-dominated community also exhibited resistance, another important component of stability. For the summer and fall treatments in block D, the *P. distincta*-dominated community exhibited resistance in that those treatments were always dominated by *P. distincta*, even though there was a fire disturbance in 1997. The *P. distincta*-dominated communities in the

summer and fall treatments of the other blocks also showed resistance in that the communities were maintained even though the adjacent refuge treatment had a relatively high abundance of *P. moesta*. Based on these results, the prediction can be made that once the spider community shifts to the *P. distincta*-dominated community, it will remain as such as long as fire is a regular disturbance. Therefore, the *P. moesta*-dominated community may be maintained only in unburned refugia. However, the results from block D, in which the refuge treatment was dominated by *P. moesta* in 1997 and 1998 but *P. distincta* became dominant in 1999 and 2000, would indicate that the *P. distincta*-dominated community might eventually take over in the refugia as well. Since the *P. distincta*-dominated community is the more stable community and no species would be extirpated, a shift to that community would be beneficial in maintaining the tallgrass prairie at the St. Charles Rifle Range as a top quality prairie ecosystem.

*Pardosa distincta*, *Hogna frondicola*, and *Arctosa rubicunda* were more abundant in the tallgrass prairie portion of the forest transect study. Only two individuals of *P. distincta* were collected in the forested portion of the transect study as compared to 380 in the tallgrass prairie portion. The two individuals collected in the forested portion were adult males and male spiders tend to be the most active sex (Aitchison 1984a), so the fact they were captured in the forest is not ecologically significant. Also, no individuals of *P. distincta* were found in the pond transect study. Therefore, *P. distincta* is a tallgrass prairie specialist at the St. Charles Rifle Range. The positive response of *P. distincta* and the other tallgrass prairie specialists in the summer and fall treatments is important because this indicates that these treatments are the best for the entire habitat because what is beneficial to the habitat specialists should be good for the habitat as a whole (Bell *et al*

2001).

### **Comparison of species composition to other similar habitats**

One hundred and twenty six species were collected at the tallgrass prairie of the St. Charles Rifle Range. This is by far the most species collected from a single habitat site within Manitoba although such studies have been limited (see Aitchison 1984a, b, 1994, Aitchison and Sutherland 2000). Of the 126 species collected, 8 species were new provincial records, compared to Aitchison-Benell and Dondale (1992). These are *Eboiviei* Sauer and Platnick, *Eridantes utibilis* Crosby and Bishop, *Euryopsis funebris* (Hentz), *Euryopsis gertschi* Levi, *Euryopsis saukea* Levi, *Goneatara nasutus*, *Schizocosa crassipalpata* Roewer, and *Schizocosa retrorsa* (Banks). Interestingly, the majority of the species collected that were new provincial records were fairly abundant and frequent (see appendices). This is especially true of *Goneatara nasutus*, which had a total abundance of almost 1000 over all four years in all habitats. Given that Aitchison (Aitchison 1984a,b, 1994, Aitchison and Sutherland 2000) did the majority of her spider research in Manitoba, it is surprising that the new records found at this study site would be so common. It does support the idea that tallgrass prairie is an important and species-rich habitat that is worthy of conserving.

Overall, 138 species were collected from all habitats sampled on the St. Charles Rifle Range. The forest transect study yielded 94 species of which nine were restricted to the aspen forest portion of the transect. The portion of the aspen forest sampled did not extend very far into the forest and therefore the high amount of species overlap was probably due to the widespread movement of the species present on the tallgrass prairie.

Also, the ecotone portion of the transect was not kept separate from the rest of the forest samples and therefore the high overlap could also be from the traps set in the ecotone. Nonetheless, there were nine species that were never caught in the tallgrass prairie and presumably were not present outside the forest. The majority of these are known to be forest specialists according to Aitchison-Benell and Dondale (1992). Since the sampling on the tallgrass prairie was so intensive, I am confident that the forest specialists are indeed forest specialists. As for the pond margin study, comparisons are hard to make due to the great difference in collecting effort. However, the three species that were unique to the pond margin study are probably adapted to wetter habitats. Overall, the tallgrass prairie had a species composition very similar to the surrounding habitats. However, there were species unique to each habitat and some species, most notably *P. distincta*, had different abundances among habitats as well.

For faunal comparisons outside the St. Charles Rifle Range, the closest habitat to compare is be Fort Whyte, Winnipeg, which was thoroughly sampled by Aitchison in the late 1970's and early 1980's (Aitchison 1984a, b). The habitat sampled at Fort Whyte was a wet meadow/aspen forest ecotone with pitfalls set up in both the aspen forest and wet meadow. This ecotone transect would be fairly similar to the habitats sampled in the forest transect study of my project. The species compositions of the spiders from the wet meadow of Fort Whyte and the tallgrass prairie of the St. Charles Rifle Range were fairly similar. Species in common included *Pardosa moesta*, *P. distincta*, *Alopecosa aculeata*, *Centromerus sylvaticus*, *Xysticus ferox* (Hentz), and *Clubiona johnsoni* Gertsch. In total, there were 20 species in common between the two grassland sites. Overall, for all habitats sampled at the St. Charles Rifle Range and Fort Whyte, there were 43 species in

common.

A comparison to the species composition of tallgrass prairies in the United States also yielded some species in common. In Riechert and Reeder's (1972) study of the Oliver and Curtis prairies in Wisconsin, species in shared with this included *Pardosa distincta*, *Haplodrassus signifer* (C.L. Koch), *Schizocosa crassipalpa*, *Hogna frondicola*, *Xysticus discursans* Keyserling, *Xysticus luctans* (C.L. Koch), *Thanatus formicinus* (Clerck), and *Clubiona johnsoni*. In total, the tallgrass prairie at St. Charles Rifle Range and Oliver prairie shared 12 species in common whereas the Curtis prairie and St. Charles Rifle Range tallgrass prairie had eight species in common. The sampling conducted by Riechert and Reeder (1972) was not as intensive as the sampling conducted for this project. Therefore, the low number of species in common maybe due to this difference in sampling intensity. The species that were shared among all the prairie sites are not necessarily habitat specialists but they tended to be more abundant in the tallgrass prairie portion of the forest transect of my study and may, therefore, prefer tallgrass prairie or prairies in general. *Pardosa distincta* in particular was common in both Aitchison's work and Riechert and Reeder's (1972) study but also showed strong preference for the tallgrass prairie portion of the forest transect study. Therefore, it may be a true prairie specialist.

### **Problems associated with experimental design**

Overall, I am very confident that the trends seen in the data reflect reality and that any recommendations I make based on the data will be appropriate. However, there are some issues surrounding the experimental design that could have influenced the results. I

will divide these issues into two subsections: experiment specific issues, and general issues. I will also suggest ways in which these problems could be avoided in future studies.

The main issue associated with the experiment specifically was the apparent sorting bias for bulk samples in the lab. Over the four years, as many as ten different people sorted the bulk samples. This could potentially influence how many spiders were picked and which types of spiders were picked most often. There was a strong bias favouring the larger and adult spiders in the first three years. Evidence comes from two sources. The number of linyphiids was much greater in 2000 (5245 specimens) compared to the first three years (1475 specimens). Coupled with this is the percentage of all adult spiders collected each year. In 1997, 1998, and 1999, the percentage of adults was around 80% but this percentage dropped to 60% in 2000. Linyphiids are an abundant group of spiders in various habitats including grasslands (Bell *et al.* 2001, Bennett 1999). However, linyphiids are small, somewhat cryptic spiders, as are the juveniles of most spiders (Bennett 1999). The lack of an expert present during the first three years and possibly an increased awareness of spiders in 2000 resulted in the apparent bias. The removal of the linyphiid data from the analysis did not alter the overall trends and therefore I am confident that my recommendations are valid. However, certain linyphiid species are pioneer species (Bell *et al.* 2001, Riechert and Reeder 1972) and therefore impacts of fire on these pioneer species may have been underestimated. For future studies, I would recommend keeping all samples separate and appropriately labeled throughout the course of the study. If we had done this, then I would have been able to sort the samples a second time to collect the spiders that were



missed initially.

Another problem associated with the experimental design specifically is that the treatment squares were adjacent to the refuge square. Based on the data from the controls, the spiders in the refuge square were not trapped out. However, there was evidence that the spider population was artificially elevated due to spiders moving into the refuge square during and after the prescribed burns. This is a problem because I am comparing the abundance of the treatment squares to the refuge square so if the refuge is higher than it should be, then the treatment squares might be doing better than the refuge instead of vice versa. If the treatment squares were separated from the refuge square, then this would have been less of a problem. How far to keep the squares apart is not easy to determine because spiders can move considerable distances and habitat heterogeneity also becomes an issue.

The last problem related specifically to the experimental design was the unequal sampling periods per year. This made between year comparisons difficult because the species active early in the year were missed in 1997 due to the late starting date for that year. To avoid this problem, the start date for sampling should be the same for each year so that sampling intensity is identical. The main reason why sampling started so late in 1997 was because the experiment had to be set up. As a result, there was only one pre-burn sampling week in 1997. In hindsight, I would recommend sampling for an entire season prior to the burns being conducted. This way more pre-burn data would be available and any problems associated with the experimental design could be corrected before the treatments were applied.

The main problem associated with our experiment in general is the bias associated with pitfall traps. Pitfall trap samples are known to be biased for many different kinds of arthropods including spiders (Topping and Sunderland 1992). This is because pitfall traps are really measuring the abundance of surface-active organisms, not the absolute abundance. Topping and Sunderland (1992) collected strikingly different numbers of spiders in winter wheat in pitfall traps compared to absolute density sampling. Of particular relevance to my study were those differences seen among the *Pardosa* species. Topping and Sunderland (1992) collected 363 individuals of *Pardosa palustris* (Linnaeus) in pitfall traps but only 4 in absolute density sampling. Overall, 509 individuals of *Pardosa* (4 species) were collected in pitfalls compared to 8 in the absolute density sampling. Similar differences were also observed for some linyphiid species. Based on their results, it is possible that my high numbers of *P. moesta* and *P. distincta* are not an accurate reflection of their absolute abundances in the habitat. Topping and Sunderland (1992) suggested that pitfall traps are fine for within experiment analysis. Topping and Sunderland (1992) also suggested that making broad generalizations based on pitfall traps should be done with caution. Therefore, based on their recommendations, using pitfalls to compare treatments within my experiment is valid but I should not use this data to suggest that *P. moesta* and *P. distincta* are necessarily the two most abundant spiders. I should also not suggest that those two species are the two most important species in the tallgrass prairie at the St. Charles Rifle Range or tallgrass prairie habitat in general.

### **Recommendations to tallgrass prairie managers**

Based on the results of this study, the recommendation to prairie managers is to incorporate all three burn seasons into the management strategy, using a four to five year burn rotation. All three burn treatments had positive results compared to the refuge treatment but each treatment had a slightly different outcome. By incorporating all three burn seasons, the diversity of the entire site will be maximized. Refugia are still required to protect species from the physical effects of fire. Refugia are also needed to ensure species restricted to the tallgrass prairie (e.g. *P. distincta*) and species that prefer "old growth" prairie are not extirpated. The *P. moesta*-dominated community may be eliminated following these recommendations but it was the least stable community and no species was restricted to this treatment, so the ecological significance of its loss would be minimal. The spider communities should be monitored using pitfall traps to determine the long term effects of burn management. These recommendations are in line with the recommendations based on the plant and ground beetle data proposed by Sveinson (2001) and Roughley (2001), respectively. A detailed burn management strategy for the St. Charles Rifle Range was developed by Roughley (2001) (see Appendix 6) and is fully supported by this study.

In terms of the practical application of the proposed burn management strategy, it would be no different than current management practices. Current management practices are predominately annual spring burns but our management strategy would be only one burn a year but at different times of the year. Therefore, the total number of burns does not change. In terms of the monitoring, pitfall traps are recommended because they are the least labour intensive sampling technique. Ideally, more thorough sampling would be

conducted but at a minimum, pitfall trapping should be done. The monitoring of *P. distincta* and *P. moesta* would be simple as the two species are easy to distinguish from each other and from other lycosids. The management strategy proposed by Roughley (2001) (Appendix 6) will not require any additional labour or costs compared to the current management strategy and therefore is practical to implement.

### **Future studies for tallgrass prairie research**

Future studies are needed to examine factors that were not examined in this study but that are relevant when these recommendations are implemented on a larger scale. The first issue is the effect of burn size on recolonization rates. Our study plots were 50 meters by 50 meters, which is relatively small compared to normal burn areas, which normally cover hectares. If the burn area is increased, this will presumably reduce how quickly spider populations can recover following a fire. A larger burn area will also presumably result in the more rapidly colonizing species invading first which will be more noticeable because this effect will not be diluted which was probably the case in this study.

The second issue is the specific timing of the burns. Our burns were conducted on 6 June, 5 August, and 9 September for the spring, summer, and fall burns, respectively. The spring burn of this study was relatively late for a spring burn compared to other studies. Therefore, the impact on the spider community was presumably high because many species were active during this time period. Spiders are active all year round, even in Manitoba (Aitchison 1984a), so there will never be an ideal time to conduct the burns but avoiding the peak abundance periods would be best. Therefore,

conducting spring burns earlier in the year would be best because relatively fewer spiders are active. As for the summer and fall burns, they were relatively close together in this study (4 weeks apart) during a relatively low activity period for spiders based on pitfall trap catches. This helps explain why the summer and fall burns responded similarly in terms of the community structure. Based on the activity periods of the two most dominant species, a fire anytime in July or later will result in *P. distincta* becoming the dominant species. The timing of the summer and fall burns in this study were coincidentally an optimum time in relation to spider activity. However, a wider separation in the timing of the two burn treatments would presumably result in more disjunctive outcomes and greater community diversity.

The last two issues deal with fire frequency and fire rotation sequence. In this study, the spider populations in any of the burn treatments had not returned to the population levels of the refuge treatment. Therefore, a fire rotation of at least four to five years is recommended. Many spider species in Manitoba have two year life cycles (Aitchison 1984a) and therefore annual burns, which are commonly used today, would be detrimental to the spider community. The fire rotation issue is whether or not to use the same burn season repeatedly on the same section of prairie. The alternative is use a rotation system in which a spring burn could be followed by a summer or fall burn. Presumably, the greater diversity in burn season sequence would maintain higher species diversity and a more resilient spider community. A rotation sequence would result in the *P. distincta* dominated community becoming the only spider community type in the tallgrass prairie region of the St. Charles Rifle Range.

## Synthesis

The decision on when to burn tallgrass prairie is an important but complex problem. Any type of disturbance will negatively affect an organism, at least in the short term and therefore management decisions have to be made based on what is the best overall. The results of this study in combination with the plant and ground beetle analyses point towards all three burn seasons being appropriate for tallgrass prairie management. Burning the tallgrass prairie was definitely better than not burning but which burn season was best was not as straightforward. For the spiders, it appears summer or fall is the best burn season. However, once the spider community shifts to the *P. distincta*-dominated community, the results for spring burns might change. The most important aspect to keep in mind is that no burn treatment had a negative long term effect on any of the taxa examined. Therefore, any burn treatment could be used without negatively affecting any particular taxa. The burn management strategy proposed by Roughley (2001) is supported by three different researchers, examining three different groups of taxa, each with its own ecological requirements. Therefore, the management strategy is a consensus-based strategy and should be fully implemented to manage the St. Charles Rifle Range effectively. This management strategy is practical and is no more expensive to implement than current management techniques used on other tallgrass prairie sites. Long term monitoring will ensure that this proposed management strategy is indeed the most beneficial to tallgrass prairie and that tallgrass prairie is maintained forever.

### SUMMARY

1. The burned treatments were ecologically better than the unburned treatment.
2. Overall, the summer and fall burns were better than the spring burn.
3. The *P. distincta*-dominated community was the most stable spider community.
4. 126 spider species were collected from the tallgrass prairie including eight new provincial records.
5. Prairie managers should use a mosaic of all three burn seasons, following a four to five year burn cycle as outlined by Roughley (2001) (Appendix 6).
6. Further studies are needed to determine the optimal time to burn for each season and the effect of burn size and frequency.
7. Monitoring of spider populations, particularly *P. distincta* and *P. moesta*, via pitfall traps should be conducted on a regular basis.

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Appendix 1. Abundance of adult spiders per block per burn season treatment for species collected in tallgrass prairie at the St. Charles Rifle Range in 2000. See Fig. 3 for location of blocks.

Species	Spring					Summer					Fall					Refuge					Grand Total
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	
<i>Acanthepeira stellata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Agelenopsis actuosa</i>	0	1	1	2	4	2	0	0	1	3	0	0	0	1	1	2	0	0	1	3	11
<i>Agroeca ornata</i>	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
<i>Agroeca pratensis</i>	13	13	4	8	38	7	5	1	9	22	6	0	1	5	12	16	31	18	28	93	165
<i>Agyneta allosubtilis</i>	2	0	0	0	2	1	0	0	0	1	0	0	0	1	1	0	1	0	0	1	5
<i>Allomengea dentisetis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Alopecosa aculeata</i>	10	29	14	18	71	29	18	11	27	85	35	20	15	28	98	15	27	11	29	82	336
<i>Araneus trifolium</i>	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	2
<i>Arctosa emertoni</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1
<i>Arctosa raptor</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Arctosa rubicunda</i>	15	18	1	13	47	47	4	0	23	74	40	11	3	19	73	32	6	2	10	50	244
<i>Argenna obesa</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Argiope trifasciata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bassaniana utahensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bathypantes canadensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1
<i>Bathypantes pallidus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Castianeira descripta</i>	1	0	1	0	2	1	1	0	2	4	1	0	0	1	2	1	0	0	1	2	10
<i>Castianeira longipalpa</i>	0	0	1	1	2	2	0	2	6	10	1	1	0	1	3	0	0	0	0	0	15
<i>Centromerus sylvaticus</i>	2	0	0	0	2	0	0	0	0	0	1	0	0	3	4	0	3	0	1	4	10
<i>Ceraticelus fissiceps</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1
<i>Ceraticelus laetus</i>	1	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	4
<i>Ceraticelus laticeps</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceratinella brunnea</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1
<i>Cicurina arcuata</i>	1	1	2	1	5	0	0	2	2	4	1	2	0	1	4	3	6	0	0	9	22
<i>Clubiona abboti</i>	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Clubiona johnsoni</i>	2	1	5	1	9	3	2	6	0	11	4	0	2	1	7	2	2	5	2	11	38
<i>Clubiona moesta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Collinsia plumosa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dictyna foliacea</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1
<i>Dolomedes striatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dolomedes triton</i>	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1
<i>Drassyllus depressus</i>	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	0	0	1	1	3
<i>Drassyllus niger</i>	0	0	0	0	0	5	2	1	0	8	0	0	0	0	0	1	1	1	1	4	12
<i>Ebo iviei</i>	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	1
<i>Enoplognatha marmorata</i>	1	1	6	3	11	1	4	5	6	16	0	6	2	2	10	0	8	0	5	13	50
<i>Eperigone trilobata</i>	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	0	0	1	2
<i>Eridantes utibilis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Erigone atra</i>	0	0	0	0	0	0	1	0	0	1	0	0	2	0	2	0	0	0	0	0	3
<i>Erigone blaesa</i>	0	0	0	0	0	0	0	10	4	14	0	0	1	0	1	0	0	0	0	0	15
<i>Ero canionis</i>	2	1	0	1	4	0	0	0	0	0	0	0	0	0	0	1	0	0	1	2	6
<i>Euryopsis funebris</i>	0	1	4	6	11	0	6	3	13	22	0	6	0	18	24	1	2	1	16	20	77
<i>Euryopsis gertschi</i>	0	1	0	0	1	0	2	0	0	2	1	2	0	0	3	1	0	1	0	2	8
<i>Euryopsis saukea</i>	0	0	0	2	2	0	0	0	2	2	0	0	0	4	4	0	0	0	1	1	9

Appendix 1. cont'd

Species	Spring					Summer					Fall					Refuge					Grand Total
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	
<i>Evarcha hoyi</i>	0	2	1	2	5	1	3	0	1	5	0	0	1	0	1	0	1	1	0	2	13
<i>Gnaphosa parvula</i>	4	0	3	1	8	3	1	2	0	6	0	5	0	1	6	4	1	5	5	15	35
<i>Gonatium crassipalpm</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Goneatara nasutus</i>	0	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0	3	5
<i>Grammonota angusta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Grammonota ornata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
<i>Grammonota pictilis</i>	1	0	1	0	2	0	0	0	0	0	0	0	3	0	3	0	3	0	1	4	9
<i>Habronattus decorus</i>	0	4	2	1	7	2	0	0	0	2	0	1	1	0	2	0	0	1	1	2	13
<i>Hahnia cinerea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	2
<i>Haplodrassus hiemalis</i>	3	0	2	1	6	1	0	2	0	3	1	0	0	0	1	0	3	3	4	10	20
<i>Haplodrassus signifer</i>	0	1	0	1	2	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	4
<i>Hogna frondicola</i>	6	20	11	5	42	6	11	0	26	43	5	9	4	23	41	5	9	3	16	33	159
<i>Hypsosinga pygmaea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Islandiana flaveola</i>	0	0	0	0	0	0	0	0	0	0	1	1	1	2	5	0	0	0	0	0	5
<i>Islandiana longisetosa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Islandiana princeps</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Kaestneria pullata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micaria gertschi</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0	1	2
<i>Micaria pulicaria</i>	0	0	0	0	0	1	0	0	1	2	0	0	0	0	0	0	0	0	0	0	2
<i>Micaria rossica</i>	1	0	8	0	9	0	0	1	0	1	0	5	2	0	7	0	1	2	0	3	20
<i>Mimetus epeiroides</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	2
<i>Neoantistea magna</i>	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
<i>Neoscona arabesca</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Neriene clathrata</i>	1	0	0	1	2	2	0	0	0	2	0	1	0	1	2	0	0	0	0	0	6
<i>Neriene radiata</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2	0	0	2	3
<i>Ozyptila conspurcata</i>	14	34	35	14	97	24	15	17	12	68	22	44	22	13	101	18	12	19	7	56	322
<i>Pachygnatha dorothea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pachygnatha tristriata</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
<i>Pachygnatha xanthostoma</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pardosa distincta</i>	35	112	107	93	347	59	71	81	209	420	77	68	81	241	467	119	74	95	182	470	1704
<i>Pardosa dromaea</i>	1	0	0	1	2	0	1	0	0	1	0	0	0	0	0	0	1	0	0	1	4
<i>Pardosa fuscula</i>	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	3
<i>Pardosa modica</i>	4	1	0	4	9	0	3	0	1	4	0	1	0	1	2	0	1	1	3	5	20
<i>Pardosa moesta</i>	388	116	42	50	596	338	260	192	69	859	334	229	178	70	811	558	459	278	275	1570	3836
<i>Pardosa ontariensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pardosa xerampelina</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pelecopsis mengei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pelegrina insignis</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	1
<i>Phidippus whitmani</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Philodromus histrio</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	1	2
<i>Phrurotimpus borealis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pirata insularis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pirata minutus</i>	0	0	0	0	0	3	3	4	1	11	1	1	0	1	3	4	3	1	0	8	22
<i>Pirata piraticus</i>	2	1	0	0	3	0	0	1	1	2	0	0	2	0	2	3	0	0	1	4	11

Appendix 1. cont'd

Species	Spring					Summer					Fall					Refuge					Grand Total
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	
<i>Pocadicnemis americana</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Salticus scenicus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schizocosa crassipalpa</i>	0	1	1	2	4	1	0	0	0	1	0	2	1	1	4	0	0	0	6	6	15
<i>Schizocosa retrorsa</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1
<i>Scotinella pugnata</i>	2	0	0	0	2	0	1	0	0	1	0	0	0	3	3	1	0	0	0	1	7
<i>Sergiolus decoratus</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1
<i>Sergiolus ocellatus</i>	1	0	0	0	1	0	2	0	1	3	0	2	0	0	2	1	0	0	0	1	7
<i>Singa keyserlingi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sitticus striatus</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1
<i>Steatoda americana</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	0	0	1
<i>Stemonyphantes blauveltae</i>	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	0	1	0	1	3
<i>Talavera minuta</i>	0	0	1	1	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	3
<i>Tapinocyba minuta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2
<i>Tetragnatha laboriosa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Thanatus coloradensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Thanatus rubicellus</i>	0	0	1	0	1	0	0	1	0	1	0	0	0	1	1	1	0	0	2	3	6
<i>Thanatus striatus</i>	13	5	17	18	53	11	10	13	11	45	2	15	13	8	38	11	9	14	11	45	181
<i>Thantus formicinus</i>	0	0	0	2	2	1	0	0	3	4	0	1	1	2	4	0	0	0	3	3	13
<i>Tibellus maritimus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tibellus oblongus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
<i>Trochosa terricola</i>	11	4	4	3	22	3	2	3	1	9	3	2	2	0	7	7	6	7	6	26	64
<i>Tutelina similis</i>	0	0	0	0	0	0	0	0	4	4	0	1	0	1	2	0	0	0	0	0	6
<i>Walckenaeria directa</i>	0	0	1	0	1	0	0	0	1	1	1	0	0	1	2	0	0	0	0	0	4
<i>Walckenaeria exigua</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Walckenaeria palustris</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
<i>Walckenaeria pinocchio</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Walckenaeria spiralis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Walckenaeria tibialis</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	3	4	0	0	0	1	1	5
<i>Xysticus ampullatus</i>	8	31	24	4	67	51	22	29	36	138	35	38	30	31	134	24	15	19	11	69	408
<i>Xysticus discursans</i>	3	3	1	0	7	1	0	4	0	5	0	2	3	0	5	2	0	0	1	3	20
<i>Xysticus emertoni</i>	0	0	2	1	3	3	1	1	2	7	1	2	2	4	9	2	2	4	6	14	33
<i>Xysticus ferox</i>	5	1	5	3	14	7	4	5	13	29	7	7	9	21	44	6	6	6	17	35	122
<i>Xysticus luctans</i>	1	1	1	5	8	9	2	1	6	18	4	0	0	8	12	3	2	1	5	11	49
<i>Xysticus pellax</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1
<i>Xysticus triguttatus</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1
<i>Xysticus winnipegensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Zelotes fratris</i>	36	9	25	4	74	6	21	22	11	60	9	20	22	11	62	22	33	34	18	107	303
<i>Zelotes lasalanus</i>	0	0	0	0	0	0	0	1	0	1	3	0	0	0	3	0	0	0	0	0	4
<i>Zelotes sula</i>	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	2
<b>Total</b>	<b>595</b>	<b>418</b>	<b>335</b>	<b>276</b>	<b>1624</b>	<b>632</b>	<b>484</b>	<b>430</b>	<b>510</b>	<b>2056</b>	<b>597</b>	<b>509</b>	<b>408</b>	<b>534</b>	<b>2048</b>	<b>869</b>	<b>736</b>	<b>539</b>	<b>684</b>	<b>2828</b>	<b>8556</b>

Appendix 2. Abundance of adult spiders per block per burn season treatment for species collected in tallgrass prairie at the St. Charles Rifle Range in 2000. See Fig. 3 for location of blocks.

Species	Spring					Summer					Fall					Refuge					Control			Grand Total
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	X	Y	Total	
<i>Acanthepeira stellata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Agelenopsis actuosa</i>	1	0	0	2	3	2	0	0	0	2	0	2	1	5	8	0	0	1	0	1	1	2	3	17
<i>Agroeca ornata</i>	1	2	1	0	4	1	2	1	0	4	7	2	3	2	14	1	8	3	0	12	0	0	0	34
<i>Agroeca pratensis</i>	17	8	6	17	48	19	12	6	8	45	9	7	8	4	28	12	16	7	13	48	6	12	18	187
<i>Agyneta allosubtilis</i>	0	1	0	0	1	0	1	1	0	2	0	0	0	0	0	1	0	1	0	2	0	0	0	5
<i>Allomengea dentisetis</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	2	0	0	2	0	0	0	3
<i>Alopecosa aculeata</i>	44	54	80	33	211	18	20	9	16	63	22	8	12	20	62	55	87	81	89	312	30	67	97	745
<i>Araneus trifolium</i>	1	0	0	1	2	0	0	1	1	2	0	0	0	0	0	0	0	1	1	2	1	0	1	7
<i>Arctosa emertoni</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Arctosa raptor</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Arctosa rubicunda</i>	3	4	0	6	13	15	2	0	4	21	20	5	1	2	28	6	2	0	2	10	0	1	1	73
<i>Argenna obesa</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	3
<i>Argiope trifasciata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1
<i>Bassantiana utahensis</i>	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Bathyphanes canadensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bathyphanes pallidus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Castianeira descripta</i>	1	0	0	0	1	3	0	2	4	9	2	1	0	0	3	1	0	0	3	4	1	1	2	19
<i>Castianeira longipalpa</i>	1	3	8	2	14	5	1	5	2	13	6	9	3	2	20	0	2	6	0	8	2	2	4	59
<i>Centromerus sylvaticus</i>	10	19	2	6	37	8	11	4	2	25	7	0	1	1	9	6	25	5	4	40	6	1	7	118
<i>Ceraticelus fissiceps</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceraticelus laetus</i>	1	1	1	1	4	0	0	0	2	2	1	0	0	0	1	2	0	1	2	5	0	0	0	12
<i>Ceraticelus laticeps</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceratinella brunnea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Cicurina arcuata</i>	6	3	1	0	10	2	5	3	1	11	2	9	5	2	18	4	3	0	1	8	1	1	2	49
<i>Clubiona abboti</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Clubiona johnsoni</i>	2	2	1	0	5	1	3	2	1	7	3	0	2	0	5	2	2	0	1	5	3	1	4	26
<i>Clubiona moesta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Collinsia plumosa</i>	0	1	6	1	8	1	1	3	2	7	0	0	4	0	4	0	1	2	1	4	0	1	1	24
<i>Dictyna foliacea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dolomedes striatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1
<i>Dolomedes triton</i>	0	0	0	0	0	0	1	0	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	2
<i>Drassyllus depressus</i>	0	0	0	3	3	1	1	0	1	3	0	1	0	0	1	0	0	0	0	0	0	0	0	7
<i>Drassyllus niger</i>	0	3	0	1	4	0	3	0	0	3	2	0	0	0	2	4	3	1	1	9	0	3	3	21
<i>Ebo iviei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Enoplognatha marmorata</i>	2	1	2	8	13	0	13	12	12	37	2	6	1	1	10	2	1	1	0	4	0	2	2	66
<i>Eperigone trilobata</i>	0	0	1	0	1	0	0	0	0	0	3	0	0	0	3	0	0	0	0	0	0	0	0	4
<i>Eridantes utibilis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Erigone atra</i>	0	1	0	0	1	0	2	2	0	4	0	0	0	0	0	0	0	1	0	1	0	0	0	6
<i>Erigone blaesae</i>	0	0	0	0	0	2	1	0	0	3	0	0	2	0	2	0	0	0	0	0	0	0	0	5
<i>Ero canionis</i>	10	0	3	0	13	2	0	2	0	4	3	2	0	1	6	14	7	5	2	28	3	1	4	55
<i>Euryopsis gertschi</i>	2	0	0	0	2	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	2	1	3	6
<i>Euryopsis funebris</i>	1	2	3	1	7	0	2	3	1	6	0	0	3	2	5	1	4	0	0	5	0	0	0	23
<i>Euryopsis saukeyae</i>	1	0	0	0	1	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	3

Appendix 2. cont'd

Species	Spring					Summer					Fall					Refuge					Control			Grand Total
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	X	Y	Total	
<i>Evarcha hoyi</i>	2	2	3	1	8	0	0	1	6	7	2	3	6	5	16	0	0	5	2	7	1	8	9	47
<i>Gnaphosa parvula</i>	4	0	3	7	14	1	1	6	1	9	1	0	1	0	2	9	6	23	15	53	5	8	13	91
<i>Gonatium crassipalpus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Goneatara nasutus</i>	7	18	2	0	27	2	1	0	0	3	2	0	0	0	2	6	3	3	0	12	0	4	4	48
<i>Grammonota angusta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Grammonota ornata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Grammonota pictilis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Habronattus decorus</i>	1	0	4	2	7	0	3	1	1	5	1	6	5	6	18	5	1	0	2	8	1	0	1	39
<i>Hahnina cinerea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Haplodrassus hiemalis</i>	2	0	5	0	7	0	0	3	0	3	0	0	0	1	1	6	6	12	3	27	7	12	19	57
<i>Haplodrassus signifer</i>	1	0	1	0	2	3	4	3	1	11	1	6	0	2	9	1	0	2	1	4	0	0	0	26
<i>Hogna frondicola</i>	9	73	66	24	172	83	62	22	52	219	97	64	39	43	243	30	33	37	36	136	11	6	17	787
<i>Hypososinga pygmaea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Islandiana flaveola</i>	4	3	0	2	9	0	0	2	1	3	1	0	0	1	2	0	0	0	3	3	0	0	0	17
<i>Islandiana longisetosa</i>	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Islandiana princeps</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Kaestneria pullata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micaria gertschi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micaria pulicaria</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micaria rossica</i>	0	3	0	0	3	0	7	12	1	20	0	2	3	0	5	0	1	1	0	2	3	0	3	33
<i>Mimetus epeiroides</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	1	0	1	0	0	0	2
<i>Neoantistea magna</i>	0	0	0	0	0	0	1	0	1	2	0	0	0	0	0	1	0	0	1	2	0	1	1	5
<i>Neoscona arabesca</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	1	0	0	1	0	0	0	2
<i>Neriene clathrata</i>	1	1	0	1	3	0	0	0	0	0	2	1	0	0	3	2	2	1	0	5	0	0	0	11
<i>Neriene radiata</i>	0	2	1	0	3	0	0	0	0	0	1	0	0	0	1	1	2	3	0	6	0	0	0	10
<i>Ozyptila conspurcata</i>	2	11	11	0	24	4	3	0	2	9	4	6	1	3	14	10	7	10	5	32	8	7	15	94
<i>Pachygnatha dorothea</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Pachygnatha tristriata</i>	3	8	1	0	12	2	3	1	1	7	3	1	0	1	5	3	11	1	1	16	4	1	5	45
<i>Pachygnatha xanthostoma</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Pardosa distincta</i>	61	139	175	93	468	192	142	115	156	605	153	130	155	109	547	255	176	185	196	812	101	236	337	2769
<i>Pardosa dromaea</i>	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	1	0	1	0	0	0	3
<i>Pardosa fuscula</i>	0	0	0	0	0	0	1	0	0	1	1	0	0	1	2	0	1	0	0	1	1	0	1	5
<i>Pardosa modica</i>	50	4	4	31	89	2	0	7	2	11	2	5	3	0	10	10	36	23	16	85	7	4	11	206
<i>Pardosa moesta</i>	486	514	373	127	1500	70	90	58	20	238	58	39	24	7	128	608	1172	322	273	2375	233	172	405	4646
<i>Pardosa ontariensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
<i>Pardosa xerampelina</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pelecopsis mengei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pelegrina insignis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	1
<i>Phidippus whitmani</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	1	1	0	0	2	0	1	1	6
<i>Philodromus histrio</i>	0	0	4	0	4	4	2	0	1	7	1	2	2	2	7	0	1	0	1	2	0	0	0	20
<i>Phrurotimpus borealis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pirata insularis</i>	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	1	0	0	1	0	0	0	3
<i>Pirata minutus</i>	9	12	5	2	28	5	5	1	0	11	1	1	0	0	2	4	3	5	10	22	2	0	2	65
<i>Pirata piraticus</i>	0	0	1	0	1	1	1	0	1	3	0	2	1	0	3	0	2	3	2	7	1	0	1	15



Appendix 2. cont'd

Species	Spring					Summer					Fall					Refuge					Control			Grand Total
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	X	Y	Total	
<i>Pocadicnemis americana</i>	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Salticus scenicus</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Schizocosa crassipalpa</i>	3	2	0	3	8	1	0	1	0	2	2	0	0	1	3	2	3	0	18	23	1	5	6	42
<i>Schizocosa retrorsa</i>	0	0	0	0	0	0	0	0	0	0	0	1	1	4	6	0	0	0	1	1	0	0	0	7
<i>Scotinella pugnata</i>	0	2	1	0	3	1	0	0	0	1	0	1	1	2	4	2	1	1	0	4	0	0	0	12
<i>Sergiolus decoratus</i>	0	0	0	1	1	1	3	6	0	10	1	2	1	0	4	0	0	0	0	0	0	0	0	15
<i>Sergiolus ocellatus</i>	0	2	1	0	3	0	1	0	0	1	1	1	1	0	3	1	0	0	0	1	0	0	0	8
<i>Singa keyserlingi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Sitticus striatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
<i>Steatoda americana</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Stemonyphantes blauveltae</i>	1	0	1	0	2	0	0	0	0	0	1	1	1	0	3	0	0	1	0	1	0	0	0	6
<i>Talavera minuta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tapinocyba minuta</i>	2	1	1	0	4	1	0	1	0	2	3	0	0	2	5	0	1	0	0	1	2	0	2	14
<i>Tetragnatha laboriosa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Thanatus coloradensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Thanatus formicinus</i>	3	8	4	7	22	5	5	1	8	19	2	7	3	9	21	3	7	9	15	34	2	5	7	103
<i>Thanatus rubicellus</i>	0	1	2	2	5	0	1	0	5	6	1	0	0	4	5	2	4	1	2	9	0	11	11	36
<i>Thanatus striatus</i>	14	17	17	10	58	13	18	17	18	66	20	15	7	2	44	26	19	18	7	70	8	17	25	263
<i>Tibellus maritimus</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Tibellus oblongus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Trochosa terricola</i>	58	17	28	1	104	1	5	2	0	8	4	5	3	3	15	5	21	26	15	67	7	2	9	203
<i>Tutelina similis</i>	0	0	0	0	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	2
<i>Walckenaeria directa</i>	0	1	0	2	3	2	0	0	0	2	0	0	0	0	0	0	0	1	0	1	0	1	1	7
<i>Walckenaeria exigua</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1
<i>Walckenaeria palustris</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	0	0	0	2
<i>Walckenaeria pinocchio</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Walckenaeria spiralis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Walckenaeria tibialis</i>	0	0	5	0	5	0	0	1	0	1	0	1	0	0	1	0	0	0	0	0	0	0	0	7
<i>Xysticus ampullatus</i>	4	17	16	4	41	12	17	11	10	50	29	21	12	11	73	10	16	22	3	51	13	12	25	240
<i>Xysticus discursans</i>	0	1	3	3	7	0	1	3	1	5	2	1	4	1	8	1	1	3	0	5	0	0	0	25
<i>Xysticus emertoni</i>	4	4	27	0	35	3	3	3	1	10	0	0	0	2	2	3	14	32	10	59	21	31	52	158
<i>Xysticus ferox</i>	5	21	26	22	74	8	13	8	22	51	13	4	27	30	74	9	38	35	31	113	14	31	45	357
<i>Xysticus luctans</i>	1	0	3	1	5	6	3	3	6	18	5	3	1	3	12	3	5	2	3	13	2	5	7	55
<i>Xysticus pellax</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Xysticus triguttatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Xysticus winnipegensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Zelotes fratris</i>	33	18	42	12	105	6	16	7	7	36	7	11	10	9	37	28	43	49	39	159	40	41	81	418
<i>Zelotes lasalanus</i>	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Zelotes sula</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Totals</b>	<b>878</b>	<b>1007</b>	<b>952</b>	<b>441</b>	<b>3278</b>	<b>511</b>	<b>494</b>	<b>354</b>	<b>384</b>	<b>1743</b>	<b>515</b>	<b>397</b>	<b>359</b>	<b>311</b>	<b>1582</b>	<b>1161</b>	<b>1805</b>	<b>955</b>	<b>833</b>	<b>4754</b>	<b>551</b>	<b>717</b>	<b>1268</b>	<b>12625</b>

Appendix 3. Abundance of adult spiders per block per burn season treatment for species collected in tallgrass prairie at the St. Charles Rifle Range in 2000. See Fig. 3 for location of blocks.

Species	Spring					Summer					Fall					Refuge					Control			Grand Total
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	X	Y	Total	
<i>Acanthepeira stellata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	1
<i>Agelenopsis actuosa</i>	0	0	0	3	3	0	0	2	1	3	0	1	1	0	2	1	2	1	2	6	0	3	3	17
<i>Agroeca ornata</i>	6	3	5	0	14	0	4	1	2	7	2	0	11	1	14	8	4	9	0	21	2	1	3	59
<i>Agroeca pratensis</i>	72	104	58	28	262	73	60	33	30	196	68	68	17	21	174	68	165	87	60	380	73	84	157	1169
<i>Agyneta allosubtilis</i>	1	1	0	1	3	1	0	1	0	2	2	1	5	0	8	0	4	0	0	4	0	0	0	17
<i>Allomengea dentisetis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Alopecosa aculeata</i>	50	61	62	30	203	37	44	30	19	130	44	21	15	13	93	36	43	59	60	198	55	88	143	767
<i>Araneus trifolium</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1
<i>Arctosa emertoni</i>	0	0	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Arctosa raptor</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2	0	0	0	2
<i>Arctosa rubicunda</i>	2	1	0	8	11	13	3	1	6	23	7	2	2	9	20	3	2	2	7	14	1	4	5	73
<i>Argenna obesa</i>	8	1	0	0	9	0	0	0	0	0	1	0	0	0	1	1	3	2	2	8	1	0	1	19
<i>Argiope trifasciata</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	2
<i>Bassianiana utahensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bathypantes canadensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bathypantes pallidus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Castianeira descripta</i>	0	0	1	0	1	0	0	0	3	3	2	2	0	2	6	1	0	0	2	3	0	1	1	14
<i>Castianeira longipalpa</i>	4	8	9	8	29	8	3	1	4	16	5	10	0	9	24	5	9	6	6	26	5	5	10	105
<i>Centromerus sylvaticus</i>	2	2	0	1	5	6	6	0	2	14	0	5	0	1	6	2	19	5	1	27	3	2	5	57
<i>Ceraticelus fissiceps</i>	1	0	5	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6
<i>Ceraticelus laetus</i>	7	4	5	1	17	1	0	0	0	1	5	1	0	0	6	11	2	2	1	16	0	0	0	40
<i>Ceraticelus laticeps</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ceratinella brunnea</i>	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Cicurina arcuata</i>	7	18	2	3	30	6	12	6	14	38	4	34	7	7	52	7	8	3	7	25	7	5	12	157
<i>Clubiona abboti</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Clubiona johnsoni</i>	3	1	5	1	10	2	1	2	0	5	6	3	0	1	10	1	1	3	1	6	2	3	5	36
<i>Clubiona moesta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Collinsia plumosa</i>	0	1	1	1	3	2	0	4	0	6	0	0	1	0	1	0	0	0	0	0	0	0	0	10
<i>Dictyna foliacea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1
<i>Dolomedes striatus</i>	0	0	0	1	1	0	0	1	1	2	0	0	0	1	1	0	0	0	0	0	0	0	0	4
<i>Dolomedes triton</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Drassyllus depressus</i>	0	0	0	2	2	0	1	2	1	4	0	1	0	0	1	0	1	1	2	3	0	2	2	12
<i>Drassyllus niger</i>	1	2	2	0	5	3	6	2	0	11	0	2	0	0	2	0	0	0	0	0	0	2	2	20
<i>Ebo iviei</i>	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2
<i>Enoplognatha marmorata</i>	10	4	3	15	32	7	17	18	15	57	24	20	11	16	71	7	2	3	0	12	0	7	7	179
<i>Eperigone trilobata</i>	1	4	1	0	6	1	0	1	2	4	2	2	1	0	5	1	2	0	0	3	0	1	1	19
<i>Eridantes utibilis</i>	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Erigone atra</i>	0	0	0	0	0	1	0	0	0	1	0	1	1	0	2	0	0	0	0	0	0	0	0	3
<i>Erigone blaesae</i>	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	2
<i>Ero canionis</i>	3	1	3	1	8	1	0	0	2	3	1	1	0	1	3	0	1	0	2	3	1	0	1	18
<i>Euryopsis fumebris</i>	12	14	22	5	53	11	3	11	0	25	13	7	10	4	34	4	10	15	5	34	18	6	24	170
<i>Euryopsis gertschi</i>	5	1	1	4	11	0	0	0	0	0	0	0	0	1	1	3	3	1	0	7	0	5	5	24
<i>Euryopsis saukeya</i>	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	4	4	7

Appendix 3. cont'd

Species	Spring				Summer					Fall					Refuge					Control			Grand Total	
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	X	Y		Total
<i>Evarcha hoyi</i>	2	2	0	0	4	1	0	0	1	2	1	0	0	0	1	0	0	0	2	2	1	2	3	12
<i>Gnaphosa parvula</i>	11	8	5	2	26	0	1	6	2	9	2	2	1	1	6	11	11	8	3	33	8	3	11	85
<i>Gonatium crassipalpus</i>	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2	0	0	0	0	0	0	0	0	2
<i>Goneatara nasutus</i>	2	6	2	6	16	2	6	4	12	24	4	8	5	15	32	1	7	1	10	19	3	3	6	97
<i>Grammonota angusta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Grammonota ornata</i>	0	1	0	1	2	0	0	1	2	3	0	0	0	0	0	0	0	1	0	1	0	0	0	6
<i>Grammonota pictilis</i>	9	5	1	0	15	0	0	2	0	2	1	2	3	0	6	1	1	2	1	5	2	5	7	35
<i>Habronattus decorus</i>	1	2	0	0	3	1	0	1	1	3	1	2	0	1	4	0	0	1	2	3	1	0	1	14
<i>Hahnia cinerea</i>	2	1	0	0	3	1	0	0	0	1	0	0	0	0	0	1	0	1	0	2	0	0	0	6
<i>Haplodrassus hiemalis</i>	6	3	6	1	16	3	2	2	0	7	2	1	0	0	3	6	6	1	3	2	11	2	13	41
<i>Haplodrassus signifer</i>	1	0	0	1	2	1	3	0	0	4	1	3	1	0	5	0	1	0	0	1	0	0	0	12
<i>Hogna frondicola</i>	16	30	31	11	88	27	10	25	19	81	28	24	21	19	92	17	20	24	16	77	16	7	23	361
<i>Hypsosinga pygmaea</i>	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Islandiana flaveola</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1	1	0	0	0	2
<i>Islandiana longisetosa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Islandiana princeps</i>	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	1	2
<i>Kaestneria pullata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micaria gertschi</i>	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3	0	0	0	0	0	0	0	0	3
<i>Micaria pulicaria</i>	1	0	0	0	1	0	1	1	0	2	0	0	0	0	0	0	1	4	0	5	1	0	1	9
<i>Micaria rossica</i>	0	0	0	1	1	1	2	2	3	8	1	8	4	0	13	0	0	1	0	1	0	1	1	24
<i>Mimetus epeiroides</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
<i>Neoantistea magna</i>	0	0	0	0	0	0	1	0	0	1	1	0	1	0	2	1	0	1	0	2	2	0	2	7
<i>Neoscona arabesca</i>	1	0	0	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2
<i>Neriene clathrata</i>	6	12	2	0	20	2	3	1	1	7	3	1	0	0	4	3	7	1	0	11	2	0	2	44
<i>Neriene radiata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Ozyptila conspurcata</i>	16	27	14	3	60	8	1	4	3	16	14	25	11	2	52	36	20	13	11	80	24	19	43	251
<i>Pachygnatha dorothea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pachygnatha tristriata</i>	4	9	6	0	19	6	11	5	1	23	8	3	1	2	14	2	6	6	2	16	2	1	3	75
<i>Pachygnatha xanthostoma</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	0	0	1	0	0	0	2
<i>Pardosa distincta</i>	111	166	215	128	620	212	222	277	214	925	184	238	203	209	834	171	146	164	232	713	120	299	419	3511
<i>Pardosa dromaea</i>	0	0	0	0	0	0	0	0	0	0	0	0	2	1	3	0	0	0	0	0	0	0	0	3
<i>Pardosa fuscula</i>	2	0	0	0	2	1	2	0	0	3	0	0	2	0	2	0	0	2	0	2	0	0	0	9
<i>Pardosa modica</i>	22	7	10	17	56	2	16	29	0	47	1	2	4	4	11	11	18	26	9	64	29	1	30	208
<i>Pardosa moesta</i>	428	374	284	104	1190	190	175	156	20	541	163	157	69	59	448	350	640	298	219	1507	298	181	479	4165
<i>Pardosa ontariensis</i>	1	0	0	0	1	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	2
<i>Pardosa xerampelina</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pelecopsis mengei</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1	0	1	0	2	0	0	0	3
<i>Pelegrina insignis</i>	0	0	1	0	1	0	1	0	0	1	1	0	0	0	1	0	1	0	0	1	0	0	0	4
<i>Phidippus whitmani</i>	0	0	1	0	1	0	0	1	0	1	1	0	0	0	1	1	0	0	1	2	0	1	1	6
<i>Philodromus histrio</i>	1	0	1	3	5	0	1	0	3	4	1	0	0	2	3	1	0	0	1	2	0	0	0	14
<i>Phrurotimpus borealis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pirata insularis</i>	1	0	0	0	1	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	3
<i>Pirata minutus</i>	4	21	6	22	53	19	24	36	6	85	3	13	17	3	36	4	19	7	24	54	8	5	13	241
<i>Pirata piraticus</i>	2	0	0	2	4	0	0	0	1	1	0	0	5	0	5	0	1	0	0	1	0	4	4	15

Appendix 3. cont'd

Species	Spring					Summer					Fall					Refuge					Control			Grand Total
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	X	Y	Total	
<i>Pocadicnemis americana</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	2
<i>Salcticus scenicus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	1
<i>Schizocosa crassipalata</i>	2	7	3	17	29	8	2	13	3	26	8	1	1	8	18	13	6	1	26	46	1	7	8	127
<i>Schizocosa retrorsa</i>	1	0	0	1	2	1	1	0	0	2	1	0	4	1	6	0	0	0	0	0	0	0	0	10
<i>Scotinella pugnata</i>	1	0	2	1	4	3	0	3	1	7	0	3	1	1	5	1	0	1	1	3	0	1	1	20
<i>Sergiolus decoratus</i>	2	0	0	1	3	3	1	13	1	18	0	0	3	0	3	1	0	0	0	1	0	0	0	25
<i>Sergiolus ocellatus</i>	0	1	0	1	2	0	1	0	0	1	2	0	0	0	2	0	0	0	0	0	0	0	0	5
<i>Singa keyserlingi</i>	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Sitticus striatus</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	2
<i>Steatoda americana</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	0	0	2	0	0	0	3
<i>Stemonyphantes blauveltae</i>	1	0	0	0	1	0	0	0	0	0	0	2	0	0	2	0	1	0	0	1	0	0	0	4
<i>Talavera minuta</i>	1	1	2	0	4	1	0	0	0	1	0	0	0	0	0	2	2	0	0	4	1	1	2	11
<i>Tapinocyba minuta</i>	1	0	0	0	1	0	1	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	3
<i>Tetragnatha laboriosa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Thanatus coloradensis</i>	0	0	1	0	1	1	0	1	0	2	0	1	0	0	1	1	2	0	1	4	0	0	0	8
<i>Thanatus formicinus</i>	4	1	8	9	22	6	4	4	8	22	6	5	6	5	22	2	2	5	4	13	1	3	4	83
<i>Thanatus rubicellus</i>	0	0	1	3	4	0	0	0	2	2	1	0	0	2	3	1	0	0	3	4	1	3	4	17
<i>Thanatus striatus</i>	5	13	18	3	39	5	6	8	3	22	11	8	4	4	27	16	9	11	3	39	4	1	5	132
<i>Tibellus maritimus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Tibellus oblongus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
<i>Trochosa terricola</i>	34	6	13	5	58	4	4	5	2	15	1	7	5	4	17	14	25	11	6	56	13	2	15	161
<i>Tutelina similis</i>	0	0	0	0	0	0	0	0	3	3	0	0	1	1	2	0	0	0	0	0	0	0	0	5
<i>Walckenaeria directa</i>	1	0	0	0	1	0	0	2	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	3
<i>Walckenaeria exigua</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
<i>Walckenaeria palustris</i>	0	0	1	0	1	1	0	0	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	3
<i>Walckenaeria pinocchio</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Walckenaeria spiralis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Walckenaeria tibialis</i>	0	0	0	0	0	0	0	0	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	2
<i>Xysticus ampullatus</i>	13	20	31	9	73	19	11	15	13	58	33	14	16	17	80	27	10	27	12	76	25	26	51	338
<i>Xysticus discursans</i>	0	1	2	4	7	4	1	11	0	16	4	1	4	0	9	0	1	2	0	3	1	0	1	36
<i>Xysticus emertoni</i>	5	2	10	2	19	2	3	3	0	8	2	2	2	0	6	2	6	4	2	14	9	9	18	65
<i>Xysticus ferox</i>	20	16	21	8	65	12	8	26	7	53	10	9	10	1	30	8	9	21	22	60	19	16	35	243
<i>Xysticus luctans</i>	5	10	6	3	24	5	5	1	3	14	7	2	4	2	15	4	6	5	6	21	2	4	6	80
<i>Xysticus pellax</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Xysticus triguttatus</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Xysticus winnipegensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	1
<i>Zelotes fratris</i>	27	38	44	10	119	13	7	20	8	48	16	16	6	6	44	46	40	31	28	145	41	33	74	430
<i>Zelotes lasalanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Zelotes sula</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	971	1024	936	493	3424	739	698	799	446	2682	712	749	508	459	2428	920	1311	881	811	3908	815	866	1681	14123

Appendix 4. Abundance of adult spiders per block per burn season treatment for species collected in tallgrass prairie at the St. Charles Rifle Range in 2000. See Fig. 3 for location of blocks.

Species	Spring				Summer				Fall				Refuge				Control			Grand Total				
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D		Total	X	Y	Total
<i>Acanthepeira stellata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Agelenopsis actuosa</i>	5	4	1	4	14	2	1	3	1	7	3	2	0	2	7	0	0	1	6	7	1	1	2	37
<i>Agroeca ornata</i>	35	14	15	5	69	28	15	2	5	50	18	18	17	11	64	21	21	13	5	60	4	9	13	256
<i>Agroeca pratensis</i>	25	32	27	12	96	19	32	22	22	95	22	26	24	14	86	22	18	32	18	90	29	15	44	411
<i>Agneta allosubtilis</i>	4	5	2	6	17	3	2	7	1	13	0	4	13	1	18	1	2	1	2	6	2	0	2	56
<i>Allomengea dentisetis</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Alopecosa aculeata</i>	107	97	99	55	358	84	59	104	38	285	108	52	85	52	297	65	57	124	82	328	161	164	325	1593
<i>Araneus trifolium</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
<i>Arctosa emertoni</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Arctosa raptor</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Arctosa rubicunda</i>	5	10	1	10	26	9	3	3	16	31	17	1	3	15	36	7	2	0	7	16	0	6	6	115
<i>Argenna obesa</i>	5	0	4	0	9	0	2	1	0	3	0	0	0	0	0	0	0	4	5	9	2	3	5	26
<i>Argiope trifasciata</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bassaniana utahensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Bathyphantes canadensis</i>	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Bathyphantes pallidus</i>	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	2
<i>Castianeira descripta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Castianeira longipalpa</i>	1	7	2	1	11	2	11	2	3	18	6	10	4	4	24	5	1	3	10	19	4	6	10	82
<i>Centromerus sylvaticus</i>	77	72	85	9	243	39	66	44	11	160	36	76	28	12	152	37	164	60	12	273	109	18	127	955
<i>Ceraticelus fissiceps</i>	6	3	2	0	11	2	0	1	0	3	0	0	0	0	0	1	0	2	0	3	1	0	1	18
<i>Ceraticelus laetus</i>	63	18	21	11	113	5	3	9	1	18	8	2	2	2	14	38	35	21	5	99	16	8	24	268
<i>Ceraticelus laticeps</i>	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	3
<i>Ceratinella brunnea</i>	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Cicurina arcuata</i>	5	9	5	5	24	19	9	3	5	36	7	26	9	9	51	5	1	5	2	13	3	7	10	134
<i>Clubiona abboti</i>	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Clubiona johnsoni</i>	9	5	10	1	25	10	5	4	3	22	3	7	11	3	24	4	2	6	2	14	4	5	9	94
<i>Clubiona moesta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Collinsia plumosa</i>	29	16	23	11	79	33	25	61	3	122	5	2	19	4	30	14	1	24	4	43	16	0	16	290
<i>Dictyna foliacea</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Dolomedes striatus</i>	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	4
<i>Dolomedes triton</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
<i>Drassyllus depressus</i>	0	0	2	0	2	0	3	2	1	6	0	0	1	3	4	0	1	0	0	1	0	0	0	13
<i>Drassyllus niger</i>	1	2	3	1	7	7	5	3	1	16	3	7	0	3	13	3	3	0	4	10	1	5	6	52
<i>Ebo iviei</i>	1	1	0	0	2	0	0	0	0	0	0	0	1	0	1	0	2	0	0	2	0	0	0	5
<i>Enoplognatha marmorata</i>	0	0	0	1	1	1	2	1	3	7	3	0	2	10	15	0	0	0	0	0	0	0	0	23
<i>Eperigone trilobata</i>	14	5	3	2	24	14	8	20	0	42	9	8	11	2	30	6	5	14	5	30	25	4	29	155
<i>Eridantes utibilis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Erigone atra</i>	5	4	2	0	11	1	3	3	3	10	7	0	10	3	20	2	1	2	6	11	2	3	5	57
<i>Erigone blaesae</i>	1	0	0	0	1	0	2	1	0	3	0	0	2	1	3	0	0	0	0	0	0	0	0	7
<i>Ero canionis</i>	0	1	2	0	3	1	2	4	0	7	0	2	2	0	4	1	3	2	0	6	9	0	9	29
<i>Euryopsis gertschi</i>	5	2	2	0	9	3	1	0	1	5	1	1	4	0	6	2	4	4	2	12	8	2	10	42
<i>Euryopsis pepini</i>	3	8	5	0	16	5	6	3	2	16	4	0	9	0	13	2	2	10	1	15	7	4	11	71
<i>Euryopsis sauwea</i>	2	3	0	0	5	1	0	0	0	1	1	0	2	2	5	1	0	2	0	3	1	0	1	15

Appendix 4. cont'd

Species	Spring				Summer				Fall				Refuge				Control			Grand Total				
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D		Total	X	Y	Total
<i>Evarcha hoyi</i>	2	1	0	0	3	1	0	0	1	2	0	0	1	0	1	1	1	1	0	3	2	1	3	12
<i>Gnaphosa parvula</i>	14	6	8	0	28	10	3	11	0	24	4	6	6	1	17	16	13	13	4	46	19	13	32	147
<i>Gonatium crassipalpum</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	1
<i>Goneatara nasutus</i>	133	31	22	6	192	132	59	32	10	233	62	26	34	2	124	43	96	24	21	184	11	6	17	750
<i>Grammonota angusta</i>	0	1	0	0	1	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	4
<i>Grammonota ornata</i>	0	0	0	0	0	0	0	0	1	1	0	0	3	0	3	0	0	0	0	0	1	0	1	5
<i>Grammonota pictilis</i>	25	16	18	2	61	10	16	32	0	58	11	9	38	1	59	22	13	26	5	66	19	10	29	273
<i>Habronattus decorus</i>	0	0	0	1	1	0	0	0	0	0	1	2	0	3	6	1	1	1	2	5	0	1	1	13
<i>Hahnia cinerea</i>	15	4	1	2	22	1	4	0	0	5	5	0	1	0	6	2	3	5	2	12	7	1	8	53
<i>Haplodrassus hiemalis</i>	5	2	10	2	19	1	7	5	2	15	2	2	3	7	14	5	2	11	1	19	9	6	15	82
<i>Haplodrassus signifer</i>	1	0	2	1	4	1	4	0	2	7	1	3	2	3	9	0	0	0	0	0	0	0	0	20
<i>Hogna frondicola</i>	29	22	32	9	92	54	50	37	30	171	38	53	42	33	166	21	29	28	22	100	25	20	45	574
<i>Hypsosinga pygmaea</i>	0	0	0	0	0	1	0	0	0	1	1	0	0	0	1	1	1	1	0	3	0	0	0	5
<i>Islandiana flaveola</i>	5	3	0	2	10	1	3	16	0	20	0	0	0	0	0	0	0	2	0	2	0	0	0	32
<i>Islandiana longisetosa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Islandiana princeps</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Kaestneria pullata</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Micaria gertschi</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Micaria pulicaria</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	4	0	4	5
<i>Micaria rossica</i>	0	0	0	0	0	0	0	0	3	3	0	0	0	1	1	0	1	0	1	2	0	0	0	6
<i>Mimetus epeiroides</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Neoantistea magna</i>	2	3	0	0	5	0	0	1	1	2	0	0	1	1	2	1	2	0	1	4	0	2	2	15
<i>Neoscona arabesca</i>	0	0	0	1	1	0	0	1	0	1	1	1	2	0	4	0	0	0	0	0	1	0	1	7
<i>Neriere radiata</i>	0	0	3	0	3	2	0	4	1	7	0	0	0	0	0	0	2	4	0	6	4	0	4	20
<i>Neriere clathrata</i>	2	9	4	0	15	6	0	5	0	11	8	9	7	0	24	1	4	0	0	5	0	0	0	55
<i>Ozyptila conspurcata</i>	17	29	49	3	98	20	7	6	4	37	23	16	29	5	73	58	22	68	15	163	82	33	115	486
<i>Pachygnatha dorothea</i>	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Pachygnatha tristriata</i>	5	12	5	1	23	5	19	7	0	31	5	13	3	0	21	5	17	3	2	27	6	3	9	111
<i>Pachygnatha xanthostoma</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pardosa distincta</i>	54	170	197	134	555	210	306	214	307	1037	176	235	255	256	922	209	106	229	234	778	138	387	525	3817
<i>Pardosa dromaea</i>	0	1	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Pardosa fuscica</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pardosa modica</i>	15	13	9	17	54	3	10	47	2	62	5	11	10	3	29	6	22	12	8	48	6	1	7	200
<i>Pardosa moesta</i>	488	502	324	75	1389	191	225	203	29	648	162	133	130	19	444	315	631	356	136	1438	402	104	506	4425
<i>Pardosa ontariensis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pardosa xerampelina</i>	0	1	0	0	1	0	0	0	0	0	1	0	0	1	2	1	0	0	0	1	0	0	0	4
<i>Pelecopsis menzei</i>	6	0	0	0	6	0	2	3	1	6	0	0	0	0	0	0	0	1	0	1	0	0	0	13
<i>Pelegrina insignis</i>	0	0	1	0	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	2
<i>Phidippus whitmani</i>	1	1	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2	0	2	2	6
<i>Philodromus histrio</i>	1	0	1	2	4	2	0	0	1	3	4	2	3	1	10	2	1	0	0	3	0	6	6	26
<i>Phrurotimpus borealis</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Pirata insularis</i>	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Pirata minutus</i>	11	19	13	49	92	42	28	48	11	129	11	12	25	5	53	9	12	26	13	60	16	6	22	356
<i>Pirata piraticus</i>	1	0	0	1	2	0	1	3	0	4	0	1	0	0	1	0	0	1	0	1	0	1	1	9

Appendix 4. cont'd

Species	Spring					Summer					Fall					Refuge					Control			Grand Total
	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	A	B	C	D	Total	X	Y	Total	
<i>Pocadicnemis americana</i>	2	2	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	5
<i>Salticus scenicus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Schizocosa crassipalata</i>	12	17	3	28	60	14	10	17	11	52	29	8	14	11	62	25	5	21	41	92	6	21	27	293
<i>Schizocosa retrorsa</i>	1	0	0	0	1	0	0	0	1	1	1	0	0	0	1	0	0	0	1	1	0	0	0	4
<i>Scotinella pugnata</i>	5	5	2	0	12	8	1	1	1	11	2	4	4	1	11	5	7	8	2	22	6	4	10	66
<i>Sergiolus decoratus</i>	0	0	1	0	1	1	3	1	1	6	2	1	2	2	7	1	0	0	0	1	0	0	0	15
<i>Sergiolus ocellatus</i>	0	1	0	0	1	2	0	1	0	3	0	0	0	0	0	0	1	1	0	2	1	1	2	8
<i>Singa keyserlingi</i>	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2
<i>Sitticus striatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Steatoda americana</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	0	1	0	0	0	2
<i>Stemonyphantes blauveltae</i>	0	0	2	0	2	1	3	0	0	4	0	2	0	0	2	0	2	0	0	2	1	0	1	11
<i>Talavera minuta</i>	3	0	1	0	4	0	0	1	1	2	1	0	0	0	1	1	0	1	0	2	0	1	1	10
<i>Tapinocyba minuta</i>	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	1	0	1	2
<i>Tetragnatha laboriosa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	2	0	0	0	2
<i>Thanatus coloradensis</i>	0	0	0	0	0	2	1	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	3
<i>Thanatus formicinus</i>	9	3	5	6	23	9	5	8	4	26	9	1	2	5	17	2	8	7	12	29	1	11	12	107
<i>Thanatus rubicellus</i>	0	0	0	1	1	2	2	1	1	6	5	1	2	2	10	2	0	2	4	8	5	3	8	33
<i>Thanatus striatus</i>	2	15	12	5	34	5	1	6	4	16	4	2	10	1	17	9	9	8	0	26	4	2	6	99
<i>Tibellus maritimus</i>	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2
<i>Tibellus oblongus</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	0	0	0	0	0	0	0	0	3
<i>Trochosa terricola</i>	68	51	30	10	159	42	22	33	3	100	28	21	14	2	65	24	48	42	16	130	67	30	97	551
<i>Tutelina similis</i>	0	0	0	0	0	0	0	0	2	2	1	0	0	0	1	0	0	0	1	1	0	0	0	4
<i>Walckenaeria directa</i>	3	0	3	0	6	1	1	2	1	5	1	0	1	0	2	0	1	1	0	2	1	8	9	24
<i>Walckenaeria exigua</i>	0	2	0	0	2	0	1	0	0	1	0	1	0	0	1	0	1	0	1	2	0	0	0	6
<i>Walckenaeria palustris</i>	0	3	0	0	3	1	0	1	0	2	1	0	0	0	1	0	1	0	0	1	1	0	1	8
<i>Walckenaeria pinocchio</i>	0	1	0	0	1	0	1	0	0	1	0	1	3	0	4	0	0	2	0	2	0	0	0	8
<i>Walckenaeria spiralis</i>	0	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Walckenaeria tibialis</i>	1	1	0	0	2	0	1	0	0	1	0	1	1	1	3	3	3	0	0	6	1	2	3	15
<i>Xysticus ampullatus</i>	16	18	29	6	69	12	15	14	4	45	21	13	22	12	68	22	9	22	8	61	20	18	38	281
<i>Xysticus discursans</i>	0	1	1	5	7	0	0	2	0	2	1	3	8	3	15	0	0	0	0	0	0	0	0	24
<i>Xysticus emertoni</i>	17	13	18	3	51	11	4	9	3	27	21	13	6	4	44	12	12	17	2	43	6	29	35	200
<i>Xysticus ferox</i>	6	37	18	7	68	15	15	20	13	63	9	13	45	17	84	13	11	26	14	64	9	34	43	322
<i>Xysticus luctans</i>	5	2	0	3	10	4	2	7	2	15	2	2	3	0	7	7	3	3	3	16	3	7	10	58
<i>Xysticus pellax</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Xysticus triguttatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	2
<i>Xysticus winnipegensis</i>	5	0	0	0	5	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	6
<i>Zelotes fratris</i>	37	46	39	13	135	36	24	23	11	94	32	29	13	3	77	40	53	40	30	163	57	28	85	554
<i>Zelotes lasalanus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Zelotes sula</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total</b>	<b>1438</b>	<b>1386</b>	<b>1180</b>	<b>529</b>	<b>4533</b>	<b>1149</b>	<b>1125</b>	<b>1130</b>	<b>592</b>	<b>3996</b>	<b>954</b>	<b>895</b>	<b>1008</b>	<b>561</b>	<b>3418</b>	<b>1127</b>	<b>1478</b>	<b>1346</b>	<b>781</b>	<b>4732</b>	<b>1348</b>	<b>1065</b>	<b>2413</b>	<b>19092</b>

Appendix 5. Adult abundance of spider species by year and subsection collected on the St. Charles Rifle Range from 1998 to 2000. Pitfalls 1-5 and 16-21 were in tallgrass prairie. Pitfalls 6-10 and 11-15 were in aspen forest.

Species	Pitfalls 1-5				Pitfalls 6-10				Pitfalls 11-15				Pitfalls 16-21				Grand
	1998	1999	2000	Total	1998	1999	2000	Total	1998	1999	2000	Total	1998	1999	2000	Total	Total
<i>Agelenopsis arcuata</i>	0	1	1	2	0	0	0	0	0	0	1	1	0	1	0	1	4
<i>Agroeca ornata</i>	9	0	8	17	64	19	53	136	33	14	50	97	29	4	22	55	305
<i>Agroeca pratensis</i>	4	14	8	26	1	2	3	6	0	2	3	5	2	14	18	34	71
<i>Agyneta allosubtilis</i>	0	0	4	4	0	0	3	3	0	1	12	13	0	1	1	2	22
<i>Allomengea dentisetis</i>	0	1	0	1	2	0	0	2	6	1	0	7	1	0	0	1	11
<i>Alopecosa aculeata</i>	3	38	46	87	0	5	10	15	18	9	40	67	16	25	41	82	251
<i>Arctosa rubicunda</i>	3	5	1	9	0	0	1	1	1	1	0	2	4	11	23	38	50
<i>Argenna obesa</i>	0	2	2	4	0	0	1	1	0	0	1	1	0	0	0	0	6
<i>Bathyphantes canadensis</i>	0	0	0	0	0	1	0	1	0	1	0	1	0	0	0	0	2
<i>Bathyphantes pallidus</i>	0	1	0	1	0	0	2	2	1	2	0	3	0	0	0	0	6
<i>Castianaira cingulata</i>	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1
<i>Castianaira longipalpa</i>	6	4	5	15	2	3	0	5	2	0	0	2	10	2	6	18	40
<i>Centromerus sylvaticus</i>	7	3	17	27	10	3	26	39	46	9	63	118	37	6	30	73	257
<i>Ceraticelus fissiceps</i>	0	0	1	1	0	1	0	1	0	0	0	0	0	0	0	0	2
<i>Ceraticelus laetus</i>	0	1	5	6	0	5	13	18	0	5	14	19	0	3	15	18	61
<i>Ceraticelus laticeps</i>	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	1
<i>Cicurina arcuata</i>	1	3	3	7	0	1	1	2	0	0	0	0	1	3	1	5	14
<i>Clubiona johnsoni</i>	2	1	2	5	0	0	1	1	0	0	0	0	0	0	3	3	9
<i>Clubiona kastoni</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	2	2
<i>Collinsia plumosa</i>	0	0	1	1	0	2	3	5	0	2	0	2	0	0	1	1	9
<i>Dolomedes striatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
<i>Dolomedes triton</i>	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1
<i>Drassyllus depressus</i>	0	1	5	6	0	0	0	0	0	0	0	0	0	0	0	0	6
<i>Drassyllus niger</i>	1	2	0	3	0	0	2	2	4	1	4	9	1	1	3	5	19
<i>Ebo iviei</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
<i>Enoplognatha marmorata</i>	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Eperigone trilobata</i>	0	0	5	5	0	0	0	0	0	0	2	2	0	0	3	3	10
<i>Eridantes utibilis</i>	0	0	0	0	0	2	0	2	0	0	0	0	0	0	0	0	2
<i>Erigone atra</i>	0	0	1	1	0	0	1	1	0	0	1	1	0	0	0	0	3
<i>Ero canionis</i>	1	0	0	1	3	0	0	3	1	2	1	4	1	0	0	1	9



Appendix 5 cont'd.

Species	Pitfalls 1-5				Pitfalls 6-10				Pitfalls 11-15				Pitfalls 16-21				Grand
	1998	1999	2000	Total	1998	1999	2000	Total	1998	1999	2000	Total	1998	1999	2000	Total	Total
<i>Euryopis funebris</i>	1	2	2	5	0	0	0	0	0	0	0	0	0	1	0	1	6
<i>Evarcha hoyi</i>	1	0	1	2	0	0	0	0	0	0	0	0	1	1	0	2	4
<i>Gnaphosa parvula</i>	1	3	0	4	2	2	1	5	0	3	2	5	2	3	1	6	20
<i>Goneatara nasutus</i>	2	1	14	17	2	4	17	23	1	9	34	44	1	1	74	76	160
<i>Grammonota gigas</i>	0	0	0	0	0	13	2	15	0	3	5	8	0	0	0	0	23
<i>Grammonota pictilis</i>	0	4	2	6	0	0	0	0	0	0	0	0	0	0	5	5	11
<i>Habronattus decorus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
<i>Hahnia cinerea</i>	0	0	6	6	0	0	8	8	0	1	11	12	0	0	5	5	31
<i>Haplodrassus hiemalis</i>	2	0	4	6	4	3	2	9	2	3	1	6	2	2	2	6	27
<i>Hogna frondicola</i>	2	0	5	7	0	0	0	0	0	0	0	0	6	2	13	21	28
<i>Hypsosinga pygmaea</i>	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Islandiana flaveola</i>	0	0	2	2	0	1	13	14	0	1	8	9	0	0	7	7	32
<i>Micaria pulicaria</i>	0	0	0	0	0	7	1	8	0	7	1	8	0	0	2	2	18
<i>Micaria rossica</i>	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Neoantistea magna</i>	0	0	0	0	0	0	3	3	0	0	1	1	0	1	0	1	5
<i>Nerieue clathrata</i>	1	0	0	1	0	1	1	2	0	1	4	5	0	0	1	1	9
<i>Ozyptila conspurcata</i>	0	1	1	2	0	1	0	1	0	1	0	1	1	0	2	3	7
<i>Ozyptila sincera canadensis</i>	0	0	0	0	0	1	0	1	0	1	0	1	1	0	0	1	3
<i>Pachygnatha tristriata</i>	2	1	0	3	0	1	0	1	0	0	0	0	0	0	0	0	4
<i>Pachygnatha xanthostoma</i>	0	0	0	0	0	0	0	0	3	1	1	5	0	0	0	0	5
<i>Pardosa distincta</i>	84	53	71	208	0	0	0	0	1	1	0	2	75	37	60	172	382
<i>Pardosa fuscula</i>	0	0	0	0	5	0	1	6	1	0	0	1	0	0	0	0	7
<i>Pardosa mackenziana</i>	0	0	0	0	1	1	0	2	2	0	0	2	0	0	0	0	4
<i>Pardosa modica</i>	3	2	3	8	0	0	0	0	0	1	0	1	0	0	0	0	9
<i>Pardosa moesta</i>	135	136	149	420	151	373	170	694	102	263	176	541	95	133	83	311	1966
<i>Pardosa xerampelina</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
<i>Pelecopsis mengei</i>	0	0	2	2	0	1	5	6	5	17	25	47	0	0	2	2	57
<i>Phidippus whitmani</i>	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	2	3
<i>Philodromus histrio</i>	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	1	2
<i>Phrurotimpus borealis</i>	0	0	0	0	0	0	0	0	0	0	1	1	0	1	3	4	5
<i>Pirata insularis</i>	1	1	0	2	4	0	0	4	4	1	3	8	1	0	1	2	16
<i>Pirata minutus</i>	3	4	1	8	0	0	0	0	0	2	0	2	1	1	1	3	13

## Appendix 5 cont'd.

Species	Pitfalls 1-5				Pitfalls 6-10				Pitfalls 11-15				Pitfalls 16-21				Grand
	1998	1999	2000	Total	1998	1999	2000	Total	1998	1999	2000	Total	1998	1999	2000	Total	Total
<i>Pirata montanus</i>	0	0	0	0	0	0	0	0	0	1	0	1	0	1	0	1	2
<i>Pirata piraticus</i>	2	3	0	5	6	5	0	11	3	0	2	5	1	0	0	1	22
<i>Pocadenemis americana</i>	0	0	1	1	0	0	0	0	0	1	0	1	0	0	1	1	3
<i>Robertus banksi</i>	1	0	0	1	8	0	7	15	4	1	8	13	0	0	1	1	30
<i>Schizocosa crassipalpa</i>	0	2	3	5	0	0	0	0	0	0	0	0	0	0	3	3	8
<i>Schizocosa retrorsa</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	1
<i>Scotinella pugnata</i>	0	0	2	2	0	0	0	0	0	0	0	0	0	0	1	1	3
<i>Sergiolus ocellatus</i>	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	1
<i>Steatoda americana</i>	0	0	0	0	0	2	1	3	0	0	0	0	0	0	0	0	3
<i>Talavera minuta</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2
<i>Tapinocyba minuta</i>	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1
<i>Thanatus formicinus</i>	3	1	3	7	0	0	0	0	0	0	0	0	0	5	3	8	15
<i>Thanatus striatus</i>	6	1	1	8	0	0	0	0	0	1	0	1	2	3	0	5	14
<i>Tibellus maritimus</i>	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	1
<i>Tibellus oblongus</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	2
<i>Titanoeca nivalis</i>	0	0	0	0	0	0	0	0	1	0	1	2	0	0	0	0	2
<i>Trochosa terricola</i>	1	4	18	23	2	5	8	15	5	7	25	37	3	3	29	35	110
<i>Tutelina similis</i>	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
<i>Walckenaeria directa</i>	0	1	1	2	0	0	0	0	0	1	0	1	0	0	0	0	3
<i>Walckenaeria exigua</i>	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1
<i>Walckenaeria palustris</i>	0	0	0	0	0	0	0	0	0	0	1	1	0	2	0	2	3
<i>Walckenaeria spiralis</i>	0	0	1	1	4	1	1	6	0	0	1	1	1	0	0	1	9
<i>Xysticus ampulatus</i>	1	4	3	8	0	0	0	0	0	0	0	0	1	5	6	12	20
<i>Xysticus discursans</i>	2	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
<i>Xysticus elegans</i>	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	2
<i>Xysticus emertoni</i>	3	4	4	11	0	0	0	0	3	4	1	8	0	6	6	12	31
<i>Xysticus ferox</i>	7	6	10	23	0	0	0	0	0	0	1	1	3	0	6	9	33
<i>Xysticus luctans</i>	1	3	2	6	0	0	0	0	0	0	0	0	0	1	3	4	10
<i>Xysticus winnipegensis</i>	0	0	2	2	0	0	1	1	1	0	1	2	1	5	1	7	12
<i>Zelotes fratris</i>	19	17	14	50	6	10	7	23	6	4	8	18	9	6	8	23	114
	323	333	445	1101	277	476	371	1124	258	388	516	1162	314	297	501	1112	4499

Appendix 6. Burn management plan for tallgrass prairie region of St. Charles Rifle Range (from Roughley 2001).

The conclusions based on a combination of arthropod and plant data are that a mosaic pattern of burn treatments would be most appropriate for maintenance and management of tallgrass prairie habitat. The nature of unmanaged prairie prior to human intervention was an unknown and unknowable pattern of disturbance. However, from the literature, reports of travelers, historical weather patterns and the information provided in this study it is becoming clear that the scale of variation was continuous and composed of many factors. For instance, in a drier climatic cycle the fuel load could burn at any time of year producing a subsequent pulse of green vegetation, which might attract large herbivores that would further disturb the prairie. These kinds of disturbance were happening continuously and the plants and animals of the prairie, over time, became adapted to it. Suppression of these disturbances has led to a degradation of prairie. Obviously we can not control climate as a disturbance. We are unlikely to ever again achieve the pulses of large herbivores of historical times. The most appropriate method of historical disturbance would be fire.

So when is the most appropriate time of year to burn the tallgrass prairie of SCRR? The results of our study suggest that there is no single most appropriate time of year to achieve appropriate health and species diversity of tallgrass prairie. Rather a mosaic of burns was the historical pattern and would be the most appropriate pattern of present day disturbance. The timing of the burns should be spread among spring, summer, and fall burns and each time leaving some somewhat older portion of the prairie as a refuge. Some of these should probably be overlapping at intervals.

The following schematic is proposed for all of the area of SCRR north of the rifle butts. SCRR is divided into arbitrary north-south units labeled W, X, Y, and Z and east-west units labeled 1, 2, and 3. Each unit is therefore 1/12 of the area north of the rifle butts. The burn regime outlined here is independent of a poplar management plan. We suggest that various blocks of the base be burned in a rotation system among years. With the northernmost strip (W1, W2, W3) burned in one season (for instance, spring 2001), followed the next year by a summer burn across the southernmost strip (Z1, Z2, Z3). This burn could occur in the summer of 2002. In year three (2003), the easternmost strip would be burned in the fall. This would mean that two blocks, W3 and Z3, would both have received treatments within the first three years. A scheme of burn management is laid out for nine years of the plan, below. The suggestion of this plan is based in part on the plant, insect and spider data from the present study but also it takes into consideration some forest management plans developed for sustainable harvest of forests. In year ten, the plan would revert to the burn regime suggested for the present year one.

Year 1, Spring Burn W1-W3

	1	2	3
W			
X			
Y			
Z			

Year 2, Summer Burn Z1-Z3

	1	2	3
W			
X			
Y			
Z			

Year 3, Fall Burn W3-Z3

	1	2	3
W			
X			
Y			
Z			

Year 4, Spring Burn W1-Z1

	1	2	3
W			
X			
Y			
Z			

Year 5, Summer Burn W2-Z2

	1	2	3
W			
X			
Y			
Z			

Year 6, Fall Burn W3-Z3

	1	2	3
W			
X			
Y			
Z			

Year 7, Spring Burn Z1-Z3

	1	2	3
W			
X			
Y			
Z			

Year 8, Summer Burn W1-W3

	1	2	3
W			
X			
Y			
Z			

Year 9, Fall Burn W1-Z1

	1	2	3
W			
X			
Y			
Z			